ECONOMICS OF AGRICULTURE (AGBUS 40)



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Economics of Agriculture (AGBUS 40)

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1: INTRODUCTION TO AGRICULTURAL ECONOMICS

1.1: Preface
1.2: Defining Economics
1.3: Introduction to the Study of Economics
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1.1: Preface

Economics of Agriculture is an Open Educational Resource (OER) textbook developed to support students at **Coalinga College** and other community colleges studying Agricultural Business and related fields. This text is designed as the **primary textbook** for introductory agricultural economics courses and serves as a foundational resource for all Agricultural Business majors at the community college level.

Agriculture plays a critical role in California's economy and our local San Joaquin Valley communities. This textbook aims to connect economic theory with real-world agricultural practices, policy discussions, and industry applications relevant to both local and global food systems. Students will explore key concepts in supply and demand, production, markets, resource use, and agricultural policy—grounded in examples from crop and livestock production, agribusiness operations, food systems, and agricultural trade.

This course assumes no prior coursework beyond college algebra and an introductory understanding of basic economic principles. It is intended to bridge the gap between high school or entry-level college economics and upper-division agricultural economics courses at four-year universities. Students who complete this course will build a strong foundation in economic reasoning and will be prepared for more advanced coursework in agricultural business, agricultural marketing, and applied economics.

Upon successful completion of the course, students should be able to:

- Understand core economic concepts as they apply to food and agricultural systems
- Analyze decisions made by producers, agribusinesses, and policymakers
- Apply economic tools to real-world agricultural challenges and industry settings
- Demonstrate problem-solving and quantitative reasoning skills
- Connect agricultural economics to future academic goals and career pathways

To support student success, each chapter begins with clear learning objectives and integrates practice problems, data-driven examples, and applied activities. Students are encouraged to review the objectives before reading and revisit them as they complete problem sets and case studies. The textbook also includes interactive opportunities, real agricultural scenarios, and self-assessment tools to help students monitor their learning.

This OER textbook draws inspiration from other open agricultural economics learning materials and is part of a growing effort to make higher education **affordable, accessible, and relevant** to diverse community college learners—including first-generation college students, working adults, and students exploring careers in agriculture and food systems. By openly licensing this work, we aim to support **equitable access to education** and invite instructors to adapt, expand, and build upon this resource to meet the needs of their students and local agricultural communities.

Economics of Agriculture is licensed under the Creative Commons **CC BY-SA** license, allowing educators and students to freely use, share, and remix the material as long as proper credit is given and adaptations are shared under the same license.

Thank you for choosing this OER text. We look forward to learning together, exploring how economics shapes agriculture, and preparing the next generation of agricultural leaders, business professionals, and community innovators.

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1.2: Defining Economics

Learning Objective

1. Define economics.
2. Explain the concepts of scarcity and opportunity cost and how they relate to the definition of economics.
3. Understand the three fundamental economic questions: What should be produced? How should goods and services be produced? For whom should goods and services be produced?

Economics is a social science that examines how people choose among the alternatives available to them. It is social because it involves people and their behavior. It is a science because it uses, as much as possible, a scientific approach in its investigation of choices.

Scarcity, Choice, and Cost

All choices mean that one alternative is selected over another. Selecting among alternatives involves three ideas central to economics: scarcity, choice, and opportunity cost.

Scarcity

Our resources are limited. At any one time, we have only so much land, so many factories, so much oil, so many people. But our wants, our desires for the things that we can produce with those resources, are unlimited. We would always like more and better housing, more and better education—more and better of practically everything.

If our resources were also unlimited, we could say yes to each of our wants—and there would be no economics. Because our resources are limited, we cannot say yes to everything. To say yes to one thing requires that we say no to another. Whether we like it or not, we must make choices.

Our unlimited wants are continually colliding with the limits of our resources, forcing us to pick some activities and to reject others. Scarcity is the condition of having to choose among alternatives. A scarce good is one for which the choice of one alternative requires that another be given up.

Consider a parcel of land. The parcel presents us with several alternative uses. We could build a house on it. We could put a gas station on it. We could create a small park on it. We could leave the land undeveloped in order to be able to make a decision later as to how it should be used.

Suppose we have decided the land should be used for housing. Should it be a large and expensive house or several modest ones? Suppose it is to be a large and expensive house. Who should live in the house? If the Lees live in it, the Nguyens cannot. There are alternative uses of the land both in the sense of the type of use and also in the sense of who gets to use it. The fact that land is scarce means that society must make choices concerning its use.

Virtually everything is scarce. Consider the air we breathe, which is available in huge quantity at no charge to us. Could it possibly be scarce?

The test of whether air is scarce is whether it has alternative uses. What uses can we make of the air? We breathe it. We pollute it when we drive our cars, heat our houses, or operate our factories. In effect, one use of the air is as a garbage dump. We certainly need the air to breathe. But just as certainly, we choose to dump garbage in it. Those two uses are clearly alternatives to each other. The more garbage we dump in the air, the less desirable—and healthy—it will be to breathe. If we decide we want to breathe cleaner air, we must limit the activities that generate pollution. Air is a scarce good because it has alternative uses.

Not all goods, however, confront us with such choices. A free good is one for which the choice of one use does not require that we give up another. One example of a free good is gravity. The fact that gravity is holding you to the earth does not mean that your neighbor is forced to drift up into space! One person's use of gravity is not an alternative to another person's use.

There are not many free goods. Outer space, for example, was a free good when the only use we made of it was to gaze at it. But now, our use of space has reached the point where one use can be an alternative to another. Conflicts have already arisen over the allocation of orbital slots for communications satellites. Thus, even parts of outer space are scarce. Space will surely become more scarce as we find new ways to use it. Scarcity characterizes virtually everything. Consequently, the scope of economics is wide indeed.

Scarcity and the Fundamental Economic Questions

The choices we confront as a result of scarcity raise three sets of issues. Every economy must answer the following questions:

1. **What should be produced?** Using the economy's scarce resources to produce one thing requires giving up another. Producing better education, for example, may require cutting back on other services, such as health care. A decision to preserve a wilderness area requires giving up other uses of the land. Every society must decide what it will produce with its scarce resources.
2. **How should goods and services be produced?** There are all sorts of choices to be made in determining how goods and services should be produced. Should a firm employ a few skilled or a lot of unskilled workers? Should it produce in its own country or should it use foreign plants? Should manufacturing firms use new or recycled raw materials to make their products?
3. **For whom should goods and services be produced?** If a good or service is produced, a decision must be made about who will get it. A decision to have one person or group receive a good or service usually means it will not be available to someone else. For example, representatives of the poorest nations on earth often complain that energy consumption per person in the United States is 17 *times* greater than energy consumption per person in the world's 62 poorest countries. Critics argue that the world's energy should be more evenly allocated. Should it? That is a "for whom" question.

Every economy must determine what should be produced, how it should be produced, and for whom it should be produced. We shall return to these questions again and again.

Opportunity Cost

It is within the context of scarcity that economists define what is perhaps the most important concept in all of economics, the concept of opportunity cost. Opportunity cost is the value of the best alternative forgone in making any choice.

The opportunity cost to you of reading the remainder of this chapter will be the value of the best other use to which you could have put your time. If you choose to spend $20 on a potted plant, you have simultaneously chosen to give up the benefits of spending the $20 on pizzas or a paperback book or a night at the movies. If the book is the most valuable of those alternatives, then the opportunity cost of the plant is the value of the enjoyment you otherwise expected to receive from the book.

The concept of opportunity cost must not be confused with the purchase price of an item. Consider the cost of a college or university education. That includes the value of the best alternative use of money spent for tuition, fees, and books. But the most important cost of a college education is the value of the forgone alternative uses of time spent studying and attending class instead of using the time in some other endeavor. Students sacrifice that time in hopes of even greater earnings in the future or because they place a value on the opportunity to learn. Or consider the cost of going to the doctor. Part of that cost is the value of the best alternative use of the money required to see the doctor. But, the cost also includes the value of the best alternative use of the time required to see the doctor. The essential thing to see in the concept of opportunity cost is found in the name of the concept. Opportunity cost is the value of the best opportunity forgone in a particular choice. It is not simply the amount spent on that choice.

The concepts of scarcity, choice, and opportunity cost are at the heart of economics. A good is scarce if the choice of one alternative requires that another be given up. The existence of alternative uses forces us to make choices. The opportunity cost of any choice is the value of the best alternative forgone in making it.

Key Takeaways

- Economics is a social science that examines how people choose among the alternatives available to them.
- Scarcity implies that we must give up one alternative in selecting another. A good that is not scarce is a free good.
- The three fundamental economic questions are: What should be produced? How should goods and services be produced?

For whom should goods and services be produced?

- Every choice has an opportunity cost and opportunity costs affect the choices people make. The opportunity cost of any choice is the value of the best alternative that had to be forgone in making that choice.

Try It!

Identify the elements of scarcity, choice, and opportunity cost in each of the following:

1. The Environmental Protection Agency is considering an order that a 500-acre area on the outskirts of a large city be preserved in its natural state, because the area is home to a rodent that is considered an endangered species. Developers had planned to build a housing development on the land.
2. The manager of an automobile assembly plant is considering whether to produce cars or sport utility vehicles (SUVs) next month. Assume that the quantities of labor and other materials required would be the same for either type of production.
3. A young man who went to work as a nurses' aide after graduating from high school leaves his job to go to college, where he will obtain training as a registered nurse.

Case in Point: The Rising Cost of Energy

Oil is an exhaustible resource. The oil we burn today will not be available for use in the future. Part of the opportunity cost of our consumption of goods such as gasoline that are produced from oil includes the value people in the future might have placed on oil we use today.

It appears that the cost of our use of oil may be rising. We have been using "light crude," the oil found in the ground in deposits that can be readily tapped. As light crude becomes more scarce, the world may need to turn to so-called "heavy crude," the crude oil that is found in the sandy soil of places such as Canada and Venezuela. That oil exists in such abundance that it propels Venezuela to the top of the world list of available oil. Saudi Arabia moves to the second position; Canada is third.

The difficulty with the oil mixed in the sand is that extracting it is far more costly than light crude, both in terms of the expenditures required and in terms of the environmental damage that mining it creates. Northern Alberta, in Canada, boasts a Florida-sized area whose sandy soils are rich in crude oil. Some of that oil is 1,200 feet underground. Extracting it requires pumping steam into the oily sand and then pumping up the resultant oily syrup. That syrup is then placed into huge, industrial-sized washing machines that separate crude oil. What is left over is toxic and will be placed in huge lakes that are being created by digging pits in the ground 200 feet deep. The oil produced from these sands has become important—Alberta is the largest foreign supplier of oil to the United States.

Sands that are closer to the surface are removed by bulldozers and giant cranes; the forest over it is cleared away. The oily sand is then hauled off in two-story dump trucks which, when filled, weigh more than a Boeing 747. Total SA, a French company, is leading the race to develop Canada's oil. Jean Luc-Guiziou, the president of Total SA's Canadian operations, says that the extraordinarily costly process of extracting heavy crude is something the world is going to have to get used to. "The light crude undiscovered today is getting scarcer and scarcer," he told *The Wall Street Journal*. "We have to accept the reality of geoscience, which is that the next generation of oil resources will be heavier."



Figure 1.1: IFPRI – IMAGES – oil barrels – CC BY-NC-ND 2.0.

Already, Total SA has clear-cut thousands of acres of forest land in order to gain access to the oily sand below. The process of extracting heavy crude oil costs the company $25 a barrel—compared to the $6 per barrel cost of extracting and refining light crude. Extracting heavy crude generates three times as much greenhouse gas per barrel as does light crude. By 2015, Fort McMurray, the small (population 61,000) town that has become the headquarters of Northern Alberta's crude oil boom, will emit more greenhouse gas than the entire country of Denmark (population 5.4 million). Canada will exceed its greenhouse gas quota set by the Kyoto Accords—an international treaty aimed at limiting global warming—largely as a result of developing its heavy crude deposits.

No one even considered the extraction of heavy crude when light crude was cheap. In the late 1990s, oil cost just $12 per barrel, and deposits of heavy crude such as those in Canada attracted little attention. By mid-2006, oil sold for more than $70 per barrel, and Canada's heavy crude was suddenly a hot commodity. "It moved from being just an interesting experiment in northern Canada to really this is the future source of oil supply," Greg Stringham of the Canadian Association of Petroleum Producers told Al Jazeera.

Alberta's energy minister, Greg Melchin, defends the province's decision to proceed with the exploitation of its oily sand. "There is a cost to it, but the benefits are substantially greater," he insists.

Not everyone agrees. George Poitras, a member of the Mikisew Cree tribe, lives downstream from the oil sands development. "You see a lot of the land dug up, a lot of the boreal forest struck down and it's upsetting, it fills me with rage," he says. Diana Gibson of the Parkland Institute, an environmental advocacy group, says that you can see the environmental damage generated by the extraction of oil sands around Fort McMurray from the moon. "What we are going to be having is destruction of very, very valuable ecosystems, and permanent pollution," she says.

Sources: "Alberta's Heavy Oil Burden," Al Jazeera English, March 17, 2008 (see english.aljazeera.net); and Russell Gold, "As Prices Surge, Oil Giants Turn Sludge into Gold," *The Wall Street Journal Online*, March 27, 2006, A1.

Answers to Try It! Problems

1. The 500-acre area is scarce because it has alternative uses: preservation in its natural state or a site for homes. A choice must be made between these uses. The opportunity cost of preserving the land in its natural state is the forgone value of the land as a housing development. The opportunity cost of using the land as a housing development is the forgone value of preserving the land.
2. The scarce resources are the plant and the labor at the plant. The manager must choose between producing cars and producing SUVs. The opportunity cost of producing cars is the profit that could be earned from producing SUVs; the opportunity cost of producing SUVs is the profit that could be earned from producing cars.
3. The man can devote his time to his current career or to an education; his time is a scarce resource. He must choose between

these alternatives. The opportunity cost of continuing as a nurses' aide is the forgone benefit he expects from training as a registered nurse; the opportunity cost of going to college is the forgone income he could have earned working full-time as a nurses' aide.

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1.3: Introduction to the Study of Economics

Learning Objectives

- **Define** agricultural economics and explain how it connects to real-world food and agriculture sectors.
- **Describe** scarcity and opportunity cost in agricultural decision-making.
- **Explain** the role of economics in food production, agribusiness, and policy.
- **Identify** major players across the food and agricultural supply chain.

Economics is Important and Interesting!

The Economics of food and agriculture is important and interesting! Food and agricultural markets are in the news and on social media every day. Numerous fascinating and complex issues are the subject of this course: food prices, food safety, diet and nutrition, agricultural policy, globalization, immigration, agricultural labor markets, obesity, use of antibiotics and hormones in meat production, hog confinement, and many more. As we work through the course material this semester, please find examples of the economics of food and agriculture in the news. Application of economic principles to food and agricultural issues in real time will enhance the relevance, timeliness, and importance of learning economics.

Scarcity

Economics can be defined as, “the study of choice.” The concept of **scarcity** is the foundation of economics. Scarcity reflects the human condition: fixed resources and unlimited wants, needs, and desires.

Scarcity = Unlimited wants and needs, together with fixed resources.

Since we have unlimited desires, and only a fixed amount of resources available to meet those desires, we can’t have everything that we want. Thus, scarcity forces us to choose: we can’t have everything. Since scarcity forces us to choose, and economics is the study of choice, scarcity is the fundamental concept of all economics. If there were no scarcity, there would be no need to choose between alternatives, and no economics!

Microeconomics and Macroeconomics

The subject of economics is divided into two major categories: microeconomics and macroeconomics.

Microeconomics = The study of individual decision-making units, such as firms and households.

Macroeconomics = The study of economy-wide aggregates, such as inflation, unemployment, economic growth, and international trade.

This course studies microeconomics, the investigation of firm and household decision making. Our basic assumption is that firms desire to maximize profits, and households seek to maximize utility, also called satisfaction.

Economic Models and Theories

The real world is enormously complex. Think of how complicated your daily life is: just waking up and getting ready for class has a huge number of possible complications! Since our world is complicated, we must simplify the real world to understand it. A **Model** is a simplified representation of the world, not intended to be realistic.

Model = A theoretical construct, or representation of a system using symbols, such as a flow chart, schematic, or equation.

We frequently use models in physical sciences such as biology, chemistry, and physics. Think of the model of an atom, with the

atomic particles: neutron, proton, and electrons. No one has ever seen an atom, but there is significant evidence for this model. It is easy to be critical of economic models, since we are in many cases more familiar with economic events than scientific observations. When we simplify supply and demand into a model, we can think of many oversimplifications and limitations of the theory... the real world is complicated. However, this is how all science works: we must simplify the complex real world in order to understand it.

The Scientific Method

Our economic models are built and used following the **Scientific Method**.

Scientific Method = A body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge.

The major characteristic of the scientific method is to use measurable evidence to support or detract from a given model or theory. Following this method, economists will keep a theory as long as evidence backs it up. If the evidence does not support the model, the theory will be modified or replaced. Science, or knowledge, advances in this imperfect manner. To repeat, "We have to simplify the real world in order to understand it." Science is limited, and the human condition continues to be one of imperfect knowledge, finite lives, and an enduring search for solutions to poverty, pain, and suffering.

Positive Economics and Normative Economics

As social scientists, economists seek to be unbiased and objective in their study of the world. Economists have developed two terms to separate factual statements from value judgments, or opinions.

Positive Economics = Statements that include only factual information, with no value judgments. "What is."

Normative Economics = Statements that include value judgments, or opinions. "What ought to be."

In our study of food and agriculture, we will strive to purge our discussions, analysis, and understanding from opinions and value judgments. Our background and experience can make this challenging. For example, a corn producer might say, "The price of corn is higher, which is a good thing." But, the buyer of the corn, a livestock feedlot operator, might see things differently. All price changes have winners and losers, so economists try to avoid describing price movements in terms of "good" or "bad."

Economists who study food and agriculture seek to be neutral, unbiased, and professional in their work. This can be challenging at times, when we present our finding and observations to individuals or groups who may not like the outcomes. For example, an economist might be asked to study organic, natural, or local foods and report eh results to farmers and ranchers of conventional food products. Economists could be asked to study and report Chipotle's impact on the demand for beef, or the profit margins on cage-free eggs. Although some individuals may not like the results of these studies, economists try to be unbiased and objective in reporting their scientific work.

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1.4: Problem Sets

Exercise 1.1

Define economics.

Answer available at the end of this section.

Exercise 1.2

What is scarcity and why does it exist?

Answer available at the end of this section.

Exercise 1.3

Define opportunity cost and provide an example.

Answer available at the end of this section.

Exercise 1.4

What are the three fundamental economic questions?

Answer available at the end of this section.

Exercise 1.5

Why is economics important in agriculture?

Answer available at the end of this section.

Exercise 1.6

Define microeconomics and macroeconomics.

Answer available at the end of this section.

Exercise 1.7

What is an economic model and why do economists use them?

Answer available at the end of this section.

Exercise 1.8

What is the scientific method in economics?

Answer available at the end of this section.

Exercise 1.9

What is the difference between positive and normative economics? Provide examples.

Answer available at the end of this section.

Exercise 1.10

Provide a real-world agricultural example of opportunity cost.

Answer available at the end of this section.

Answers

Exercise 1.1

Economics is a social science that studies how individuals, businesses, and societies make choices in a world with limited resources and unlimited wants. It focuses on decision-making, trade-offs, and how people allocate scarce resources to satisfy needs and desires. It is considered a *social* science because it studies human behavior, and a *science* because it uses systematic methods and data to analyze and explain decisions.

Exercise 1.2

Scarcity means that resources — such as land, labor, machinery, and time — are limited, while human wants for goods and services are unlimited. Because we cannot have everything we want, individuals and societies must make choices about how to use resources. Scarcity is unavoidable and is the foundation of economic decision-making.

Exercise 1.3

Opportunity cost is the value of the best alternative that is given up when a choice is made. It represents the benefit you could have received from the next-best option.

Example:

If a farmer plants almonds instead of cotton, the opportunity cost is the profit that could have been earned from producing cotton. For a student, choosing to study for two hours instead of working means giving up potential wages — this foregone income is the opportunity cost.

Exercise 1.4

Because of scarcity, every society must answer three key questions:

Fundamental Question	Meaning
What to produce?	Decide which goods and services to produce, and in what quantities.
How to produce?	Decide the methods, technology, and resources used to produce goods.
For whom to produce?	Decide how goods and services are distributed among people.

Exercise 1.5

Agriculture operates in a world of scarce land, labor, water, capital, and natural resources. Economics helps producers, consumers, and policymakers make informed decisions about food production, trade, sustainability, farm labor, technology, and resource use. Concepts like cost-benefit analysis, supply and demand, and opportunity cost help analyze issues like crop choice, farm prices, food security, environmental trade-offs, and agricultural policy.

Exercise 1.6

Term	Definition	Examples in Agriculture
Microeconomics	Study of decisions made by individuals, households, and firms.	Why a farmer chooses corn vs. soybeans, pricing at a farmers market

Term	Definition	Examples in Agriculture
Macroeconomics	Study of the economy as a whole — GDP, unemployment, inflation, trade.	National food prices, agricultural trade policy, interest rates on farm loans

Exercise 1.7

An economic model is a simplified representation of real-world behavior used to understand complex systems and make predictions. Models use assumptions, graphs, equations, and diagrams to explain and predict behavior because the real world is too complex to analyze every detail. Economists use models like supply and demand to understand pricing, production, and consumer choices.

Exercise 1.8

The scientific method uses observation, measurement, and data to develop and test theories. Economists form hypotheses, collect evidence, evaluate results, and revise models based on real-world behavior. If evidence contradicts a theory, the theory must be modified. Economics relies on measurable data to explain and predict outcomes in markets.

Exercise 1.9

Type	Definition	Example
Positive economics	Fact-based statements that can be tested and verified (what *is*)	"Higher fertilizer costs increase food prices."
Normative economics	Opinion-based statements about what should happen (what *ought* to be*)	"The government should subsidize organic farming."

Exercise 1.10

A farmer who chooses to plant strawberries instead of lettuce gives up the revenue that lettuce would have produced. The opportunity cost is the forgone profit from lettuce sales. On a ranch, if land is used to graze cattle, the opportunity cost may be the income lost from not planting hay or leasing the land for solar panels.

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2: MARKET DEMAND AND SUPPLY IN AGRICULUTURAL CONTEXT

Learning Objectives

The learning objectives for this chapter are as follows.

- Distinguish between different states of demand and explain contexts wherein each state may be relevant.
- Describe the demand relationship and explain the law of demand.
- Identify and describe variables that shift demand. You should be able to say something about the direction of the demand shift.
- Explain the difference between substitutes and complements. Provide examples of each.
- Explain the difference between normal and inferior goods.
- Graph the inverse demand schedule given a demand equation and values of shift variables.
- Describe the concept of consumer surplus. Compute consumer surplus.

This chapter addresses the demand side of the market. This is also the buyer or customer side of the market. The overall aim of the chapter is to provide the background you need to use demand constructs to understand marketing strategies and models of market equilibrium that you will encounter later in the course. The chapter is organized into three sections. The first covers the states of effective, latent, and negative demand. Most of the course will deal with marketing problems for products or services in a state of effective demand. However, latent and negative demand states are important in product development and many social-marketing contexts. The second section introduces the basic mechanics of demand for a product or service under an effective demand state with a particular focus on the law of demand, the demand schedule, and variables that shift the demand schedule. Some of this will be a review of material you encountered in your introductory microeconomics course, but some will likely be new and/or will be presented in a way you have not yet encountered. The third section of the chapter introduces the idea of consumer surplus. Consumer surplus is presented in a way that should deepen your understanding of the law of demand. The concept will come up later in the course as a measure of economic welfare and will be used to understand pricing strategies used by sellers, many of which can characterized as attempts to convert consumer surplus into profits.

2.1: Demand States

2.2: The Demand Schedule

2.3: Supply and Demand

2.4: Markets - Supply and Demand

2.5: Consumer Surplus

2.6: Concluding Comments

2.7: References

2.8: Problem Sets

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2.1: Demand States

It is useful to think about different demand conditions or states. Specifically, there are three: effective demand, latent demand, and negative demand. Much of the class will emphasize effective demand because markets exist for products in a state of effective demand. For products in an effective demand state, you can see equilibrium prices and quantities. It is also possible estimate demand and understand how demand responds to changes in prices, consumer income, or other factors that affect the desirability of the product. In the other two demand states, markets do not yet exist, but there could or would be a market provided technological barriers can be addressed or consumer preferences can be changed. In fact, many product development efforts are aimed at overcoming some hurdle or limitation that would allow a product or service to move from a latent or negative demand state to an effective demand state.

Effective Demand

Normally, the word “demand” refers to a product in a state of effective demand. Effective demand refers to the demand for products that are commercially feasible. These products satisfy consumer wants and needs, and consumers (or some segments thereof) are willing to buy them at prices that justify their production. Automobiles, apples, vacation trips, restaurant meals, or any other good or service readily available in the economy is in a state of effective demand. Since market transactions are observed for products in a state of effective demand, it is possible to measure variables that influence demand. These measurements can be used to estimate and forecast demand to gain insight into business or policy decisions.

Latent Demand

A state of latent demand is said to exist in cases where a need or want exists but a product does not. For example, if there was a cure for cancer, there would be a demand for it. Because of this latent demand, biotechnology companies spend large amounts of money on research and development efforts to create new drugs to more effectively combat cancer. A latent demand state exists when the following conditions are present:

1. the product in question is not technically feasible given the current state of science and engineering (as in the case of a complete cure to cancer) or has yet to be conceived by an inventor or entrepreneur, or
2. the product is technically feasible but not commercially feasible given current technology, existing infrastructure, or the existing regulatory environment.

With latent demand, one does not actually see market transactions. For this reason, estimating the potential value of products in a latent demand state is often more difficult. Economists often use experimental methods to assess willingness to pay for products in a state of latent demand.

A change in technology, such as the introduction of the microwave oven, can unleash a number of new products that address latent demands and thereby bring them into a state of effective demand. The first link below points to an early television commercial for the microwave. This commercial speaks directly to how the microwave meets the latent demands of those who prepare meals over the eons of human history. Today, much of what is in the frozen section of a supermarket is tailored to the microwave oven. Here is a link to an early microwave oven advertisement emphasizing how the microwave addresses latent demand (visit youtube.com).

Negative Demand

Negative demand refers to cases where there is a potential product that could meet a consumer want or need, but consumers are reluctant to purchase the product for one reason or another. For example, many insect species are edible and could be produced at a cost that compares favorably to other food sources. However, insects are not commonly being sold in attractive displays at the local supermarket. The reason for this is that cultural norms in the USA frown upon consumption of insects. This example is a bit “creepy,” and I hope it does not “bug” you too much, but the same general idea can apply to many actual or potential products that are viewed skeptically by consumers. When confronted with negative demand, it may be possible to change the image of the product so that consumers view it as desirable.

- National Geographic segment on edible insects (visit youtube.com).
- Fact sheet on entomophagy from the UN Food and Agriculture Organization (FAO) (visit fao.org).

Food Irradiation: A Case Example

Food irradiation is a process that many thought could potentially address latent demands for safer food. For example, irradiation could destroy Trichina parasites allowing pork to be cooked and served rare. In the late 1990's, irradiation was approved by US regulatory agencies for use on raw meat and poultry. There were some predictions that this would become a standard process, akin to pasteurization. This turned out not to be the case. One reason is that irradiated foods also faced a negative demand problem. Consumers have been hesitant to embrace irradiated foods. Review the fact sheet and short video clip from the links below. Both are from reputable organizations: a land-grant university and the United Nations.

- Fact sheet from the University of Wisconsin on food irradiation (visit wisc.edu).
- Short video from International Atomic Energy Agency and FAO (visit youtube.com).

Now consider the following questions:

1. What fundamental problem (or problems) can food irradiation address?
2. Is food irradiation safe?
3. Are there labeling requirements that would allow you tell if a food item in a retail store was irradiated?
4. Why might consumers be reluctant to accept irradiated foods?
5. Why is microwaveable food so widely accepted but irradiated food not?

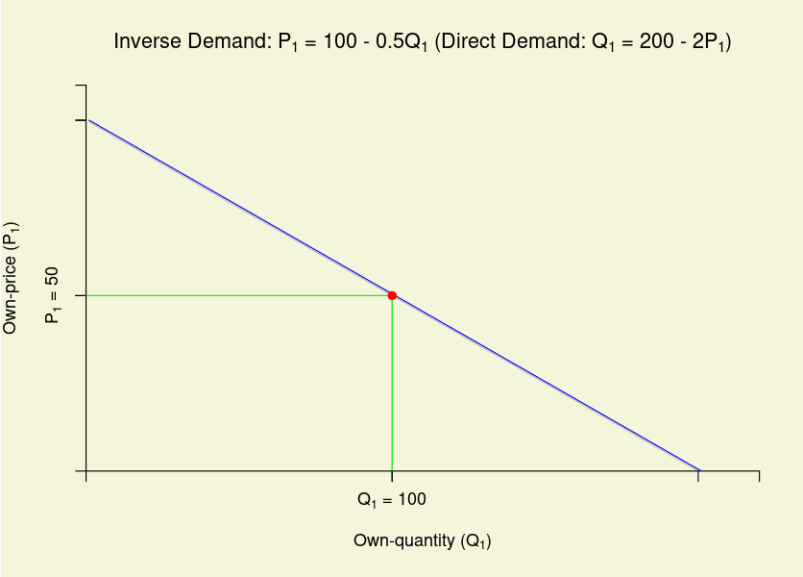
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2.2: The Demand Schedule

The demand schedule is the relationship between own-quantity demanded and corresponding own-price levels. Several variables could affect the demand for a product, including the prices or quantities of related goods. The adjective "own-quantity" is used to mean the quantity of the product being analyzed. For example, the own-quantity of beef could be represented as Q_{BEEF} and the own-price of beef as P_{BEEF}. The price of pork, P_{PORK}, could conceivably affect demand for beef, but this is not the own-price of beef. The point to be made is that the demand schedule is the relationship between the product's own-quantity and its own-price holding all other variables that could affect demand constant at some fixed value. The normal convention in this course will be to use subscripts to denote the product in question. For example, Q_1 refers to the demand for good 1, P_2 refers to the price of good 2, etc.

The demand schedule can be expressed mathematically as $Q_1 = fP_1$ or $P_1 = f^{-1}(Q_1)$. The term "direct demand" is used when Q_1 is on the left-hand side of the equation and the term "inverse demand" when P_1 is on the left-hand side. When showing a demand relationship as an equation, the normal practice is to express the relationship in terms of direct demand. However, it will generally be graphed in inverse form with the price of the product on the vertical axis and the quantity on the horizontal axis. This convention is consistent with most microeconomics text books and can be useful when you want to simultaneously show production (supply side) relationships on the same plot. Many textbooks, however, do not distinguish between direct and inverse demand. The distinction is being made here because you learned back in middle-school algebra that if $y = f(x)$, then y goes on the vertical axis and x goes on the horizontal. The term "inverse demand," permits adherence to both algebraic and economic conventions.



Demonstration 2.2.1: **An inverse market demand schedule**

The Law of Demand

The law of demand states that quantity and price are negatively related. In other words, if the price of the product increases, then the quantity demanded will decrease and *vice versa*. The law of demand reflects two phenomena. First, consumer preferences generally exhibit diminishing marginal utility. Diminishing marginal utility is a technical way of saying that consumers receive lower amounts of additional satisfaction from each additional unit of a product they consume. Because of diminishing marginal utility, the price will need to fall to induce consumers to buy more units of products that they already consume. This contributes to the negative relationship between quantity demanded and price. Second, in most cases, different consumers place different valuations on the same product. For example, suppose that Jane and John Doe would both enjoy tickets to a St. Louis Cardinals baseball game. Jane loves baseball and is a huge Cardinals fan. John mildly enjoys baseball and prefers the Minnesota Twins. It would stand to reason that Jane would probably place a higher value on the tickets than John would. The point here is that it is often the case that some consumers are very enthusiastic about a product and are willing to participate in the market even when

the price is high. Other, less enthusiastic, consumers stay out of the market at high prices but are willing to participate once the price comes down a bit. For this reason, the number of consumers willing to participate in the market increases as the price falls and decreases as the price rises. This also contributes to the negative relationship between quantity demanded and price.

Because of diminishing marginal utility and differences in valuation across consumers, an increase (decrease) in price has two potential effects, each of which contributes to the negative relationship between quantity and price.

1. Each consumer buys less (more) of the product due to diminishing marginal utility.
2. The total number of consumers decreases (increases) as consumers with valuations close to the prevailing price exit (enter) the marketplace.

Demand Shifters

The demand schedule characterizes the relationship between quantity demanded and that product's own-price. For instance, the demand schedule for beef would show the relationship between quantity of beef demanded and the price of beef holding everything else constant. What happens if something else changes? There are other prices that could affect the demand for beef. For many consumers, pork or poultry serve as reasonable substitutes for beef. Consequently, if pork or poultry prices decline (rise) relative to beef prices, one would expect reduced (increased) quantities of beef to be demanded. This suggests that other factors, aside from a product's own-price, need to be considered. These other factors are called demand-shift variables. If the value of a shift variable changes, you will need to plot a new demand schedule that reflects the updated relationship between quantity demanded and the product's own-price. The following are some common demand shift variables.

Prices of related goods (substitutes or complements)

Related goods in demand are classified as substitutes in consumption or complements in consumption. A substitute in consumption is a good that the consumer can use instead of the good in question to meet his or her underlying want or need. For example, if you are analyzing the demand schedule for beef, then chicken, pork, or fish are all reasonable substitute products. After all, one could order a chicken, pork, or seafood entree from the menu in lieu of beef; or the supermarket shopper may decide to cook chicken breasts, pork chops, or fish fillets for dinner instead of beef. Formally, product 2 is considered to be a substitute for product 1 if an increase (decrease) in the price of product 2 causes an increase (decrease) in the demand schedule for product 1. In other words, there is a positive relationship between the price of product 2 and the quantity of product 1 that consumers demand.

A complement in consumption is a good that the consumer uses along with the good in question. For example, if you are analyzing the demand for sport utility vehicles (SUVs), then gasoline is reasonable complementary product. After all, an SUV is a large automobile and uses a lot of gas. In recent years, gasoline prices appear to have had an effect on the demand schedule for SUVs. During periods of high gasoline prices, sales of SUVs suffer. Formally, product 2 is considered to be a complement for product 1 if an increase (decrease) in the price of product 2 causes a decrease (increase) in the demand schedule for product 1. In other words, there is a negative relationship between the price of product 2 and the quantity of product 1 that consumers demand.

Consumer income

Consumer incomes can also shift the demand schedule, but the direction and magnitude of the shift depend on the characteristics of the good in question. Some goods are classified as normal goods. Consumption of a normal good increases as income increases. Formally, good 1 is said to be a normal good if an increase (decrease) in income causes an increase (decrease) in the demand schedule for good 1. In other words, there is a positive relationship between consumption of good 1 and the amount of income available to consumers. Other goods are classified as inferior goods. Consumption of an inferior good decreases as income increases. Formally, good 1 is said to be an inferior good if an increase (decrease) in income causes an decrease (increase) in the demand schedule for good 1. In other words, there is a negative relationship between consumption of good 1 and the amount of income available to consumers. It is important to emphasize that the adjective "inferior" only refers to the income relationship and does not imply that the consumer dislikes the good in question.

Tastes and preferences

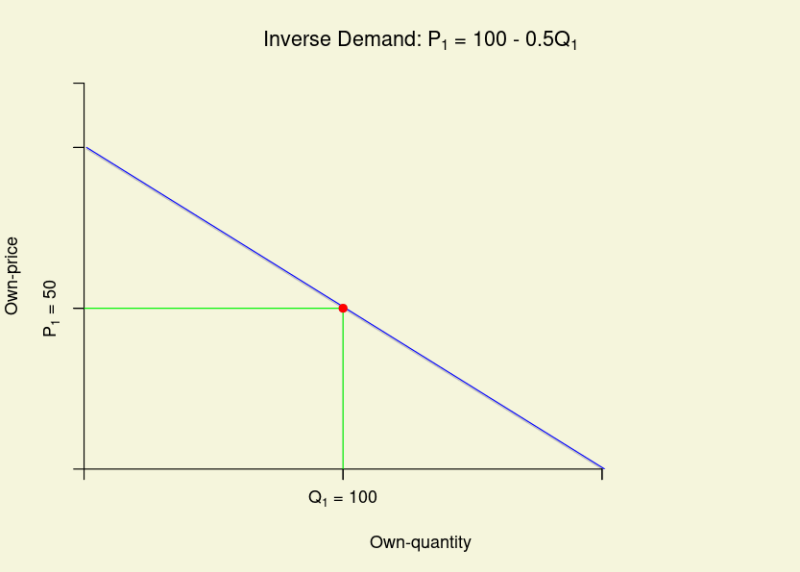
Demand is subject to trends, fashions, health concerns, and a variety of other considerations. For example, in 2012, media

coverage of lean finely textured beef (LFTB), characterized as “pink slime”, had an impact on demand for ground beef. This would classify as information that led to an unfavorable change in preferences (meaning the product in question is less favored by consumers than before). Conversely, a growing number of studies linking blueberries to improved health has impacted demand for blueberries in a positive way. This would classify as a favorable change in preferences.

- Link to a 2012 magazine article on the LFTB controversy by economists J. Ross Pruitt and David P. Anderson (visit choicesmagazine.org).
- Link to the 2012 ABC News Segment on LFTB mentioned in the magazine article (visit youtube.com).
- Link to LSU AgCenter publication *Blueberries and Your Health* (visit lsuagcenter.com).

Population

Market demand reflects the sum of all consumers in the marketplace. All else equal, as the number of consumers increases (decreases), the demand schedule will increase (decrease).



Demonstration 2.2.2: **Demand shift variables change the demand schedule**

Demand Schedules from a Linear Demand Relationship

A general demand relationship would need to include all the demand shifters that could affect demand in addition to own-price. With this in mind, consider the following demand equation for good A:

$$Q_A = 20Pop + 0.01M + 2P_B - 4P_A$$

In this equation, Q_A is the quantity of good A in thousands of units, Pop is population in millions of persons, M is disposable income in dollars, P_B is the price of good B in dollars, and P_A is the price of good A in dollars. Given this equation, you are able to answer some general questions about the demand for good A.

- ***Is good A a normal good or an inferior good? How can you tell?*** Good A is a normal good. You can tell because the coefficient associated with the income variable (0.01) is a positive number. If this were a negative number, you would have an inferior good.
- ***Is good B a substitute or a complement to good A? How can you tell?*** Good B is a substitute for good A. You can tell because the coefficient associated with the price of good B is a positive number. If this were a negative number, you would instead conclude that good B is a complement to good A.
- ***Does the demand for good A conform to the law of demand? How can you tell?*** Yes. The coefficient associated with the price of good A is a negative number showing an inverse relationship between the quantity of good A and the price of good A.

- ***What variables shift the demand schedule?*** In this case, there are three variables: population Pop, income M, and the price of the substitute good P_B. Remember that the demand schedule is the relationship between own-price and own-quantity. In the equation above, P_A represents the own-price and Q_A represents the own-quantity. Thus, every right-hand-side variable other than P_A is a demand shifter.

The demand schedule shows the relationship between own-price and own-quantity demanded holding all else constant. In this case, "all else" consists of the three demand shifters. Thus, to get an equation for the demand schedule you need to fix these shift variables at some value. Let us use a value of 3 million for Pop, \$30,000 for M, and \$20 for P_2. Using these values, you get the direct demand schedule:

$$Q_A = 20(3) + 0.01(30000) + 2(20) - 4P_A$$

or

$$Q_A = 400 - 4P_A$$

Remember that this is the direct demand schedule because $Q_A = f(P_A)$. It is simple enough to get the inverse demand schedule. Simply solve to get P_A on the left side of the equation. The inverse demand schedule is

$$P_A = 100 - \frac{1}{4}Q_A$$

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2.3: Supply and Demand

The study of markets is a powerful, informative, and useful method for understanding the world around us, and interpreting economic events. The use of supply and demand allows us to understand how the world works, how changes in economic conditions affect prices and production, and how government policies and programs affect prices, producers, and consumers. A huge number of diverse and interesting issues can be usefully analyzed using supply and demand.

Supply

The **Supply** of a good represents the behavior of firms, or producers. Supply refers to how much of a good will be produced at a given price.

Supply = The relationship between the price of a good and quantity supplied, *ceteris paribus*.

Notice the important term, "*ceteris paribus*" at the end of the definition of supply. Recall the complexity of the real world, and how economists must simplify the world to understand it. Use of the concept, *ceteris paribus*, allows us to understand the supply of a good. In the real world, there are numerous forces affecting the supply of a good: weather, prices, input prices, just to name a few.

Ceteris Paribus = Holding all else constant (Latin).

When studying supply, we seek to isolate the relationship between the price and quantity supplied of a good. We must hold everything else constant (*ceteris paribus*) to make sure that the other supply determinants are not causing changes in supply. An example is the supply of organic cotton. Patagonia spearheaded the movement into using organic cotton in the production of clothing. Nike and other clothing manufacturers are increasing organic clothing production to meet the growing demand for this good. Interestingly, conventional (non-organic) cotton is the most chemical-intensive field crop, and can result in agricultural chemical runoff in the soil and groundwater. A small but convicted group of consumers are willing to pay high premiums for clothing made with organic cotton, to reduce the potential environmental damage from agricultural chemicals used in cotton production. Notice that this graph has two items on each axis: (1) a label, and (2) units. Every graph drawn must have both labels and units on each axis to effectively communicate what the graph is about.

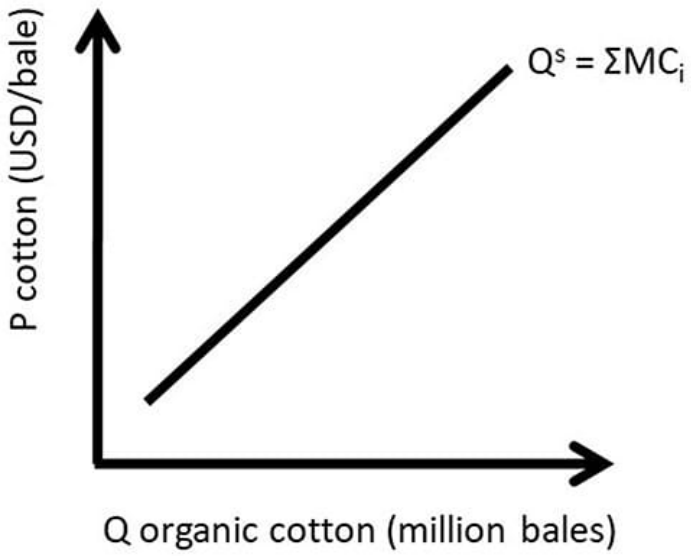


Figure 2.3.1 Market Supply Curve of Organic Cotton

The supply curve seen in Figure 2.3.1 is a market supply curve, as it represents the entire market of organic cotton (note that cotton is sold in bales). The market supply curve was derived by horizontal summation all of the individual firm supply curves. This is indicated by the notation $Q^s = \Sigma MC_i$ in Figure 2.3.1. The individual firm supply curve is the firm's marginal cost curve (MC) for all prices above the shut down point, and equal to zero for all prices below the shut down point. The shut down point is the

minimum point on the firm's average variable cost curve (AVC), as shown in Figure 2.3.2

Since the market supply curve is the sum of all of the individual firms' marginal cost curves (ΣMC_i), the market supply curve represents the cost of production: the total amount that a business firm must pay to produce a given quantity of a good.

There are three properties of a market supply curve.

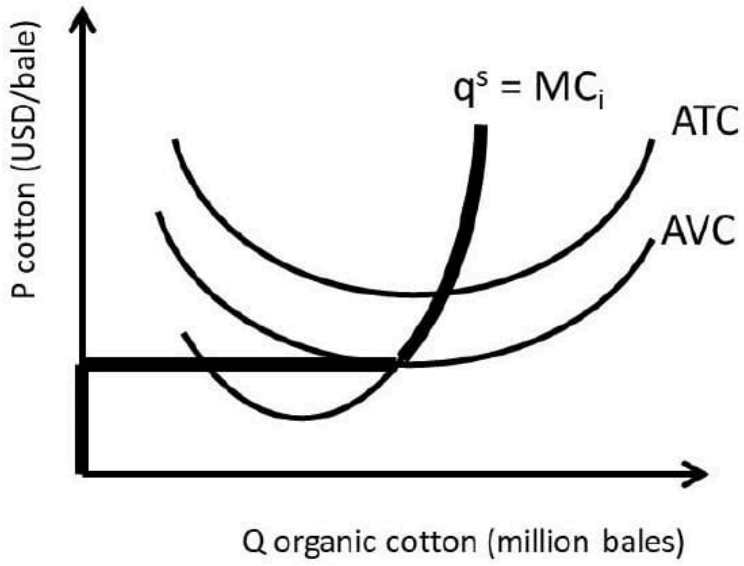


Figure 2.3.2 Individual Firm Supply Curve of Organic Cotton

Properties of Supply

1. Upward-sloping: if price increases, quantity supplied increases,
2. $Q^s = f(P)$, and
3. *Ceteris Paribus*, Latin for "holding all else constant."

The first property reflects the Law of Supply, which states that there is a direct relationship between price and quantity supplied.

Law of Supply = There is a direct, positive relationship between the price of a good and the quantity supplied, *ceteris paribus*.

The second property demonstrates that price (P) is the independent variable, and quantity supplied (Q^s) is the dependent variable. Graphs of supply and demand are drawn "backward" with the independent variable (P) on the vertical axis. In all other fields of mathematics and science, when a function such as $y = f(x)$ is graphed, the independent variable (x) appears on the horizontal axis, and the dependent variable (y) is drawn on the vertical axis. Supply and demand graphs are drawn, "backwards" due to economist Alfred Marshall, who drew the original supply and demand graphs this way in his *Principles of Economics* book in 1890. The third property reflects the need to simplify all of the determinants of supply to isolate the relationship between price and quantity supplied, using the *ceteris paribus* assumption.

The Determinants of Supply

There are numerous determinants of supply, so we will focus on five important ones. The most important supply determinant, or driver, is price (P). Other determinants include input prices (Pi), the prices of related goods (Pr), technology (T), and government taxes and subsidies (G).

$$Q^s = f(P, Pi, Pr, T, G) \tag{2.3.1}$$

To draw a supply curve, we focus on the most important determinant of supply: the good's own price. We hold all of the other determinants constant. To show this in equation form, we use a vertical bar to designate *ceteris paribus*: all variables that appear to the right of the vertical bar are held constant. Equation 2.3.2 shows the relationship between quantity supplied and price, holding all else constant. This relationship is the market supply curve in Figure \(\PageIndex{1}\) and in supply and demand

graphs.

$$Q^s = f(P|Pi, Pr, T, G) \tag{2.3.2}$$

Input prices (Pi) are important determinants of supply, since the supply curve represents the cost of production. Prices of related goods (Pr) represent prices of substitutes and complements in production. Substitutes in production are goods that are produced either/or, such as corn and soybeans. One land parcel can be used to grow either corn or soybeans. Complements in production are goods that are produced together in a fixed ratio. Beef and leather are complements in production. Technology (T) is major driver of supply, as new methods and techniques become available, they increase the amount of food produced. Technological change allows more output to be produced with the same level of inputs. Restated, the same level of output can be produced with fewer inputs. Government policies and programs (G) can shift the supply of a good through taxes or subsidies.

Movements Along vs. Shifts In Supply

The supply curve represents the mathematical relationship between the price and quantity supplied of a good. Therefore, when a good's own price changes, it is as a **movement along** the supply curve. When any of the other supply curve determinants change, it will shift the entire curve.

A movement along a supply curve, caused by a change in the good's own price, is called a change in quantity supplied (left panel, Figure $2.3.3$). A shift in the supply curve, caused by a change in any supply determinant other than the good's own price, is called a change in supply (right panel, Figure $2.3.3$). The change in supply shown in Figure $2.3.3$ is an increase in supply, since it increases the quantity supplied at any given price.

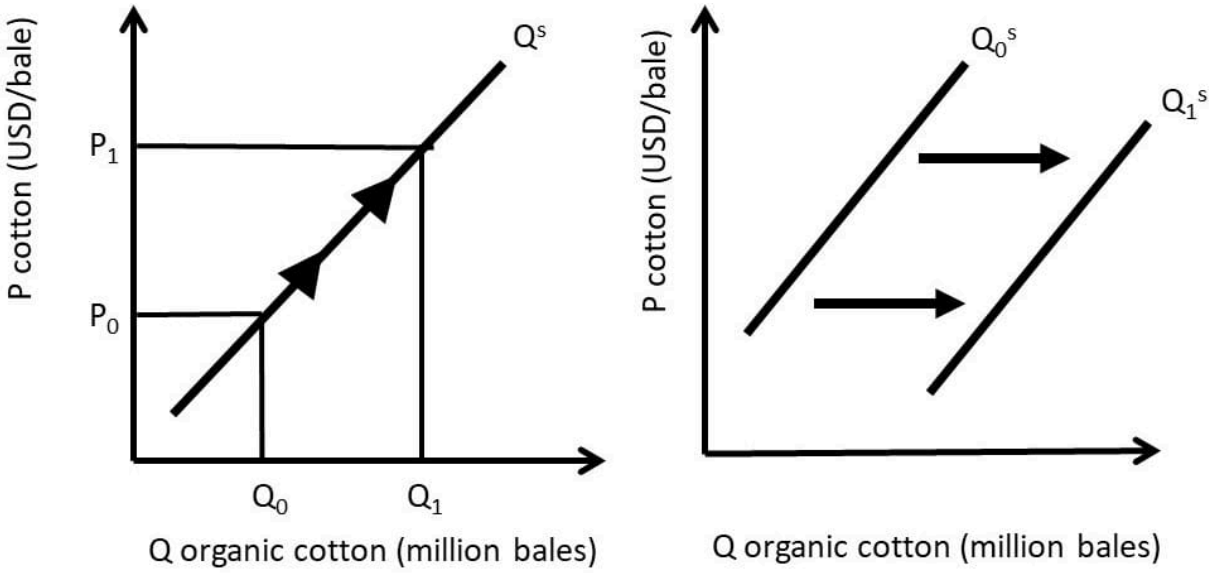


Figure $2.3.3$ Movement Along and Shift in the Supply of Organic Cotton

Notice that the supply curve has shifted down, yet this represents an increase in supply. The supply change is measured on the horizontal axis, so a movement from left to right represents an increase in supply. The shift shown could be the impact of technological change on organic cotton supply: suppose that biotechnology allows for higher yielding varieties of organic cotton.

Demand

The **Demand** of a good represents the behavior of households, or consumers. Demand refers to how much of a good will be purchased at a given price.

Demand = The relationship between the price of a good and quantity demanded, *ceteris paribus*.

Figure 1.4 shows the market demand curve for beef (Q^d), derived by the summation of all individual consumers demand curves (Σq_i). Note that beef is measured in units of one hundred pounds, or a "hundredweight" (cwt).

Demand represents the willingness and ability of consumers to purchase a good. As with supply, there are three properties of demand.

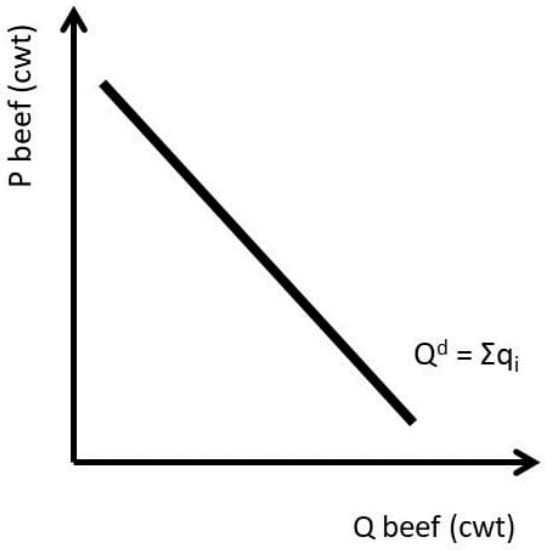


Figure 2.3.4 Market Demand for Beef

Properties of Demand

1. Downward-sloping: if price increases, quantity demanded decreases,
2. $Q^d = f(P)$, and
3. Ceteris Paribus, Latin for holding all else constant.

The first property reflects the **Law of Demand**, which states that if the price of a good increases, the quantity demanded of that good decreases, holding all else constant.

Law of Demand = There is an inverse relationship between the price of a good and the quantity supplied, *ceteris paribus*.

The Law of Demand is one of the major "take home messages" of economic principles. Price increases lead to smaller quantities of goods purchased. The Law of Demand does not say that all consumers will stop buying a good, it says that at least some consumers will decrease consumption of the good. The magnitude of the decrease will depend on the price elasticity of demand for the good, as will be discussed in Section 1.4 below.

The Determinants of Demand

There are numerous demand shifters, or determinants of demand. Six of the most important determinants are included in the demand equation in Equation 2.3.3. The good's own price (P) is the most important determinant. Demand is also influenced by: the price of related goods (Pr), futures prices (Pf), income (I), tastes and preferences (T), and government programs and policies (G).

$$Q^d = f(P, Pr, Pf, I, T, G) \tag{2.3.3}$$

Related goods include substitutes and complements in consumption. Substitutes in consumption are goods that are purchased either/or, such as hot dogs and hamburgers. If the price of hot dogs increases, at least some consumers will shift out of hot dogs and into hamburgers. Complements in consumption are goods that are consumed together, for example hot dogs and hot dog buns. If the price of hot dogs increases, consumers will purchased fewer hot dogs and fewer buns.

Expectations of future prices (Pf) have a large influence on consumption decisions today. If the price of corn was expected to increase in the future, corn demand would increase today, as corn buyers would seek to buy prior to the price increase. This would allow traders to "buy low and sell high," providing profit from arbitrage across time.

Income (I) can have a large impact on purchase decisions. Cars, houses, and other expensive items will be affected by changes in income. Inexpensive items such as used clothes or ramen noodles are also influenced greatly by income changes. During the great recession of 2008-2010, Walmart had high profit levels, while boat manufacturers and country clubs lost profits due to significant decreases in income.

Tastes and preferences (T) shift the demand for goods and services based on the diverse wants, needs, and desires of consumers in the market. Taxes and subsidies, as well as other government programs, policies, and regulations (G) influence demand, sometimes significantly. Government programs and policies will be explored in Sections 1.4 through 1.6, and in Chapter 2 below.

To draw a demand curve, the most important determinant of demand is isolated: the good's own price. We hold all of the other determinants constant, *ceteris paribus*.

$$Q^d = f(P|Pr, Pf, I, T, G) \tag{2.3.4}$$

Movements Along vs. Shifts In Demand

The demand curve represents the mathematical relationship between the price and quantity demanded of a good. Therefore, when a good's own price changes, it is depicted as a movement along the demand curve. When any of the other demand curve determinants change, it will shift the entire curve.

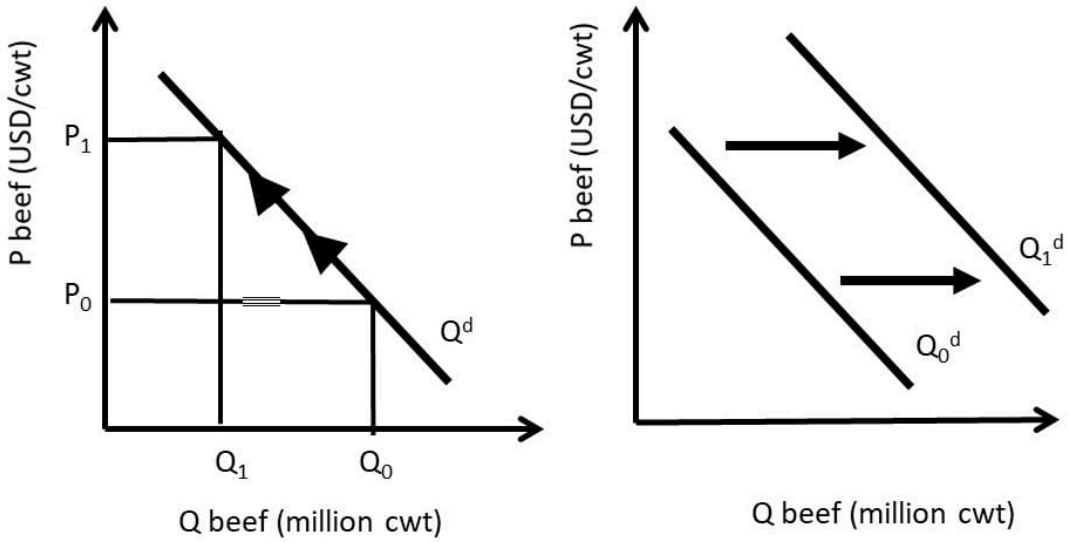


Figure 2.3.5 Movement Along and Shift in the Demand for Beef

As with supply, if the good's own price changes, it results in a movement along the demand curve, called a change in quantity demanded. If any other demand determinant changes, it causes a shift in demand, called a change in demand. The shift shown in the right panel of Figure 2.3.5 is an increase in demand, since the demand curve has shifted upward and to the right.

Supply and demand form the foundation for the study of markets. Markets are defined as the interaction of supply and demand. Market analysis is the core concept and foundation of all of economics, and will be explored in the next section.

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2.4: Markets - Supply and Demand

In the previous section, supply and demand were introduced and explored separately. In what follows, the interaction of supply and demand will be presented. The market mechanism is a useful and powerful analytical tool. The market model can be used to explain and forecast movements in prices and quantities of goods and services. The market impacts of current events, government programs and policies, and technological changes can all be evaluated and understood using supply and demand analysis. Markets are the foundation of all economics!

A market equilibrium can be found at the intersection of supply and demand curves, as illustrated for the wheat market in Figure 2.4.1. An equilibrium is defined as, "a point from which there is no tendency to change." Wheat is traded in units of metric tons (MT), or 1000 kilograms, equal to approximately 2,204.6 pounds.

Equilibrium = a point from which there is no tendency to change.

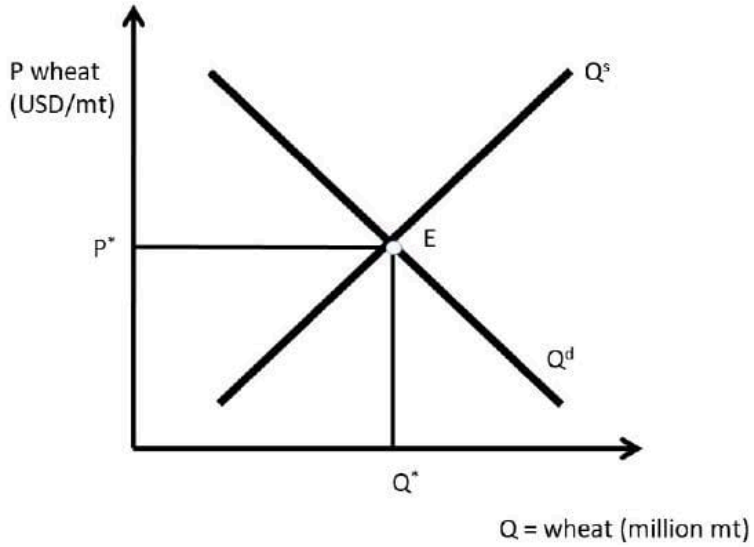


Figure 2.4.1: Wheat Market

Point E is the only equilibrium in the wheat market shown in Figure 2.4.1. At any other price, market forces would come into play, and bring the price back to the equilibrium market price, P^*. At any price higher than P^*, such as P' in Figure 2.4.2, producers would increase the quantity supplied to Q_1 million metric tons of wheat, and consumers would decrease the quantity demanded to Q_0 million metric tons of wheat. A surplus would result, since quantity supplied is greater than quantity demanded $(Q_1 > Q_0)$.

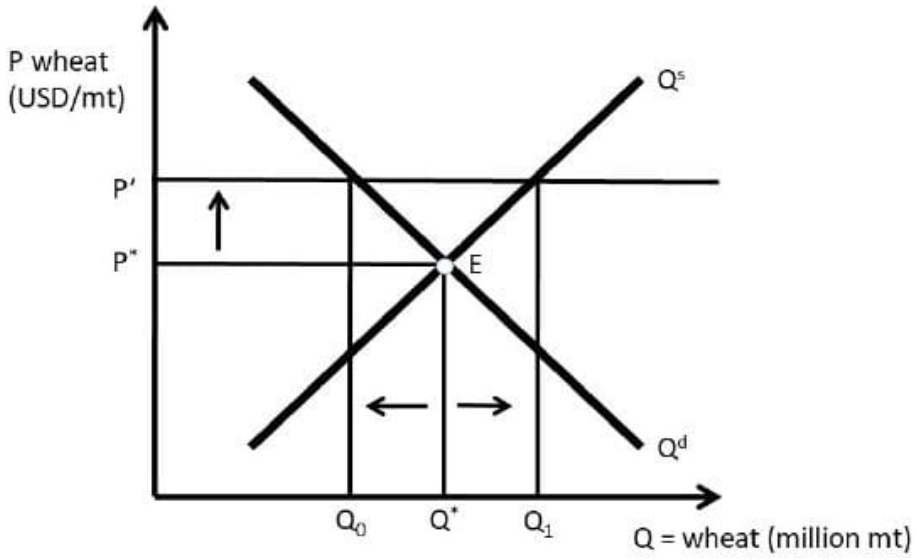


Figure 2.4.2: Wheat Market Surplus

A wheat surplus such as the one shown in Figure 2.4.2 would bring market forces into play since $Q^s \neq Q^d$. Wheat producers would lower the price of wheat in order to sell it. It would be preferable to earn a lower price than to let the surplus go unsold. Consumers would increase the quantity demanded along Q^d and producers decrease the quantity supplied along Q^s until the equilibrium point E was reached. In this way, any price higher than the market equilibrium price will be temporary, as the resulting surplus will bring the price back down to the equilibrium price P^*.

Market forces also come into play at prices lower than the equilibrium market price, as shown in Figure 2.4.3. At the lower price P'', producers reduce the quantity supplied along Q^s to Q_0, and consumers increase the quantity demanded to Q_1. A shortage occurs, since the quantity demanded is greater than the quantity supplied $Q_1 > Q_2$. The shortage will bring market forces into play, as consumers will bid up the price in order to purchase more wheat and producers will produce more wheat along Q^s. This process will continue until the market price returns to the equilibrium market price, P^*.

The market mechanism that results in an equilibrium price and quantity performs a truly amazing function in the economy. Markets are self-regulating, since no government intervention or coercion is needed to achieve desirable outcomes. If there is a drought, the price of wheat will rise, causing more resources to be devoted to wheat production, which is desirable, since wheat is in short supply during a drought. If good weather causes a surplus, the price will fall, causing wheat producers to shift resources out of wheat and into more profitable opportunities. In this fashion, the market mechanism allows voluntary trades between willing parties to allocate resources to the highest return. Efficiency of resource use and high incomes are a feature of market-based economies.

Although markets provide huge benefits to society, not everyone wins from free market economies, and market changes over time. Price increases help producers, but hurt consumers. Technological change has provided lowered food prices enormously over time, but has led to farm and ranch consolidation, and the large migration of farmers and their families out of rural regions and into urban areas.

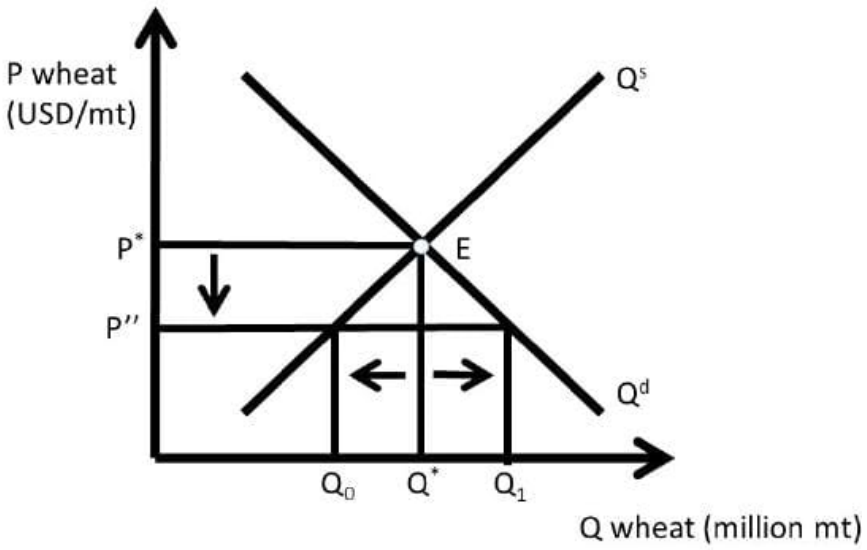


Figure 2.4.3: Wheat Market Shortage

The market graphs of supply and demand are based on the assumption of perfectly competitive markets. Perfect competition is an ideal state, different from actual market conditions in the real world. Once again, economists simplify the complex real world in order to understand it. We will begin with the extreme pure case of perfect competition, and later introduce realism into our analysis.

Competitive Market Properties

A competitive market has four properties:

1. homogeneous product,
2. numerous buyers and sellers,
3. freedom of entry and exit, and
4. perfect information.

The first property of perfect competition is a homogeneous product. This means that the consumer can not distinguish any differences in the good, no matter which firm produced it. Wheat is an example, as it is not possible to determine which farmer produced the wheat. A John Deere tractor is an example of a nonhomogeneous good, since the brand is displayed on the machine, not to mention the company's well known green paint and deer logo.

The assumption of numerous buyers and sellers means something specific. The word, "numerous" refers to an industry so large that each individual firm can not affect the price. Each firm is so small relative to the industry that it is a price taker.

Freedom of entry and exit means that there are no legal, financial, or regulatory barriers to entering the market. A wheat market allows anyone to produce and sell wheat. Attorneys and physicians, however, do not have freedom of entry. To practice law or medicine, a license is required.

Perfect information is an assumption about industries where all firms have access to information about all input and output prices, and all technologies. There are no trade secrets or patented technologies in a perfectly competitive industry. These four properties of perfect competition are stringent, and do not reflect real-world industries and markets. Our study of market structures in this course will examine each of these properties, and use them to define industries where these properties do not hold. Competitive markets have a number of attractive properties.

Outcomes of Competitive Markets

Competitive markets result in desirable outcomes for economies. A competitive market maximizes social welfare, or the total amount of well-being in a market. Competitive markets use voluntary exchange, or mutually beneficial trades, to achieve this

result. In a market-based economy, no one is forced, or coerced, to do anything that they do not want to do. In this way, all trades are mutually beneficial: a producer or consumer would never make a trade unless it made him or her better off. This idea will be a theme throughout this course: free markets and free trade lead to superior economic outcomes.

It should be emphasized that free markets and free trade are not perfect, since there are negative features associated with markets and capitalism. Income inequality is an example. Markets do not solve all of society's problems, but they do create conditions for higher levels of income and wealth than other economic organizations, such as a command economy (as found in a communist or fascist nation). There are winners and losers to market changes. An example is free trade. Free trade lowers prices for consumers, but often causes hardships for producers in importing nations. Similarly, open borders allow immigrants to improve their conditions and earnings by moving from low-income nations to high-income nations such as the United States (US) or the European Union (EU). Workers in the US and the EU will face competition from a larger labor supply, causing reductions in wages and salaries. A simple example of markets is an increase in the price of corn. Corn producers are made better off, but livestock producers, the major buyers of corn, are made worse off. Thus, the market shifts that allow prosperity also create winners and losers in a free market economy.

Supply and Demand Shift Examples

Given our knowledge of markets and the market mechanism, current events and policies can be better understood.

Demand Increase

China was a command economy until 1986. At that time, the government introduced the Household Responsibility System, which allowed farmers to earn income based on how much agricultural output they produced. The new policy worked very well, and China moved from being a net food importer to a net food exporter. Soon, the policy was extended to all industries, and China was on its way to a market-based economy. The result has been a truly unprecedented increase in income. China has gone from a low income nation to a middle income nation, and the rates of economic growth are higher than any nation in history. And, these growth rates are for the world's most populous nation: 1.4 billion people (for comparison, the United States (USA) has approximately 326 million people).

This historical income growth in China has been good for US farmers and ranchers. As incomes increase, consumers shift out of grain-based diets such as rice and wheat, and into meat. There has been a large increase in beef consumption in China as incomes increased. This is an increase in the demand for US beef, as shown in Figure $2.4.4$. The units for beef are hundredweight (cwt), or one hundred pounds. This is called an increase in demand (do you remember why this is not an increase in quantity demanded?). The outward shift in demand results in a movement from equilibrium E_0 to E_1. The movement along the supply curve for beef is called an increase in quantity supplied. The equilibrium market price increases from P_0 to P_1, and the equilibrium market quantity increases from Q_0 to Q_1. An increase in demand results in higher prices and higher quantities. As a result, the best way to increase profitability for a firm is to increase demand.

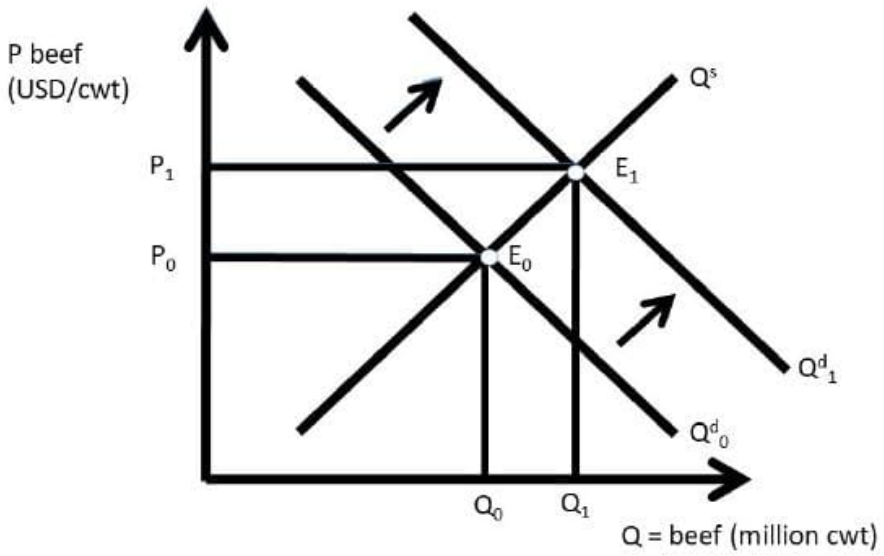


Figure 2.4.4: Increase in China Income Impact on US Beef Market

Interestingly, income growth in China is beneficial to not only US beef producers, who face an increased demand for beef, but also for grain farmers in the USA. The major input into the production of beef is corn, sorghum (also called milo), and soybeans. These grains are fed to cattle in feedlots. Seven pounds of grain are required to produce one pound of beef. Therefore, any increase in the global demand for beef will result in an increase in demand for beef, and a large increase in the demand for feed grains.

Demand Decrease

In the United States, the demand for beef offals (tripe, tongue, heart, liver, etc.) has decreased in the past few decades. As incomes increase, consumers shift out of these goods and into more expensive meat products such as hamburger and steaks. The demand for offals has decreased as a result, as in Figure 2.4.5. This is a decrease in demand (shift inward), and a decrease in quantity supplied (movement along the supply curve). The outcome is a decrease in the equilibrium market price and quantity of beef offals.

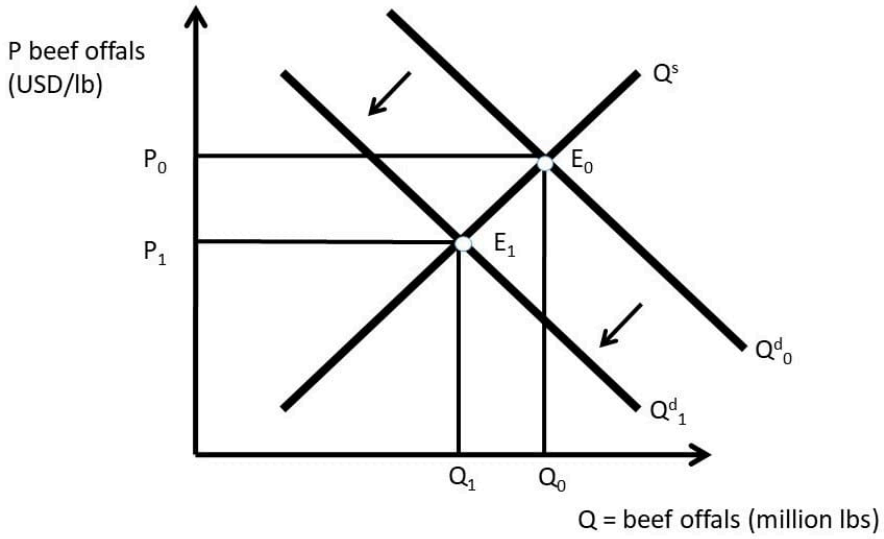


Figure 2.4.5: Increase in US Income Impact on US Beef Offal Market

Supply Decrease

A large share of citrus fruit in the US is grown in Florida and California. If there is bad weather in either State, the market for oranges, lemons, limes, and grapefruit is affected. An early freeze can damage the citrus fruit, resulting in a decrease in supply (Figure 2.4.6).

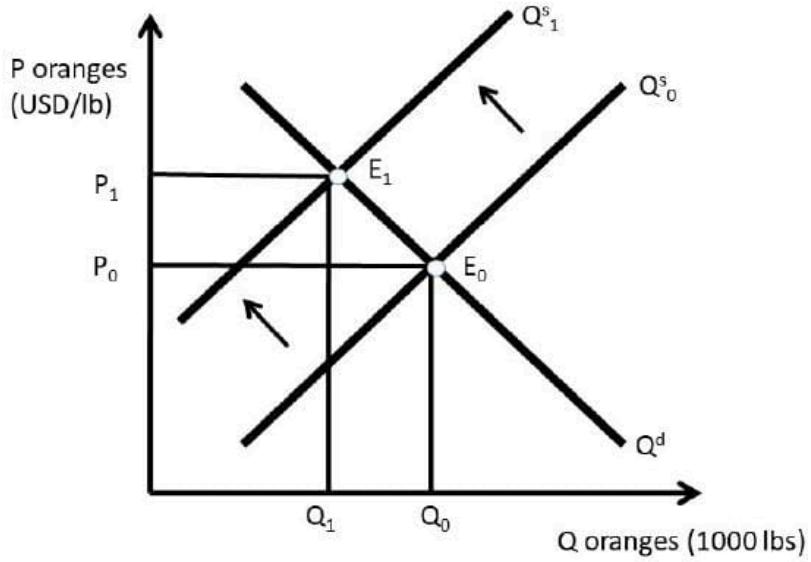


Figure 2.4.6: Frost Damage Impact on US Orange Market

The supply decrease is a shift in the supply curve to the left, resulting in a movement along the demand curve: a decrease in quantity demanded. The equilibrium price increases, and the equilibrium quantity decreases.

Supply Increase

Technological change is a constant in global agriculture. Science and technology has provided more output from the same levels of inputs for many decades, and especially since 1950. Biotechnology in field crops has been a recent enhancement in the world food supply. Biotechnology is also referred to as genetically modified organisms (GMOs). Although GMOs are often in the news media as a potential health risk or environmental risk, they have been produced and consumed in the US for many years, with no documented health issues. However, the herbicide glyphosate has been determined to be a carcinogen in recent studies. Glyphosate is the ingredient in “RoundUp,” a widely used herbicide in corn and soybean production. Genetically modified corn and soybeans are resistant to this herbicide, so it has been used extensively since the introduction of GM crops. Biotechnology has increased the availability of food enormously, and is considered the largest technological change in the history of agriculture. The impact of biotechnology is shown in Figure 2.4.7.

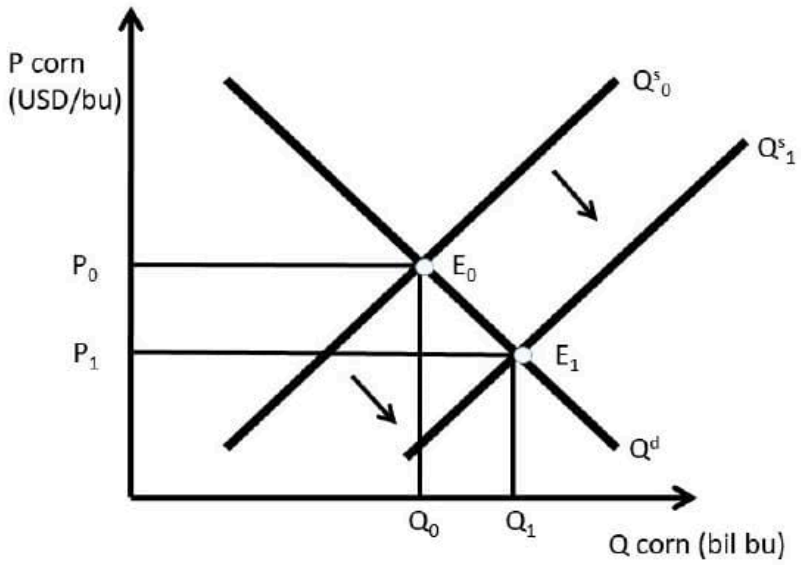


Figure 2.4.7: Biotechnology Impact on Corn Market

Biotechnology results in an increase in supply, the rightward shift in the supply curve. This supply shift results in a movement along the demand curve, an increase in quantity demanded. The equilibrium quantity increases, and the equilibrium price decreases. It may seem that the decrease in price is bad for corn producers. However, in a global economy, this keeps the US competitive in global grain markets. Since a large fraction of US grain crops are exported, this provides additional income to the corn industry.

Mathematics of Supply and Demand

The above market analyses are qualitative, or non-numerical. Numbers can be added to the supply and demand graphs to provide quantitative results. The numbers used here are simple, but can be replaced with actual estimates of supply and demand to yield important and interesting quantitative results to market events.

As an example, consider the phone market. Let the inverse demand for phones be given by Equation 2.4.1. The equation is called, "inverse" because the independent variable (P) appears on the left-hand side and the dependent variable (Q^d) appears on the right hand side. Traditionally, the independent variable (x) is on the right, and the dependent variable (y) is on the left. We use inverse supply and demand equations for easier graphing, since P is on the vertical axis, typically used for the dependent variable (can you remember why these graphs are backwards?).

$$P = 100–2Q^d \tag{2.4.1}$$

In the inverse demand equation, P is the price of phones in USD/unit, and Q is the quantity of phones in millions. The inverse supply equation is given in Equation 2.4.2.

$$P = 20 + 2Q^s \tag{2.4.2}$$

These examples of inverse supply and demand functions are called "price-dependent" for ease of graphing. The equations can be quickly and easily inverted to "quantity-dependent" form. To do this, use simple algebra to isolate Q^d or Q^s on the left-hand side of the equations.

To find equilibrium, set $Q^s = Q^d = Q^e$. This is the point where the market "clears," and supply is equal to demand. By inspection of the market graph (Figure 2.4.8), there is only one price where this can occur: the equilibrium price: P^e.

$$\begin{aligned} P &= 100–2Q^e = 20 + 2Q^e \\ 80 &= 4Q^e \\ Q^e &= 20 \end{aligned}$$

To find the equilibrium price, plug Q^e into the inverse demand equation:

$$P^e = 100–2Q^e = 100–2 * 20 = 100–40 = 60. \tag{2.4.3}$$

This result can be checked by plugging $Q^e = 20$ into the inverse supply equation:

$$P^e = 20 + 2Q^e = 20 + 2 * 20 = 20 + 40 = 60 \tag{2.4.4}$$

The equilibrium price and quantity of phones are:

$$P^e = \text{ USD } 60/\text{phones, and } Q^e = 20 \text{ million phones.} \tag{2.4.5}$$

Notice that these equilibrium values have both labels (phones) and units.

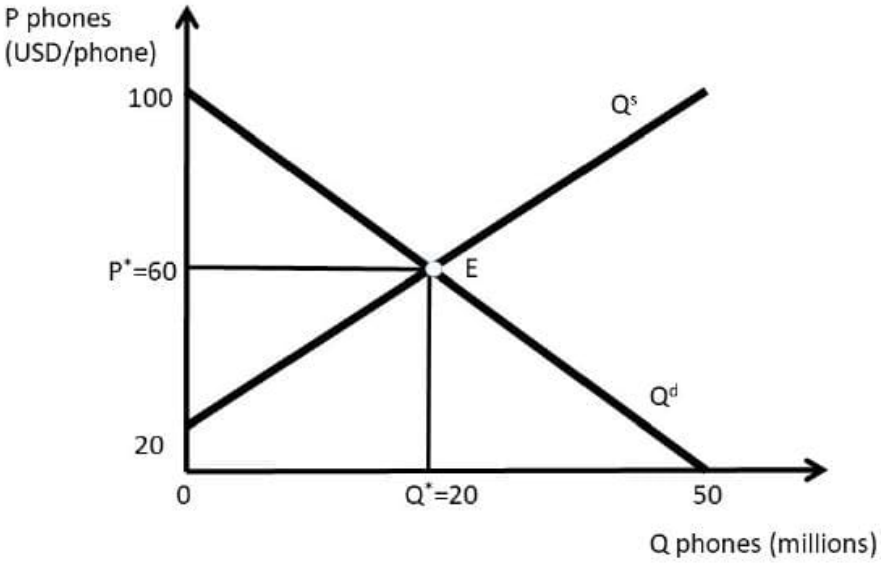


Figure 2.4.8: Phone Market Equilibrium

We will be using quantitative market analysis throughout the rest of the course. If you have any questions about how to graph the functions, or how to solve for equilibrium price and quantity, be sure to review the material in this chapter carefully. We will be using these graphs throughout our study of market structures!

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2.5: Consumer Surplus

Consumer surplus is a measure of consumer welfare. The concept is remarkably simple and can be conceptualized as the value that the consumers receive above the price paid for the product. Consumer surplus is an important part of the value created by market transactions but is often overlooked as it does not formally get recorded on the seller's financial statements nor is it quantified on customer receipts. The notion of consumer surplus will be used at different points later in the course. It is useful to introduce it now because it can be used to explain the law of demand in terms of consumers seeking to obtain surplus through market transactions.

Explaining Consumer Surplus

To motivate the idea of consumer surplus, imagine that you have a difficult exam in your 1:30 PM class. Because you are so worried about the exam you decide to forego lunch and use the time to study instead. At 2:30, after having written the exam, you realize how very hungry you are. You head to your favorite sandwich shop for lunch. You are willing to pay up to $12 for a sandwich and are pleased to see that sandwiches are priced at $8 on the menu. Does the purchase of a sandwich make you better off? Absolutely. By paying $8 you receive a good that provides you with satisfaction worth $12. Your consumer surplus is $4 and can be computed as the value you place on the product ($12) less the purchase price ($8).

Figure 1 shows that value from a market transaction such as this one is divided among the consumer (in the form of consumer surplus) and the firm (in the form of profits). Suppose the sandwich shop can produce the sandwich for $5 per unit. The shop receives a profit margin of $8 - $5 = $3. The total value created by the transaction is $7 (the $12 value you place on the sandwich less the production cost of $5) and is also equal to the $3 profit margin going to the shop plus the $4 consumer surplus going to you. Thus, there is a simple identity for the value created from a transaction such as this:

$$Value\ Created \equiv\ Consumer\ Valuation - Production\ Cost \equiv\ Consumer\ Surplus + Profit$$

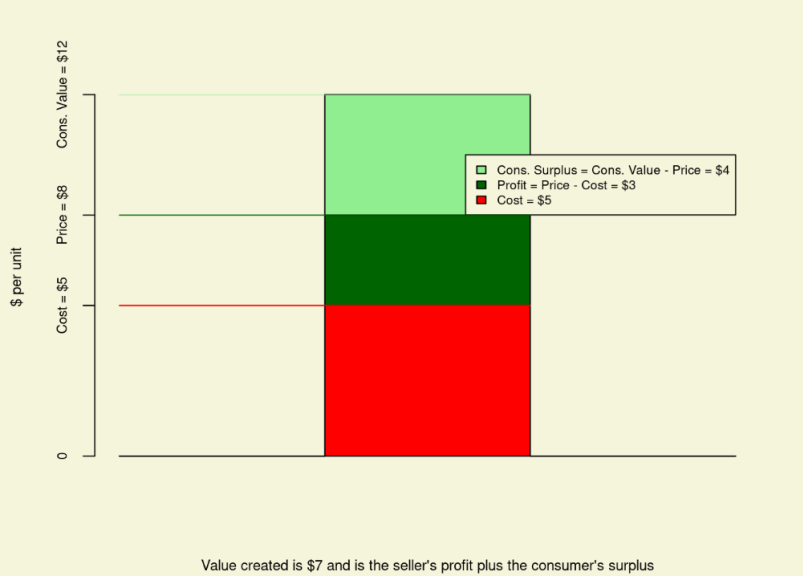


Figure 2.5.1: **Value from a market transaction is comprised of consumer surplus and profit**

Firms create value by producing goods and services that consumers value more highly than the costs of production. Typically, as in our sandwich example, some of this value will be captured as a profit margin. The rest of the value gets passed on to consumers in the form of surplus. Thus, even though consumer surplus is not entered into a company's books or onto customer receipts, it is important to profitability. Firms that create superior value can be said to have a competitive advantage in that they can gain market share by providing consumers with more-attractive surplus propositions and or can command higher profit margins while still offering consumers surplus on par with their competitors (Besanko et al. 2010).

Consumer Surplus in the Context of Diminishing Marginal Utility

Recall from above that the law of demand reflects diminishing marginal utility from successive units of a product. To see this, let us continue our sandwich example. A very hungry person receives a great deal of satisfaction from the first sandwich, probably enjoys the second, might nibble a bit on a third, but is not much interested in the fourth. What is happening here is that as the person eats more and more, he or she starts to become satiated. The first sandwich was wonderful but the fourth sandwich creates indigestion. This translates into the monetary value the consumer places on sandwiches. The hungry consumer is willing to pay a relatively high price for the first sandwich, a moderate price for the second, and much less, if anything, for the third or fourth sandwich. This leads to the negative relationship between price and quantity as stipulated by the law of demand.

Let us continue this example with Demonstration $2.5.1$ below. Suppose that your marginal valuation, the value you place on additional sandwiches, is as presented in Demonstration $2.5.1$. If sandwiches are priced at $8, you buy one and receive consumer surplus of $4. You are quite hungry and would enjoy another, but the first sandwich has taken the edge off your hunger and you only value the second sandwich at $7 which is less than the $8 purchase price. For this reason, you will only buy one sandwich if they are priced at $8. Notice from Demonstration 3 that as prices fall, you purchase additional sandwiches (again giving rise to a downward sloping demand schedule). In addition to buying more sandwiches at lower prices, you obtain more surplus from each sandwich you purchase.

With this in mind, let us consider a slightly different situation: suppose that when you showed up at the sandwich shop, you were pleasantly surprised to see that the shop owner was running a special and had sandwiches priced at $6 instead of $8. Move the price down to $6 in Demonstration $2.5.1$ to verify that in this case, you would gladly buy two sandwiches at $6 apiece. Now you would get a total $8 in consumer surplus ($7 from the first sandwich and $1 from the second).

Now let us think about this from the perspective of the shop owner. It costs her $5 to produce each sandwich, so she makes only $2 in profit by selling you the two sandwiches at $6 apiece. If she would have kept her sandwiches priced at $8 as normal, she would have only sold you one sandwich but would have made $3 in profit from the transaction with you. She faces a dilemma. She can profitably sell you a second sandwich since you value the second sandwich at $7 and it only costs her $5 to produce it. However, if she sets price low enough to induce you to buy two sandwiches, she gives up the high margin she could have commanded on the first sandwich. Moreover, there are probably less hungry customers that would have bought one sandwich at $8 but would not want a second sandwich even at the low price of $6. By pricing at $6, the shop owner sacrifices the higher margin on sandwiches sold to all these less-hungry customers as well.

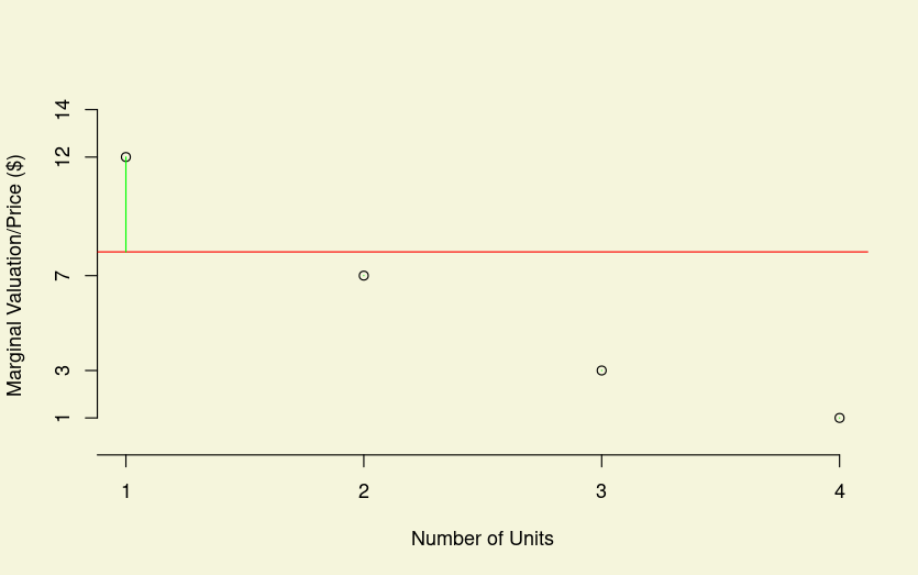
Is there a way the shop owner could resolve this dilemma? One way would be to price sandwiches so that they are $8 for one sandwich or $14 for two sandwiches. Now, a hungry customer like you would go for the two for $14 option and the shop owner will make a profit of $4 on the transactions with you and other similarly hungry customers. Better yet, she will still get a profit of $3 on transactions with the less-hungry customers who buy only one sandwich. There are some potential problems here though. What if lots of couples come to the sandwich shop? Couples would qualify for the $14 deal. The shop owner could have made a profit of $6 per couple by selling each couple two sandwiches at $8 apiece as opposed to a profit of $4 per couple under the two for $14 deal. Another way the plan could backfire would be if enterprising customers bought sandwiches on the two for $14 deal and then resold them to less hungry customers outside the shop for something like $7.50, which is lower than the $8 asking price of the shop owner.

An important point here is that consumers are only in the market when they can get positive surplus. As you progress through the course, you will learn that many marketing strategies can be characterized as efforts to capture surplus and resolve dilemmas similar to that faced by the shop owner in this example. In other words, many strategies are aimed at taking what would or could be consumer surplus and turning it into higher profits. For now, however, the main goal is to use the idea of consumer surplus to strengthen your understanding of the law of demand, and the main takeaway from Demonstration 3 is that each customer will be inclined to purchase more units at lower prices and fewer units at higher prices.

Asking Price

0 8 14

Units	Value	Surplus	Buy
1	12	4	Yes
2	7	0	No
3	3	0	No
4	1	0	No



Demonstration 2.5.1: **Surplus with diminishing marginal utility.**

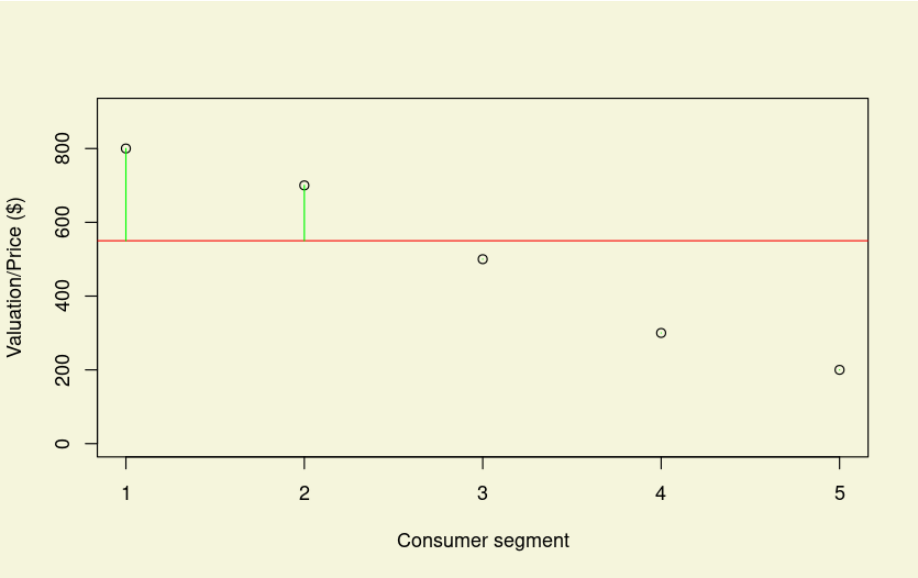
Consumer Surplus in the Context of Different Valuations Across Consumers

Another reason for the law of demand is that different consumers place different valuations on the same product. This means more consumers will participate in the market at lower prices and fewer consumers will participate at higher prices. Suppose that potential consumers of the latest electronic gadget can be divided into five segments, as shown by the points in Demonstration 2.5.2 below. Consumers in segment 1 are very enthusiastic about the gadget and value it at $800. Consumers in segment 5 are least enthusiastic and value it at $200. Segments 2, 3, and 4 fall somewhere in-between in terms of their willingness to pay for the new gadget. If the price of the device is set at $550 dollars, then only segments 1 and 2 are willing to participate in the market. These are the only two segments that could derive positive consumer surplus from buying the device. Positive surplus is denoted in the table of the demonstration as well as by the height of the green bars in the chart. If the price was lowered to below $500, consumers in segment 3 would enter the market and there would be more demanded. If the price increased to above $700, consumers in segment 2 would exit the market and fewer units would be demanded. Notice that consumers in all five segments value the gadget, but only those who can derive positive surplus participate in the market. Adjust the price-control slider in Demonstration 2.5.2. Make sure you understand the surplus calculation for consumers in each segment and are predict the price points at which different segments enter or exit the market.

Asking Price

100 550 850

Seg.	Value	Surplus	Buy
1	800	250	Yes
2	700	150	Yes
3	500	0	No
4	300	0	No
5	200	0	No



Calculating Total Consumer Surplus Using the Demand Schedule

It should be clear from Demonstrations 2.5.1 and 2.5.2 that there is a link between consumer surplus and the demand schedule. Graphically, the consumer surplus in a market can be computed as the area below the demand schedule but above the prevailing price. In Figure 2.5.2, the consumer surplus is the triangular area that is shaded in blue. If the demand schedule is linear (as in the demand schedule presented in Figure 2.5.2), you can use the formula for the area of a triangle to compute consumer surplus. You may recall that the area of a triangle is given by $12 \times \frac{base}{frac}$. With this in mind, when given a value of P, say $\overline{P}$, you can compute consumer surplus from a linear demand schedule:

$$CS = \frac{1}{2} \times Q(\overline{P}) \times (Intercept\ of\ Inverse\ Demand\ Schedule - \overline{P})$$

In Figure 2.5.2, $\overline{P}_1 = 40$. Let us use the information in the figure to compute consumer surplus.

1. Evaluate the direct demand schedule at $\overline{P}_1 = 40$ to get $Q_1(\overline{P}_1) = 200 - 2(40) = 120$. This is the base of the consumer surplus triangle.
2. Look at the equation for the inverse demand schedule provided in the figure and notice that it has an intercept of 100.

Compute the height of the consumer surplus triangle as the difference between this intercept and $\overline{P}_1$, which is $100 - 40 = 60$.
3. Use the formula for the area of a triangle to get consumer surplus as $12 \times 120 \times (60) = \$3600$.

Provided the demand schedule is linear, you can use the formula for an area of triangle to get consumer surplus. Pedagogically, linear demand schedules will be fine for most of what you will encounter in this course; however, in many empirical applications you may not want to assume that demand schedules are linear. In general, if the demand schedule is not linear you can compute consumer surplus using the integral as $\int_0^{Q*} P(Q)dQ - P(Q)Q*$, where $P(Q)$is the inverse demand curve and $Q* \geq 0$ is an arbitrary quantity value.

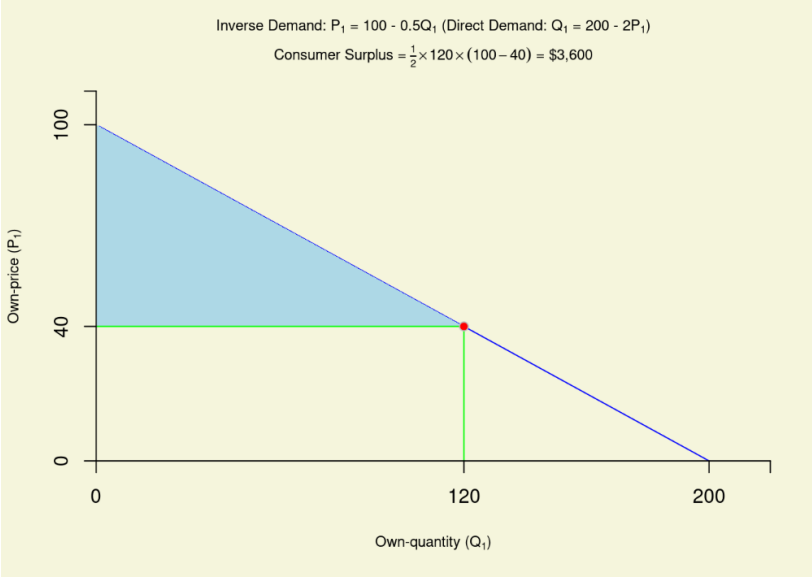


Figure 2.5.2: **Calculating consumer surplus (shaded in light blue) from a demand schedule**

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2.6: Concluding Comments

To recap, this chapter has introduced concepts essential to understanding the demand side of the market. First, you learned about different demand states. As you move forward through the course, the focus will be primarily on products in an effective demand state. You will, however, examine models appropriate for understanding products in other demand states in chapter 5. In chapter 3, you will revisit the demand shift variables as you learn elasticities. These shift variables will play a central role in chapter 4, as you model market equilibrium. Consumer surplus will central to measuring welfare in chapters 7 and 8 and will help motivate the ideas behind pricing schemes commonly used be sellers to extract consumer surplus and turn it into higher profit margins.

A question central to this course relates to how markets address the economic allocation problem. Any economic system needs to answer questions such as the following (see Kohls and Uhl 1998).

1. What to produce?
2. How much to produce?
3. How to produce?
4. How to distribute production?

In many cases, market-determined prices provide the information needed for the economy to efficiently respond to these questions. The content of this chapter relates directly to the fourth question. A consumer with a dollar to spend will use it in the market that provides him or her with the most surplus, and you have already seen that surplus depends on the price. Provided consumers know their valuation of a product, a set of market prices provides the information necessary for consumers to self-sort into markets where they obtain the most surplus. This helps to ensure that products and services are allocated to those consumers who value them most and as you will see in the coming chapters, value them sufficiently to justify the production costs.

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2.7: References

Besanko, D., D. Dranove, M. Shanley, and M. Schafer. 2010. *Economics of Strategy, 5th ed.* John Wiley & Sons.

Kohls, R. L. and J. N. Uhl. 1998. *Marketing of Agricultural Products, 8th Ed.* Pearson.

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2.8: Problem Sets

Problem Set 1: Short Answer.

Exercise 2.8.1

Given the following:

Q1 = 125 + 3 P2 - 0.1 M - 6 P1

P2 = 25; M = 500; P1 = 20

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.2

Given the following:

Q1 = 230 + 5 P2 -0.2 M -5 P1

P2 = 10; M = 400; P1 = 30

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.3

Given the following:

Q1 = 104 + 2 P2 + 0.1 M -6 P1

P2 = 30; M = 1000; P1 = 20

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.4

Given the following:

Q1 = 382 -2 P2 -0.3 M -4 P1

P2 = 30; M = 300; P1 = 40

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.5

Given the following:

Q1 = 137 -3 P2 + 0.4 M -3 P1

P2 = 25; M = 400; P1 = 50

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.6

Given the following:

Q1 = 102 + 6 P2 + 0.3 M -4 P1

P2 = 5; M = 600; P1 = 40

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.7

Given the following:

Q1 = 400 -4 P2 -0.4 M -3 P1

P2 = 20; M = 200; P1 = 50

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.8

Given the following:

Q1 = 200 + 4 P2 + 0.2 M -5 P1

P2 = 20; M = 800; P1 = 30

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.9

Given the following:

Q1 = 260 -6 P2 -0.5 M -2 P1

P2 = 5; M = 100; P1 = 60

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Exercise 2.8.10

Given the following:

Q1 = 132 -5 P2 + 0.5 M -2 P1

P2 = 10; M = 300; P1 = 60

Is good 2 a substitute or complement to good 1?

Is good 1 a normal or inferior good?

Write equations for the direct and inverse demand schedules.

Plot the inverse demand schedule. Label the vertical and horizontal intercepts along with the own-price and quantity.

Calculate consumer surplus at this data point. Shade the area that represents consumer surplus.

Answer available at the end of this section.

Problem Set 2: Multiple Choice.

Exercise 2.8.1

1. **Which best describes consumer surplus?**

a) Large surplus that result when consumers perceive the product in question to be undesirable (e.g., negative demand).

b) Value that the consumer receives from a transaction above the price he or she is required to pay.

c) Situations where the consumer only wants one unit of the product. Additional units are considered to be surplus.

d) Goods that consumers store for use at a later date.

Answer available at the end of this section.

Exercise 2.8.2

2. **Which of the following is most likely to shift the demand schedule out (to the right or northeast)?**

a) An increase in population.

b) An increase the own-price.

c) A decrease in the price of a substitute product.

d) All of the above.

Answer available at the end of this section.

Exercise 2.8.3

3. **Suppose that a prestigious journal reports that the regular consumption of walnuts reduces risk of heart disease. As a consequence, the demand for walnuts increases (walnut demand shifts to the right).**

a) Walnuts would switch from becoming inferior goods to normal goods.

b) This would be described as a change in the price of a substitute product because heart disease is something no one wants.

c) This change in demand would best be characterized as a change in preferences.

d) All of the above

Answer available at the end of this section.

Exercise 2.8.4

4. **Which best describes a direct demand schedule?**

a) Price is a function of quantity.

b) Quantity is a function of price.

c) Price is a function of income.

d) Both a and c.

Answer available at the end of this section.

Exercise 2.8.5

5. **Which condition is the best example of a product in a state of latent demand?**

a) High-protein muffins filled with roasted caterpillars.

b) Fresh salads in cold Midwestern and Northeastern cities during the winter months of the mid to late 1800s.

c) Demand for products that are outdated (e.g., unused tickets to last week's ball game).

d) Demand for apples.

Answer available at the end of this section.

Exercise 2.8.6

6. **Suppose the economy goes into recession, many people lose their jobs, and nearly everyone has a lower income. Which products will likely experience an increase in market demand?**

a) Products classified as normal goods.

b) Products that are classified as inferior goods.

c) Products classified as necessities.

d) Products classified as complements.

e) Products classified as substitutes.

Answer available at the end of this section.

Exercise 2.8.7

7. **Which best describes complements as described in class?**

a) Goods that are consumed together, for example, gasoline and automobiles.

b) Luxury items purchased in the hope of eliciting complements from friends or acquaintances.

c) Goods that can be used in lieu of one another, for example, beef and poultry.

d) Goods for which demand increases given an increase in income.

Answer available at the end of this section.

Exercise 2.8.8

8. **In demand, if the price of good A decreases and the demand for good B also decreases then which must be true?**

a) Good A is a substitute for good B.

b) Good A is a complement for good B.

c) Good A is a normal good.

d) Good B is an inferior good.

Answer available at the end of this section.

Exercise 2.8.9

9. **When you write an equation for the inverse demand curve,**

a) Price will be a function of quantity (price is on the left-hand side of the equation).

b) Quantity will be a function of price (quantity is on the left-hand side of the equation).

c) The demand schedule will slope upwards.

d) Both b and c.

Answer available at the end of this section.

Exercise 2.8.10

10. **The law of demand**

a) States that as price increases, quantity decreases and *vice versa*.

b) Reflects the fact that marginal utility usually declines as the number of units consumed increases.

c) Reflects the fact that different consumers will generally place different valuations on the product. In other words, as price declines more consumers will find it attractive to participate in the market.

d) All of the above.

Answer available at the end of this section.

Exercise 2.8.11

11. **If consumer incomes increase,**

a) demand will shift out (to the right).

b) demand will shift in (to the left).

c) demand will not shift but there will be a new quantity demanded from the same demand schedule.

d) the shift in demand cannot be determined without additional information.

Answer available at the end of this section.

Exercise 2.8.12

12. **Consumer surplus refers to**

a) The triangular area below the linear inverse demand curve and above the horizontal axis.

b) The sum of the value that consumers receive above the price they are required to pay.

c) Situations where consumers do not like a product and so the result is an excess or surplus.

d) A case where producers put too much on the market.

e) Both a and b.

Answer available at the end of this section.

Exercise 2.8.13

13. **Prepared breakfast cereal is best described as being in a state of:**

a) Latent demand.

b) Negative demand.

c) Effective demand.

d) Latent supply.

Answer available at the end of this section.

Exercise 2.8.14

14. **By definition, an inferior good is:**

a) A good that is in a state of negative demand.

b) A good for which demand increases (shifts out) when consumer incomes decline.

c) A good for which demand decreases (shifts in) when consumer incomes decline.

d) A good that would be unappetizing to most consumers.

Answer available at the end of this section.

Exercise 2.8.15

15. **The law of demand indicates:**

a) Cross-price elasticities will be negative for substitute products.

b) The demand schedule will be downward sloping.

c) Income elasticities will be positive.

d) Demand shifts when tastes and preferences change.

Answer available at the end of this section.

Exercise 2.8.16

16. **Vacations to Mars are best described as being in a state of:**

a) Latent demand.

b) Negative demand.

c) Effective demand.

d) No demand state since consumers cannot buy these products.

Answer available at the end of this section.

Exercise 2.8.17

17. **By definition a normal good is:**

a) A good that is in a state of negative demand.

b) A good for which demand increases (shifts out) when consumer incomes decline.

c) A good for which demand decreases (shifts in) when consumer incomes decline.

d) A good that consumers consider to be “normal” in the sense that there is nothing extraordinary about it. Food insects, for example, would be abnormal goods for many US consumers.

Answer available at the end of this section.

Exercise 2.8.18

18. **All else equal, if income increases and the demand schedule shifts out (to the right) then you can conclude that:**

a) The demand schedule is for a normal good.

b) The demand schedule is for an inferior good.

c) The demand schedule is for a substitute product.

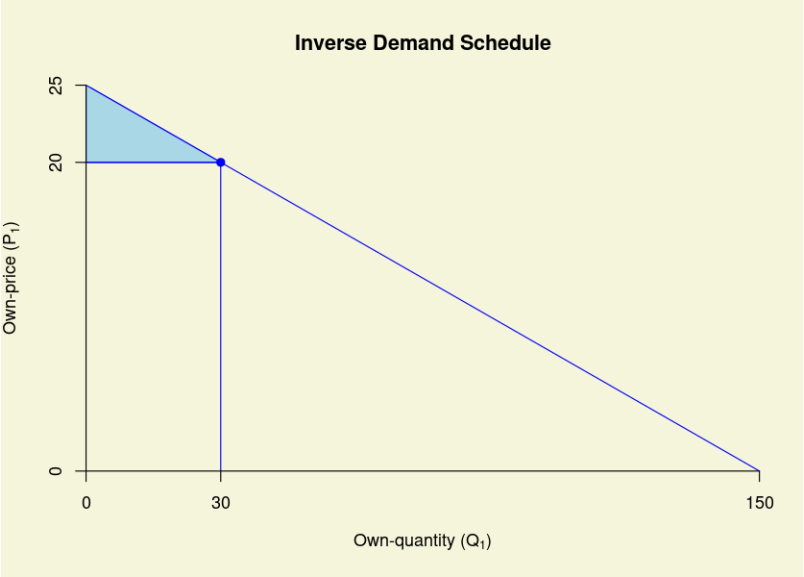
d) The demand schedule is for a complementary product.

Answer available at the end of this section.

Answers

Exercise 2.8.1

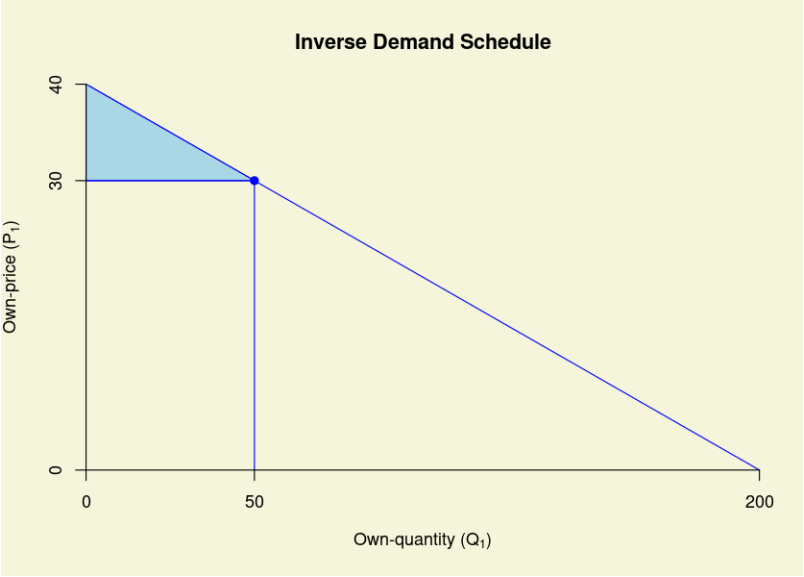
Good 2 is a substitute.
Good 1 is inferior.
Direct: Q1 = 150 -6 P1
Inverse: P1 = 25 -0.17 Q1



Consumer Surplus = $ 75

Exercise 2.8.2

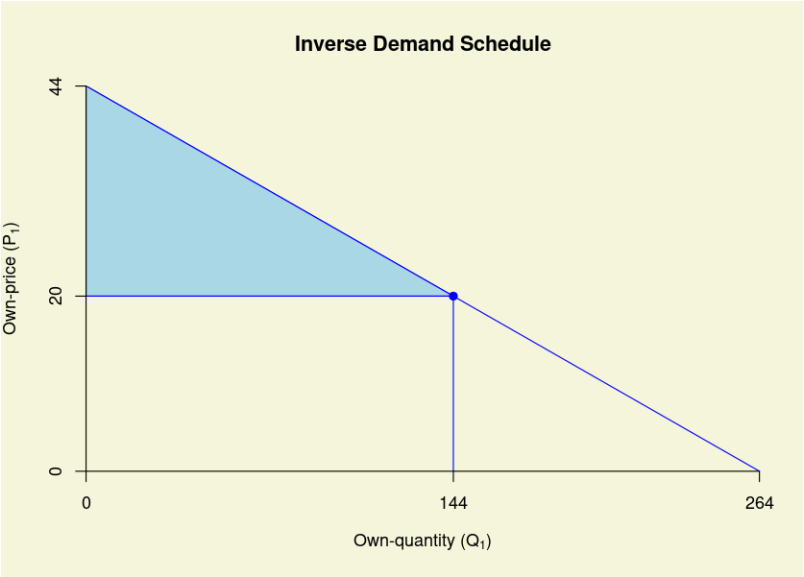
Good 2 is a substitute.
Good 1 is inferior.
Direct: Q1 = 200 -5 P1
Inverse: P1 = 40 -0.2 Q1



Consumer Surplus = $ 250

Exercise 2.8.3

Good 2 is a substitute.
Good 1 is normal.
Direct: Q1 = 264 -6 P1
Inverse: P1 = 44 -0.17 Q1



Consumer Surplus = $ 1728

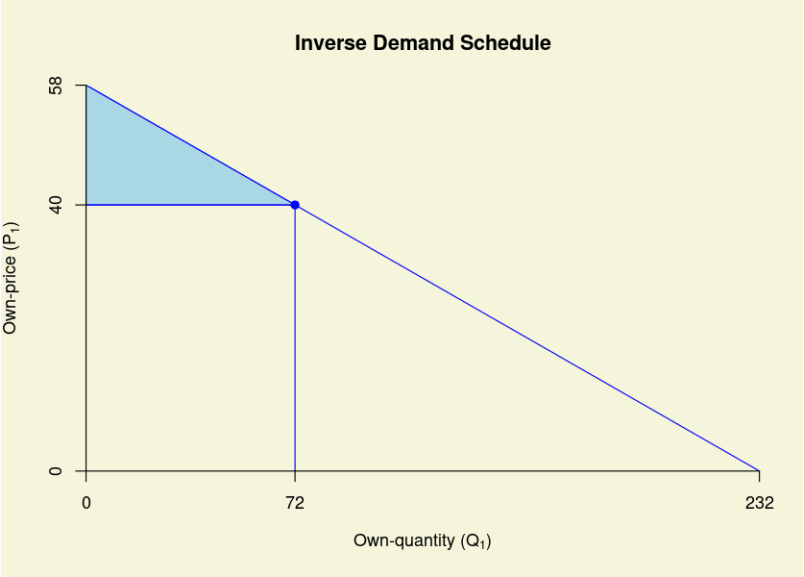
Exercise 2.8.4

Good 2 is a complement.

Good 1 is inferior.

Direct: Q1 = 232 -4 P1

Inverse: P1 = 58 -0.25 Q1



Consumer Surplus = $ 648

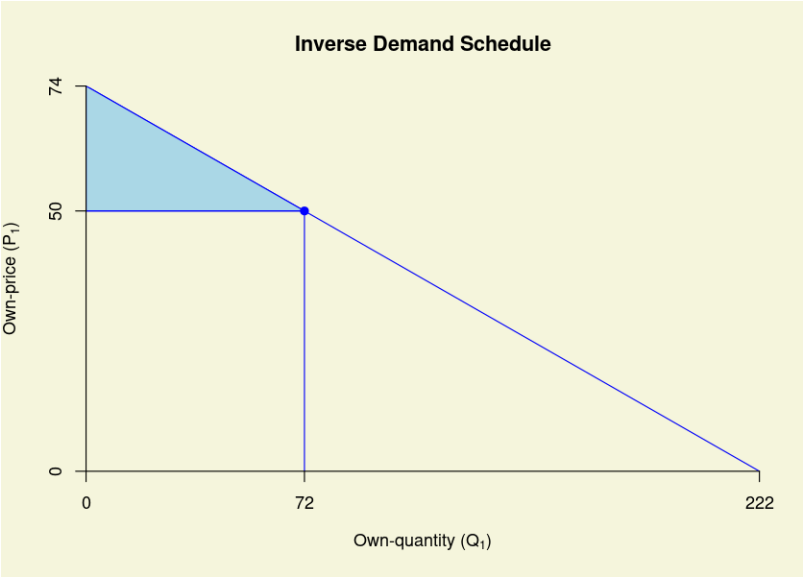
Exercise 2.8.5

Good 2 is a complement.

Good 1 is normal.

Direct: Q1 = 222 -3 P1

Inverse: P1 = 74 -0.33 Q1



Consumer Surplus = $ 864

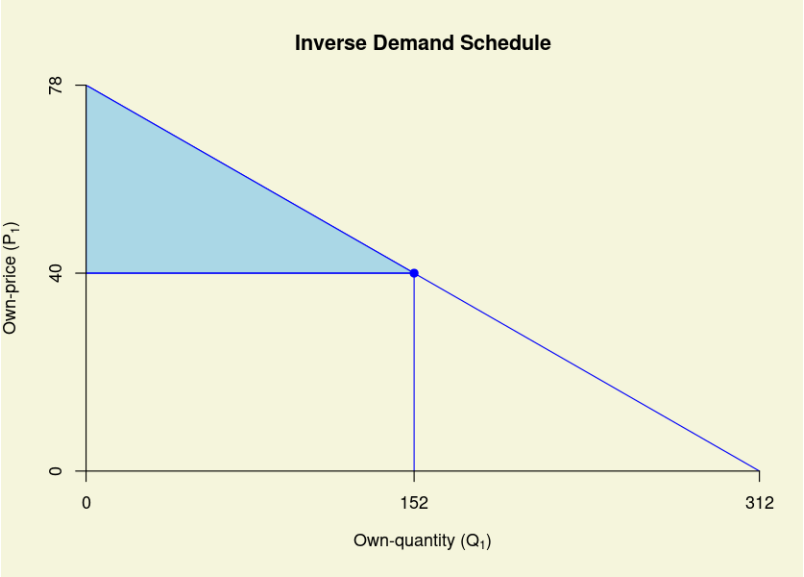
Exercise 2.8.6

Good 2 is a substitute.

Good 1 is normal.

Direct: Q1 = 312 -4 P1

Inverse: P1 = 78 -0.25 Q1



Consumer Surplus = $ 2888

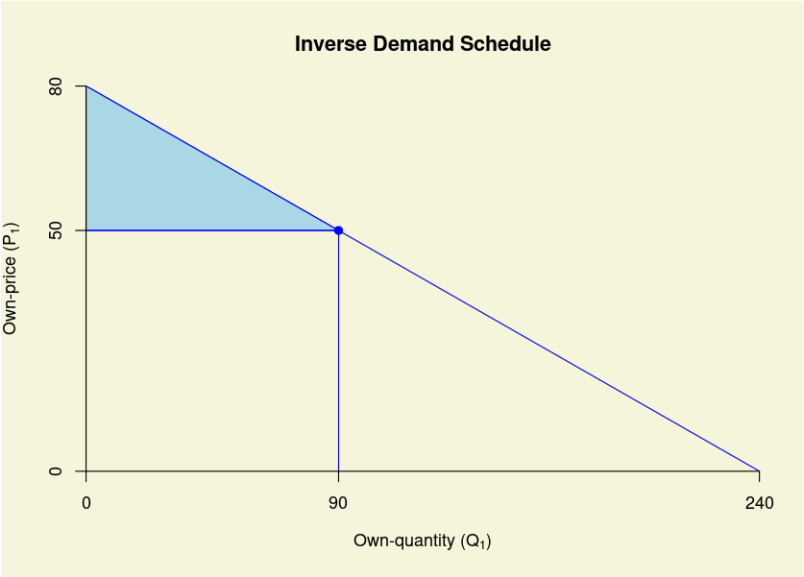
Exercise 2.8.7

Good 2 is a complement.

Good 1 is inferior.

Direct: Q1 = 240 -3 P1

Inverse: P1 = 80 -0.33 Q1



Consumer Surplus = $ 1350

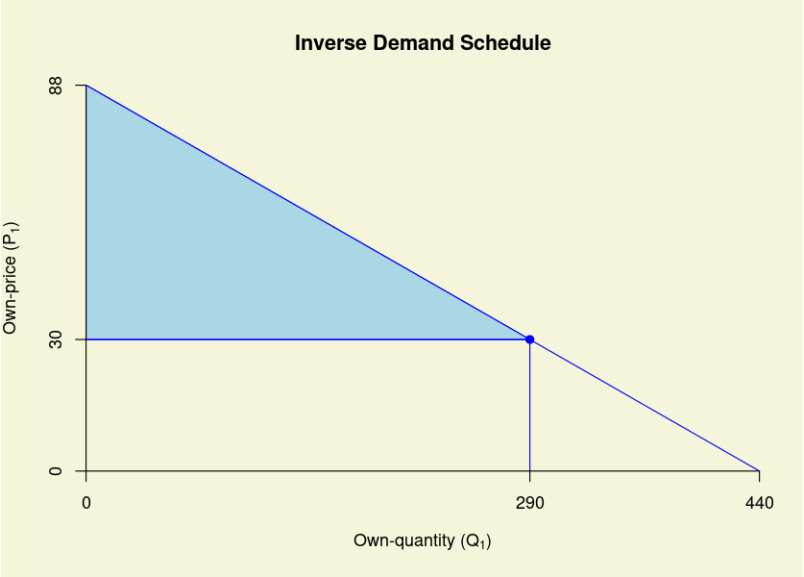
Exercise 2.8.8

Good 2 is a substitute.

Good 1 is normal.

Direct: Q1 = 440 -5 P1

Inverse: P1 = 88 -0.2 Q1



Consumer Surplus = $ 8410

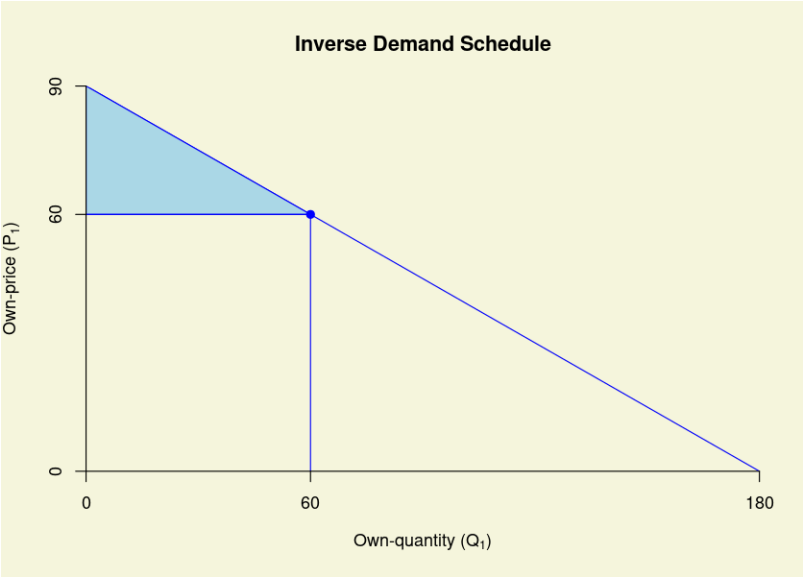
Exercise 2.8.9

Good 2 is a complement.

Good 1 is inferior.

Direct: Q1 = 180 -2 P1

Inverse: P1 = 90 -0.5 Q1



Consumer Surplus = $ 900

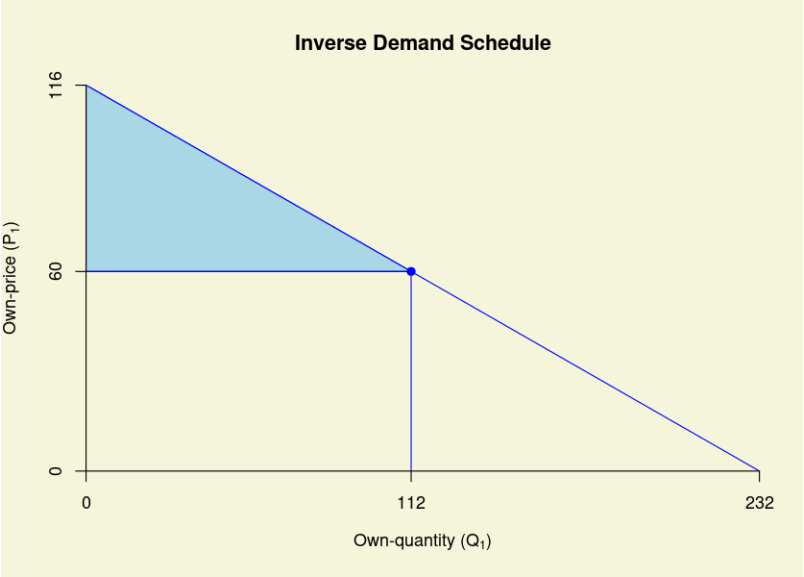
Exercise 2.8.10

Good 2 is a complement.

Good 1 is normal.

Direct: Q1 = 232 -2 P1

Inverse: P1 = 116 -0.5 Q1



Consumer Surplus = $ 3136

Exercise 2.8.1

b

Exercise 2.8.2

a

Exercise 2.8.3

c

Exercise 2.8.4

b

Exercise 2.8.5

b

Exercise 2.8.6

b

Exercise 2.8.7

a

Exercise 2.8.8

a

Exercise 2.8.9

a

Exercise 2.8.10

d

Exercise 2.8.11

d

Exercise 2.8.12

b

Exercise 2.8.13

c

Exercise 2.8.14

b

Exercise 2.8.15

b

Exercise 2.8.16

a

Exercise 2.8.17

c

Exercise 2.8.18

a

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3: ELASTICITY- UNDERSTANDING RESPONSIVENESS

Learning Objectives

- Interpret elasticity numbers and compute elasticities using both the point and arc formulas.
- Use demand elasticities to identify normal necessities, normal luxuries, inferior goods, substitutes, and complements in consumption.
- Describe factors that impact the magnitude of own-price demand elasticities.
- Show how the revenue implications of a price change depend on the own-price elasticity of demand.
- Use supply elasticities to identify competing products and joint products in production.

Imagine yourself in an internship this summer. It is your first day on the job and your supervisor asks you to develop answers for the following questions:

> How does the demand for beef respond to changes in the price of beef?
>
> How does the demand for beef respond to changes in the prices of related goods such as pork, poultry, lamb, or fish?
>
> How does the demand for beef respond to a change in consumer income levels?
>
> How does the demand for beef respond to changes in advertising expenditures by the National Cattlemen's Beef Association (NCBA)?

Having just completed a course on food and agricultural marketing, you notice immediately that each of these questions pertains to a variable that can influence market demand. Question 1 deals with the own-price relationship, question 2 with cross-price relationships, question 3 with an income relationship, and question 4 with the potential for advertising expenditures to exert a favorable influence on consumer preferences.

You are pleased to have been given such a straightforward assignment and begin to draft a memo that provides sensible answers to each question. In response to question 1, you explain that as the price of beef increases, quantity demanded will fall. After all, there is this little idea called "the law of demand" that your professor kept blabbering about. Question 2 is also easy. You simply argue that pork, poultry, lamb, or fish are usually presented as alternative protein choices to beef. Because of this, each can be classified as a substitute to beef. You conclude that as the price of one or more of these products increases, beef demand would increase as well. You find the income question to be a little harder. Nevertheless, being a resourceful person, you log into the University Libraries and locate a study showing that as incomes rise, consumers increase visits to higher-end restaurants. Since these restaurants are more likely to serve expensive table cuts from the loin and rib, you reason that this study provides the evidence you need to make a case that beef is a normal good. As such, you argue that beef demand will increase as consumer incomes rise. Finally, on question 4, you state: "If the NCBA launches a new advertising campaign, it is reasonable to expect beef demand to increase. Especially if the campaign is successful in convincing consumers that beef is a nutritious and convenient menu choice." You proofread your memo and send it off to your supervisor in an email. She acknowledges receipt with a short reply: "Wow. That was fast. I'll look at this tonight."

The next morning you arrive at work and see a hard copy of the memo on your desk. On it is a hand-written note that says: "Tell me something I don't already know." Ouch! So much for making a good first impression.

The answers you developed were correct. The problem is that answers this simple are usually not specific enough to support policy or marketing decisions. Your supervisor already had a good idea of the direction of the demand changes. What she really wanted was a better idea about the magnitude of these changes. This is where elasticities can be useful. The aim of this chapter is to help you understand how to compute and use demand and supply elasticities. You will use elasticities to address some basic decision problems in the problem sets of this chapter but will put this knowledge to work in earnest in the next chapter.

3.1: Demand Elasticities

3.2: Computing Demand Elasticities

3.3: Factors that Affect the Magnitude of Own Price Elasticities
3.4: Elasticities of Supply
3.5: Concluding Comments
3.6: Problem Sets

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3.1: Demand Elasticities

Elasticities will be important for much of what follows in this course. More importantly, an understanding of elasticities will help you think through decision problems you will encounter in your career. You were introduced to elasticities in your introductory microeconomics course, but let us take a moment to review them now.

The term “elastic” implies flexibility. An elastic material responds readily to force. An inelastic material is less responsive. For example, a rubber band is quite elastic. You can exert force by pulling on the rubber band and it responds easily and stretches according the force you apply. For this reason, the term “elastic band” is sometimes used in lieu of the term “rubber band.” In demand, the interest is in the responsiveness of a product’s quantity to forces that affect demand. The forces of interest were introduced in Chapter 1 and include the product’s own-price, prices of related products, income, and other demand shift variables.

Simply stated, an elasticity is the percentage change in one variable resulting from the percentage change in another. In this course, the symbol єє (the Greek letter epsilon) will be used to refer to demand elasticities. Subscripts will indicate the product and demand variable in question. The first subscript will always refer to the quantity of the product in question. The second subscript will refer to a price or other variable that affects demand. For example, ε_{ij} refers to the elasticity of demand for good i with respect to a change in the price of good j. Similarly, ε_{iX} refers to the elasticity of good i with respect to some non-price demand shift variable X.

There are several types of demand elasticities. ***Own-price elasticities*** measure the relationship between the quantity of a particular good, say good 1, and its own-price. The own-price elasticity of demand for good 1 is defined as

$$\varepsilon_{11} = \frac{\%\Delta Q_1}{\%\Delta P_1}$$

where Δ is the change operator. The formula for the own-price elasticity of another good, say good 2, would be

$$\varepsilon_{22} = \frac{\%\Delta Q_2}{\%\Delta P_2}$$

Cross-price elasticities measure the relationship between the quantity of one good and the price of a related good. The cross-price elasticity of demand for good ii with respect to the price of good j would be

$$\varepsilon_{ij} = \frac{\%\Delta Q_i}{\%\Delta P_j}, \ \ for \ \ i \neq j.$$

As you learned in Chapter 1, variables other than prices also affect demand. One of these variables is income. An ***income elasticity*** for good 1 would be calculated as

$$\varepsilon_{1M} = \frac{\%\Delta Q_1}{\%\Delta M},$$

where M represents income.

Interpretation of Elasticity Numbers

Because elasticities are the ratio of two percentage changes, they are easy to interpret. If $\varepsilon_{iX} = 0.5$, then you can say that quantity demanded increases (decreases) by half a percent as X increases (decreases) by one percent. You can algebraically rearrange the terms in the elasticity definitions above to use an elasticity to predict the change in quantity that would result from a change in a demand variable of interest. Specifically, the definition of an elasticity suggests the following:

$$\varepsilon_{iX} = \frac{\%\Delta Q_i}{\%\Delta X} \Rightarrow \%\Delta Q = \varepsilon_{iX} \times \%\Delta X.$$

One nice thing about the fact that elasticities are expressed as a ratio of percentages is that they are independent of units of measurement. It does not matter whether prices or income are reflected in US dollars, Euros, Pesos, or Yen. Similarly, it does not matter whether quantities are measured in bushels, pounds, kilograms, or tons. The interpretation of the elasticity number will

be unaffected. That said, one could use an elasticity to predict what would happen to physical units demanded when a demand variable changes. Suppose you knew that $\varepsilon_{11} = -2.5$. If you were interested in the effect of a three percent price increase, this elasticity can be used to tell you that

$\%\Delta Q_1 == 2.5 \times 3 = -7.5\%.$

Now, suppose that you know that before the price increase demand is 1,000 units. You could easily predict what demand would be after the 3% price increase. The new quantity demanded would be

\{1000 \: units \times (1-0.075) = 925 \: units\).

This elasticity could be used in a similar fashion to predict the quantity response given any magnitude of a price change, but there are some practical reasons why predictions will tend to be less accurate when using elasticities to predict large percentage price changes. These limitations will become clear below as you learn more about elasticities.

Ranges for Demand Elasticities

Because elasticities measure responsiveness, their magnitudes are of importance. Table 3.1.1 presents some magnitude-based classifications of demand elasticities that will be important for you in this course. Notice from the table that own-price elasticities are non-positive. This is because of the law of demand. It is common in introductory microeconomics textbooks and even in some more advanced MBA-level textbooks to take the absolute value of an own-price elasticity and report it as a positive number. This will not be done here. Elasticities will be used to predict quantity changes and to model market responses to demand or supply shocks. It will be important to preserve the direction of the negative own-price effect on quantity demanded. Another reason for not taking the absolute value of own-price demand elasticities is that such practice is uncommon in the empirical literature.

Table 3.1.1: Classifications based on magnitude of demand elasticities.

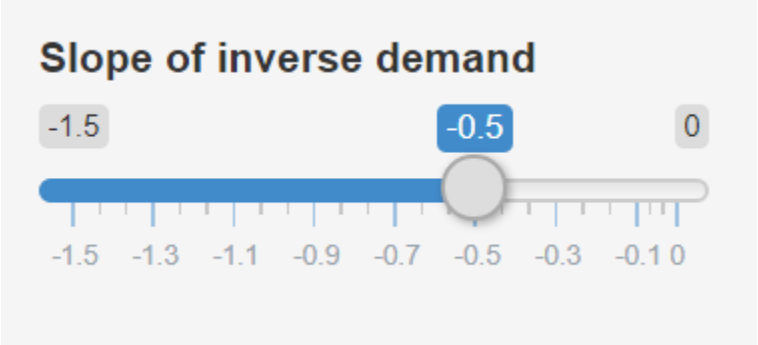
Type	Range	Implication
Own-price	$\varepsilon_{ii} \< -1$	Demand for good i is elastic
Own-price	$\varepsilon_{ii} = -1$	Demand for good i is unitary elastic
Own-price	$-1 \< \varepsilon_{ii} \leq 0$	Demand for good i is inelastic
Cross-price	$\varepsilon_{ij}\ 0, i \neq j$	Good j is a substitute for i
Cross-price	$\varepsilon_{ij} \< 0, i \neq j$	Good j is a complement to i
Income	$\varepsilon_{iM} \< 0$	Good i is an inferior good
Income	$0 \leq \varepsilon_{iM} \leq 1$	Good i is a normal necessity
Income	$\varepsilon_{iM}\ 1$	Good i is a normal luxury

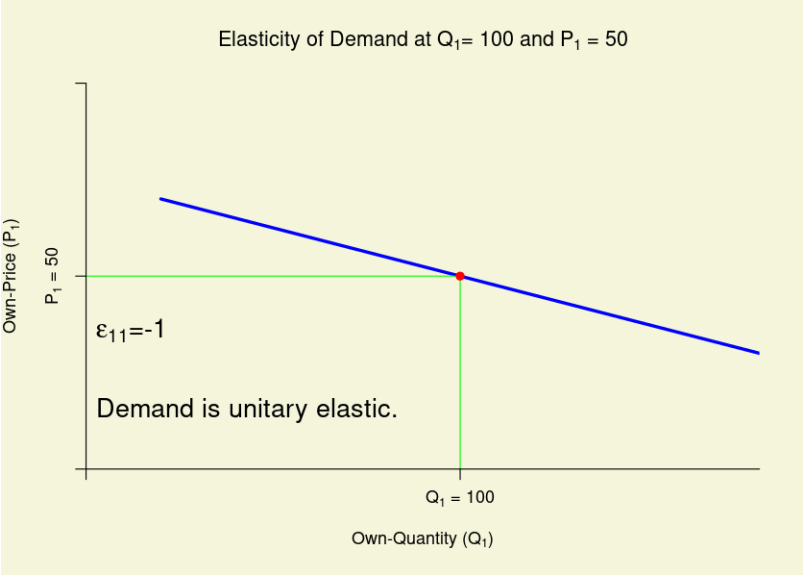
As shown in Table 3.1.1, own-price elasticities are divided into three ranges. First, when demand is elastic, the numerator of the elasticity is large in absolute value relative to the denominator. This means that demand is responsive in the sense that a change in price induces a more-than-proportional change in quantity. With elastic demand, the quantity change will be large in comparison to the price change. When demand is unitary elastic, the numerator of the elasticity is the negative of the denominator. Unitary elastic demand means that the change in quantity is exactly proportional to the change in price. Finally, when demand is inelastic, there is a less than proportional change in quantity in response to a change in price. With inelastic demand, a large change in price may not change quantity very much.

To give you some intuition about own-price elasticity, consider Demonstration 3.1.1. In this demonstration, the price is fixed at $50 and the quantity at 100 units. The only thing you can change is the slope of the inverse demand curve. When the demonstration first loads, this slope will be -0.5 and the elasticity of demand will be -1 or unitary elastic. If you see something different, set it to -1 or reload the page in your browser. Make the slope steeper by sliding the control of the demonstration to the left. As you do, you will see that demand becomes inelastic. As the slope becomes steeper, price changes quite a bit, but quantity does not change very much. This is what is meant by inelastic demand. Now slowly slide the control of the demonstration to the right to flatten the slope of inverse demand. You will see that demand switches from inelastic, to unitary elastic, to elastic as you do. When the slope of inverse demand is 0, the elasticity of demand is negative infinity. This means that any amount can be sold at the given price of $50, but that no amount can be sold at a slightly higher price (e.g., $50.01). The term “perfectly elastic” is

sometimes used in situations like this and means the same thing as infinitely elastic.

It is not likely that a market demand schedule will ever be infinitely elastic, but there are situations where the demand schedule facing an individual firm is infinitely elastic. In fact, the price-taking firms you learned about in Chapter 2 face infinitely elastic demand. If you remember, price taking firms can sell all they want at the going price. This is equivalent to saying that price taking firms face an infinite elasticity. As the course progresses, it will be useful to pay attention to whether an elasticity refers to the market demand or the demand facing the firm. The market demands for agricultural commodities are commonly inelastic but the demands facing the individual farms supplying these commodities may be infinitely elastic.





Demonstration 3.1.1: **Own-price elasticities show the responsiveness of quantity to changes to price.**

As indicated above in Table 3.1.1, cross-price elasticities of demand are used to determine whether related products are substitutes or complements. Consistent with the relationships presented in Chapter 1, positive (negative) cross-price elasticities imply substitutes (complements). The magnitude of the cross-price elasticities can be used to determine which products are strong substitutes or complements to the product in question. For instance, Brand A yogurt might be a very close substitute for Brand B yogurt. There might also be some substitutability between Brand A yogurt and cottage cheese. Nevertheless, cottage cheese is a much weaker substitute for Brand A yogurt than is Brand B yogurt. In this case, one would see a large positive cross-price elasticity of demand for the Brand A yogurt with respect to the price of Brand B yogurt. There would be a positive, albeit considerably smaller, cross-price elasticity of demand for Brand A yogurt with respect to the price of cottage cheese.

Finally, income elasticities can be used to classify goods as normal or inferior based on a positive or negative sign, respectively. As indicated in Table 1, normal goods can be further classified as a normal necessity or normal luxury goods. A normal necessity has an income elasticity that is between zero and one. For normal necessity goods, the change in quantity is less than proportionate to the change in income. Many, if not most, food items have income elasticities in the range of normal necessities. With a normal luxury, the change in quantity is more than proportionate to the change in income.

Revenue Implications of Own-Price Elasticities

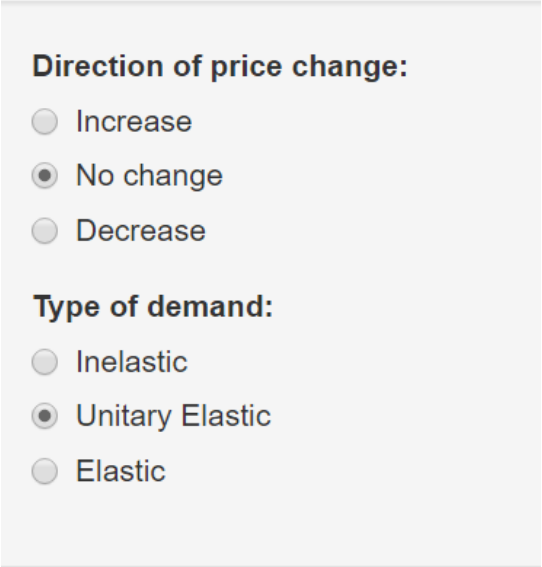
If you know the range of the own-price elasticity – whether demand is elastic, unitary elastic, or inelastic – you can predict what will happen to revenue if there is a change the product's own-price. Higher prices are not always good for revenue. When there is a price increase, two things happen: First, fewer units of the good or service are sold. This is a quantity effect. Second, a higher price is received for each of the remaining units that continue to be sold. This is a price effect. If the price effect is larger than the quantity effect, revenue will increase as price increases. If, on the other hand, the quantity effect is larger than the price effect, revenue will decrease as price increases. Fortunately, you can easily tell from the own price elasticity of demand which of these effects is largest.

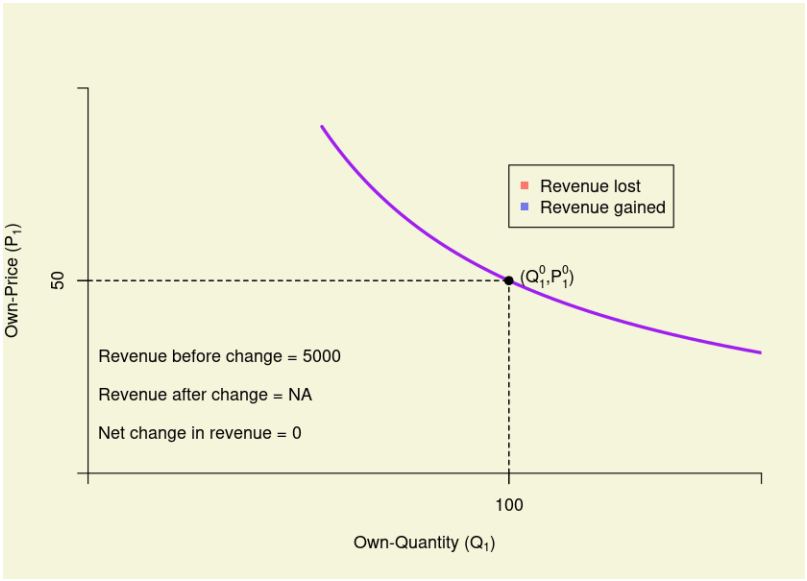
In the elastic range, an increase (decrease) in price causes a decrease (increase) in revenue. Because demand is elastic, the quantity effect dominates the price effect. The revenue lost from selling fewer units more than offsets the revenue gained from selling the remaining units at a higher price. Thus, raising price causes revenue to fall. On the other hand, when demand is elastic and price is lowered, the revenue gain from selling additional units more than offsets the revenue lost from selling each unit at a lower price. Lowering price when demand is elastic will cause revenue to rise.

In the inelastic range, an increase (decrease) in price causes an increase (decrease) in revenue. When demand is inelastic, the price effect dominates the quantity effect. The decline in quantity is proportionately smaller than the increase in price. In this case, the revenue gained from the higher price more than offsets the revenue lost from selling fewer units. Conversely, if price is lowered when demand is inelastic, the revenue gained from selling more units is not sufficient to offset the revenue lost from selling each unit at a lower price.

When demand is unitary elastic, revenue is maximized. When demand is unitary elastic, total revenue is maximized. This is because the price effect and quantity effect are of the same magnitude. The revenue gained (lost) from a price increase (decrease) is exactly offset by the revenue lost (gained) from the sale of fewer (more) units.

Use Demonstration 3.1.1 below to get some intuition about the revenue implications of price changes. As you work through the demonstration, pay attention to the size of the red and blue rectangles that appear when you change the price. The blue rectangle represents revenue gained from the price change. The red rectangle represents revenue lost. Note that whenever you change the price, there is always a blue and red rectangle. This is because the quantity effect and price effect of the change are always in opposite directions (because of the law of demand). Calculate the areas of the red and blue rectangles and notice that when you subtract the area of the red rectangle from the area of the blue rectangle you obtain the net revenue reported in the demonstration. Use the demonstration to verify that the revenue implications of price changes under different elasticity conditions match those outlined above.





Demonstration 3.1.2: **The relationship between price changes, own-price elasticity, and revenue.**

One word of caution is in order. The normal assumption is that firms maximize profit (not revenue). That said, the revenue implications of demand elasticities are important because revenue is a key part of the profit calculation you learned about in Chapter 2. Moreover, firms probably have a good idea about their production cost and so information about what happens to revenue in response to a price change may be all that is needed to make the right pricing decisions to increase profit.

Based on what you have learned up to this point in the course, you should be able to prove that a firm that controls its price (this is not a price-taking firm) will never set its price so that demand is in the inelastic or unitary elastic ranges. How could you prove this? The most straightforward way would be to show that it cannot possibly be true that a firm has maximized its profits if its demand is not in the elastic range. Start by asking the question: Could a firm have maximized its profit if its demand is inelastic or unitary elastic? The answer is no. To see why, suppose this firm raised its price by a small amount. Two things would happen:

1. First, the firm's revenue would go up if demand is inelastic or its revenue would stay the same if demand is unitary elastic. Spend some more time in Demonstration 2 and review the content above if this is not clear to you.
2. Because the firm raised its price, it would sell less (because of law of demand) and its cost would go down as a result. Remember from Chapter 2 that total cost is an increasing function of quantity. Thus, a lower quantity sold means lower cost to the firm.

In sum, a small price increase in this situation either increases or does not affect revenue but unambiguously decreases cost. This means that profit must unambiguously increase with a price increase. Thus, a firm facing demand in the inelastic or unitary elastic range cannot have possibly maximized its profit because it can raise its profit simply by raising its price.

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3.2: Computing Demand Elasticities

There are occasions in this course where you will need to compute elasticities. There are two formulas used to do this. One is the point formula. The point formula will be most important for this course and is also most commonly in published studies on food demand. The other formula is called the arc or average formula. Let us spend some time on each.

The Point Formula for Demand Elasticities

The general formula for an elasticity can be rearranged algebraically to arrive at the point formula. To illustrate, rewrite the own-price elasticity formula shown above as follows:

$$\varepsilon_{11} = \frac{\%\Delta Q_1}{\%\Delta P_1} = \frac{(\Delta Q_1/Q_1) \times 100}{(\Delta P_1/P_1) \times 100} = \frac{\Delta Q_1}{\Delta P_1} \times \frac{P_1}{Q_1} \tag{3.2.1}$$

Point formulas for different kinds of demand elasticities are reported in Table 3.2.1. Note the similarity in the formula for each kind of elasticity. As a practical matter, you need three terms (numbers) to compute an elasticity using the point formula.

1. Depending on the type of elasticity, the first number you need is $\frac{\Delta Q_i}{\Delta P_i}, \frac{\Delta Q_i}{\Delta P_j}, \frac{\Delta Q_i}{\Delta M}, \ or \ \frac{\Delta Q_i}{\Delta X}$. These numbers are slope terms from a direct demand relationship. You might remember from algebra class that the slope is the rise over the run. In this case the rise is ΔQ_i and the run is $\Delta P_i, \Delta P_j, \Delta M, \ or \ \Delta X$.
2. The second number you need is the value of the demand variable in question $P_i, P_j, M, \ or \ X$.
3. The third and final number you need is the value of Q_i.

Table 3.2.1. Point formulas for demand elasticities.

Type	Formula
Own-price elasticity	$\varepsilon_{ii} = \frac{\Delta Q_i}{\Delta P_i} \times \frac{P_i}{Q_i}$
Cross-price elasticity	$\varepsilon_{ij} = \frac{\Delta Q_i}{\Delta P_j} \times \frac{P_j}{Q_i}, i \neq j$
Income elasticity	$\varepsilon_{iM} = \frac{\Delta Q_i}{\Delta M} \times \frac{M}{Q_i}$
Elasticity for other demand shift variable X	$\varepsilon_{iX} = \frac{\Delta Q_i}{\Delta X} \times \frac{X}{Q_i}$

To illustrate the implementation of the point formula, consider the following direct demand equation for good 1:

$$Q_1 = 1.5A + 0.01M + 2P_2 - 4P_1 \tag{3.2.2}$$

In this equation, Q_1 is the quantity of good 1 in thousands of units, A is advertising, M is disposable income in dollars, P_2 is the price of good 2 in dollars, and P_1 is the price of good 1 in dollars. Let us first compute the quantity demanded for the following data point: $(A^0 = 40, M^0 = 30000, \backslash(P_2^0 = 20, \ and \ P_1^0 = 60)$. Entering these values into the demand equation provides a quantity demanded of

$$Q_1^0 = 1.5 \times 40 + 0.01 \times 30000 + 2 \times 20 - 4 \times 60 = 160 \, thousand \, units \tag{3.2.3}$$

You can now use the point formula to obtain elasticity measures. These elasticities are reported in Table 3.2.2 under the heading "Data Point 0". Take some time to look at the elasticity computations. Make sure you see where each value used in the elasticity computation originates.

Now, repeat the elasticity calculation at another, slightly different data point: $(A^1 = 40, M^1 = 30000, P_2^1 = 20, \ and \ P_1^1 = 50)$. At this new data point, let us call it "Data Point 1", we get a new quantity demanded of

$Q_1^1 = 1.5 \times 40 + 0.01 \times 30000 + 2 \times 20 - 4 \times 50 = 200 \ thousand \ units$

Elasticities for this new data point are also reported in Table 3.2.2. Notice that all the point elasticities are different even though the data points themselves differ only in the value of P_1. The takeaway here is that the point formula gives an elasticity number at a specific data point and elasticities can depend on point of location along the demand equation. This is one of the reason why caution should be used when using an elasticity to forecast the effects of a large change in one of the demand variables. The elasticity values could be very different at the new point and the old.

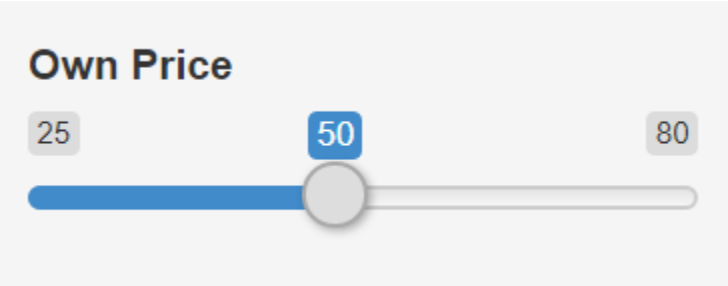
Table 3.2.2. Computing elasticities with the point formula.

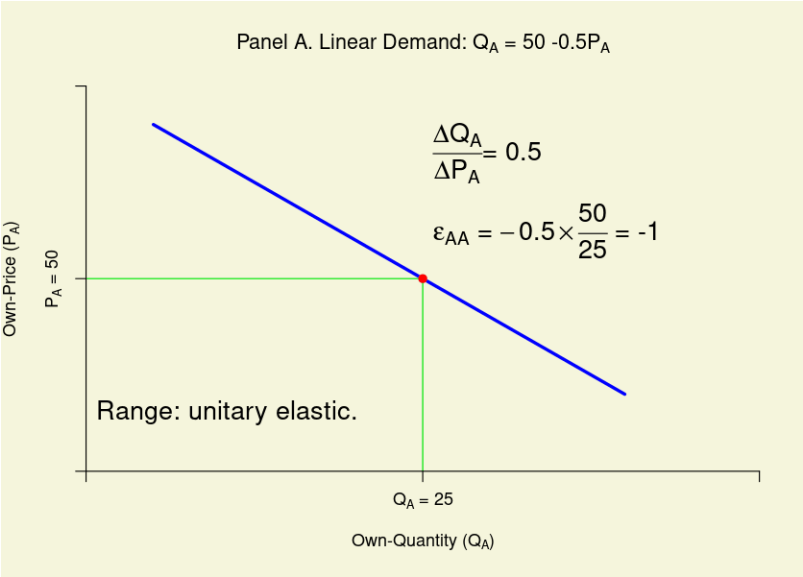
Type	Data Point 0	Data Point 1
Own-price elasticity	$\varepsilon_{11} = -4 \times \frac{60}{160} = -1.5$	$\varepsilon_{11} = -4 \times \frac{50}{200} = 1.0$
Cross-price elasticity	$\varepsilon_{12} = 2 \times \frac{20}{160} = 0.25$	$\varepsilon_{12} = 2 \times \frac{20}{200} = 0.20$
Income elasticity	$\varepsilon_{1M} = 0.01 \times \frac{30000}{160} = 1.875$	$\varepsilon_{1M} = 0.01 \times \frac{30000}{200} = 1.5$
Advertising elasticity	$\varepsilon_{1A} = 1.5 \times \frac{40}{160} = 0.375$	$\varepsilon_{1A} = 1.5 \times \frac{40}{200} = 0.30$

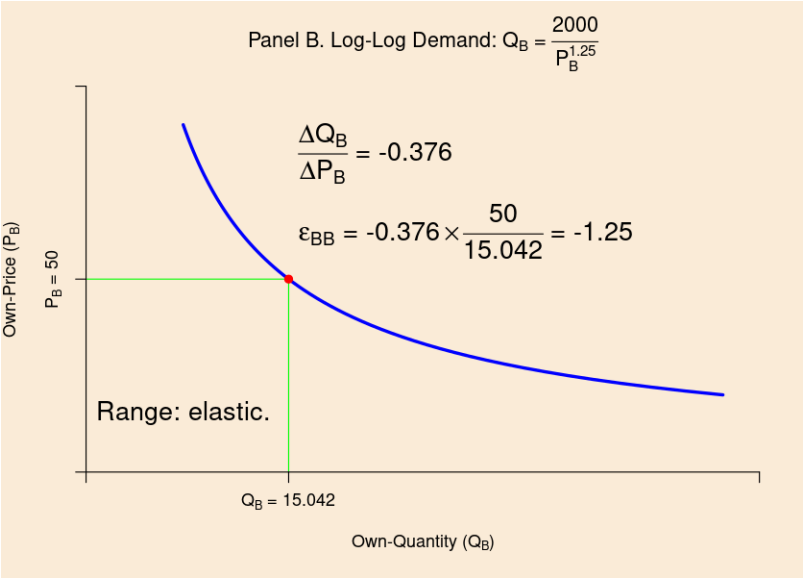
In this course, you will primarily be using linear demand specifications, such as the one we used to get the elasticity numbers in Table 3. With linear demands, the elasticity will depend on the point of location along the demand schedule. This is illustrated below in Panel A of Demonstration 3. Panel A shows that demand is elastic at high prices and inelastic at low prices.

The idea of demand being more elastic at higher prices makes intuitive sense and is probably true for most real-world cases. For instance, consumers will be more responsive when the gasoline price increases from $4.00 per gallon to $4.40 per gallon than when the gasoline price increases from $2.00 to $2.20 per gallon. In each case, there is a 10 percent increase in price, but the increase causes more pain at $4.00 than at $2.00. Nevertheless, the fact that elasticities vary along a linear demand schedule, such as that presented in Panel A of Demonstration 3.2.1, is a consequence of using a linear specification for demand.

Panel B of Demonstration 3.2.1, shows an alternative demand specification that provides a constant elasticity. This is a log-log demand specification. The term “log-log”" is used because this type of demand schedule is linear if we take its logarithmic transformation (it is linear in logarithms). With the linear demand curve, the slope does not change. In other words, $\frac{\Delta Q_1}{\Delta P_1}$ is always the same regardless of location on the demand schedule. However, as shown in Panel A of Demonstration 3.2.1, the own-price elasticity is not constant and will vary between being elastic, unitary elastic, and inelastic as we move from high to low prices. With log-log demand, the slope of the demand schedule changes as we move from high to low prices, but the elasticity is always constant.







The Arc Formula for Elasticities

An alternative formula to compute elasticities is the the arc formula. The arc formula returns the elasticity at the average of two points on the demand equation. Table 4 provides arc elasticity formulas for different demand elasticities.

Table 3.2.3. Arc formulas for demand elasticities.

Type	Formula
Own-price elasticity	$\varepsilon_{ii} = \frac{Q_i^1 - Q_i^0}{P_i^1 - P_i^0} \times \frac{P_i^1 + P_i^0}{Q_i^1 + Q_i^0}$
Cross-price elasticity	$\varepsilon_{ij} = \frac{Q_i^1 - Q_i^0}{P_j^1 - P_j^0} \times \frac{P_j^1 + P_j^0}{Q_i^1 + Q_i^0}, i \neq j$
Income elasticity	$\varepsilon_{iM} = \frac{Q_i^1 - Q_i^0}{M^1 - M^0} \times \frac{M^1 + M^0}{Q_i^1 + Q_i^0}$

Type	Formula
Elasticity for other demand shift variable X	$\varepsilon_{iX} = \frac{Q_i^1 - Q_i^0}{X^1 - X^0} \times \frac{X^1 + X^0}{Q_i^1 + Q_i^0}$

Let us compute the own-price arc elasticity over the two data points we have already considered from the demand equation above. For the own price elasticity, the two price quantity pairs are (60,160) and (50,200), respectively. Using these, the arc elasticity formula provides an elasticity at the average of these two points on the demand schedule

$$\varepsilon_{11} = \frac{200 - 160}{50 - 60} \times \frac{50 + 60}{200 + 160} = -1.22.$$

Notice that it does not matter which point is designated with a superscript 1 or superscript 0, but one must keep the points straight in the first term of the arc formula. Reverse the ordering of the points so that (60,160) is assigned the superscript 0 and (50,200) is assigned the superscript 1, you get

$$\varepsilon_{11} = \frac{160 - 200}{60 - 50} \times \frac{60 + 50}{160 + 200} = -1.22.$$

Using the point formula, you found the own-price elasticity at $(P_1 = 60, Q_1 = 160)$ to be $\varepsilon_{11} = 1.5$. At $(P_1 = 50, Q_1 = 200)$, it was $\varepsilon_{11} = -1$. The average of these two points is $(P_1 = 55, Q_1 = 180)$. Using the point formula to measure elasticity at this average point provides $\varepsilon_{11} = -1.22$, which is what was obtained from the arc formula. This should help you get some intuition about the arc formula. The arc formula provides an elasticity at the average of the two points used in its computation.

A compelling feature of the arc formula is that you only need to know two points to compute an elasticity. However, it is important to emphasize the "all else held constant" provision. In the example above, this provision was met because income, the price of good 2, and advertising were held constant. The only difference in the two data points was the price of good 1. Application of the arc formula requires you to assume that the entire change from Q_1^0 to Q_1^1 is attributable only to an observed change in P_1. In the real world, it may be hard to defend this assumption.

As an exercise, use the arc formula to replicate the elasticity ranges reported above in Demonstration 3.2.2 after you increase or decrease the price. In this case you know that all else has remained constant because you are comparing two points on the same demand schedule. There may be a small bit of rounding error in the demonstration, but the arc formula should give you something very close to the same number when you compute it from a price increase or decrease.

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3.3: Factors that Affect the Magnitude of Own Price Elasticities

Several factors affect the magnitude of the own price elasticity. Knowing these factors can help you make a determination about the likely range of an elasticity in cases where you lack the data needed to estimate it precisely.

Share of Income Devoted to the Product

As a general rule, demand will be more elastic the larger the share of the consumer's budget required to purchase the item. The rationale here is that the consumer will be more likely to shop around, wait for discounts, or delay making making large purchases until necessary. Demand tends to be more elastic because the consumer stands to capture a large dollar value of additional surplus if he or she can find a better price.

Availability of Substitutes

When substitute products are readily available, demand will be more elastic. Remember from Chapter 1 that two phenomena underpin the law of demand. First, when the price increases, consumers who continue to purchase the product will purchase less. This is a result of the law of diminishing marginal utility. Second, some consumers drop out of the market altogether because participation in this market will no longer provide them with an opportunity for positive consumer surplus at the higher price. When substitute products are readily available, the defection of consumers to lower priced alternatives becomes the driving factor and makes demand very responsive to price changes.

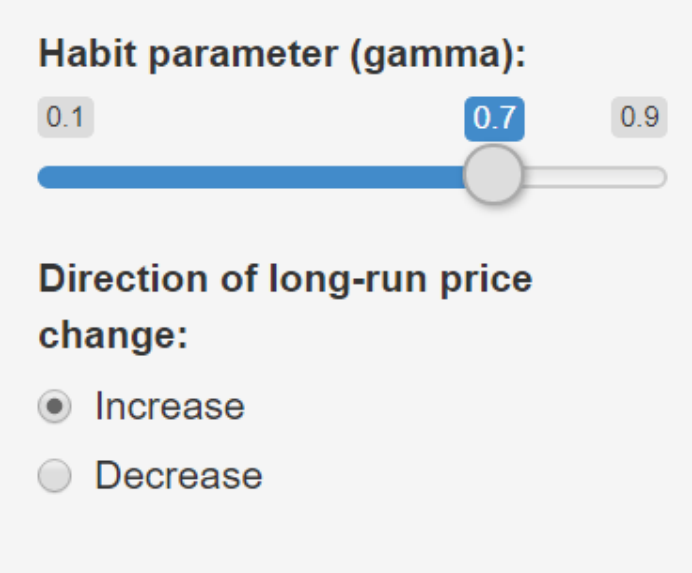
Length of Run

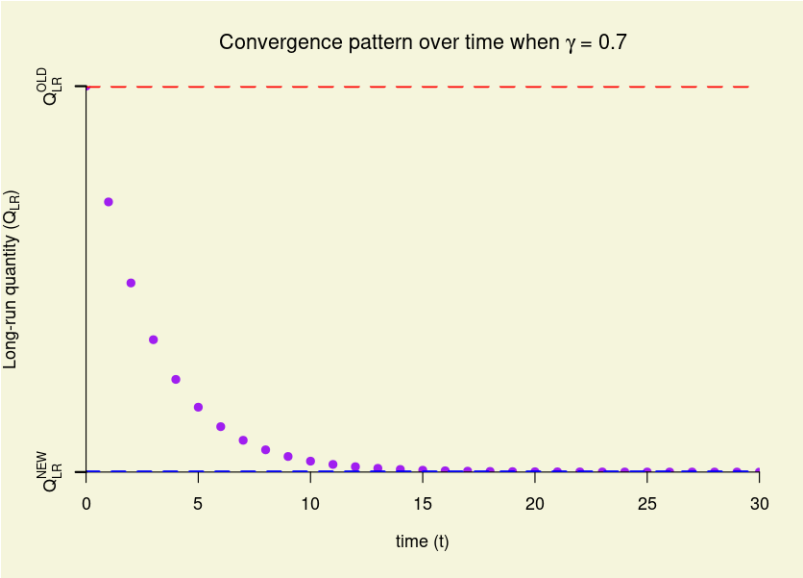
Demand will be more elastic in the long run. The rationale here is that as time passes, consumers have more opportunities to adjust their consumption behavior. One way to model demand over time is to specify quantity demanded in the current time period (period t) as a function of quantity demanded the period before (period t-1). In this case, demand in the short run can be expressed as

$$Q_1^t = \alpha + \beta P_1 + \gamma Q_1^{t-1},$$

where $\alpha > 0$, $\beta < 0$, and $0 \leq \gamma < 1$. In this equation, γ, the Greek letter gamma, is a habit parameter. As γ approaches one, habit formation is very strong and consumption in prior periods has a large impact on consumption today. Moreover, when γ is close to one, it will take many periods to converge to the new long-run demand. Demonstration $3.3.1$ is designed to help you see this. In the demonstration, you can vary the habit parameter to see the time it takes to adjust from one long-run quantity to another. When the habit parameter is small, adjustment takes place rapidly. When it is large, complete adjustment takes much longer.

Demonstration 4. The habit parameter affects the time to converge to a new point on the long-run demand schedule.



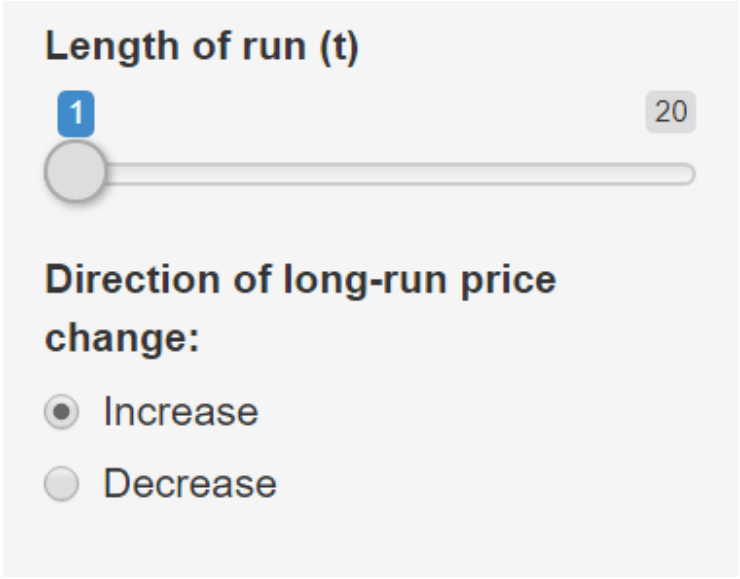


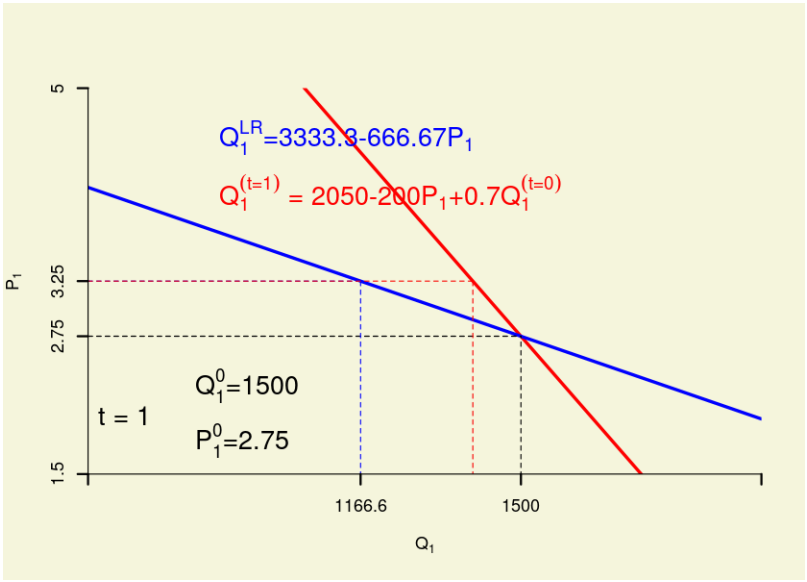
In the long-run, demand at time t will converge to demand at time $(t-1)$. With this in mind, one can set $Q_1^{LR} = Q_1^t = Q_1^{t-1}$ in the short run demand equation and solve for Q_1^{LR} to get long-run demand as

$$Q_1^{LR} = \frac{\alpha}{1-\gamma} + \frac{\beta}{1-\gamma} P_1.$$

Demonstration 3.3.2, shows the convergence process as time passes. Note that as time goes on, the effect of $Q_1^{t=0}$ becomes less and less until it disappears completely. This is an asymptotic process so you do not see complete convergence in the 20 periods represented below. Nevertheless, after 20 periods, there is very little difference between the short-run and long-run demands. You should also be able to verify from Demonstration 3.3.2 that demand is more elastic in the long run than in the short run.

Demonstration 3.3.2. Convergence to long-run demand over time.





Demand at Different Stages of the Market

Many retail food products require fixed proportions of farm products. For example, a pint of blueberries at the retail level requires a pint of blueberries from the farm. A few pints will be damaged in transit from the farm to retail and so offering a certain quantity of blueberries on the retail market may be some fixed proportion ττ of the number of pints from the farm, and ττ may not be equal to one. Nevertheless, there is a clear relationship between the quantity of the farm and retail product. If the assumption of fixed proportions applies, one can express the farm and retail product on the same quantity axis as is done below in Figure 3.3.1.

Figure 3.3.1 shows demand at the farm level and the retail level. The vertical difference between these two demand schedules represents the cost of getting the product from farm to retail. In the case of blueberries, these costs would include things like shipping and stocking. If these costs are independent of the quantity of the farm product being offered for sale at retail, the farm-to-retail markup will be constant. This means that the farm demand will be parallel to the retail demand. This is also shown below in Figure 3.3.1.

What does any of this have to do with elasticity? Well, it can be shown that under certain conditions, the farm demand will be less elastic than the retail demand. Note that the farm and retail demand schedules have the same slope. Let $\beta < 0$ represent this

slope. Also note that $Q_1^{Farm} = \tau Q_1^{Retail}$. Using the point formula one can see that $0 > \beta \times \frac{P_1^{Farm}}{Q_1^{Farm}} > \beta \times \frac{P_1^{Retail}}{\tau Q_1^{Retail}}$.

In other words, $0 > \varepsilon_{11}^{Farm} > \varepsilon_{11}^{Retail}$ farm demand is less elastic than retail demand.

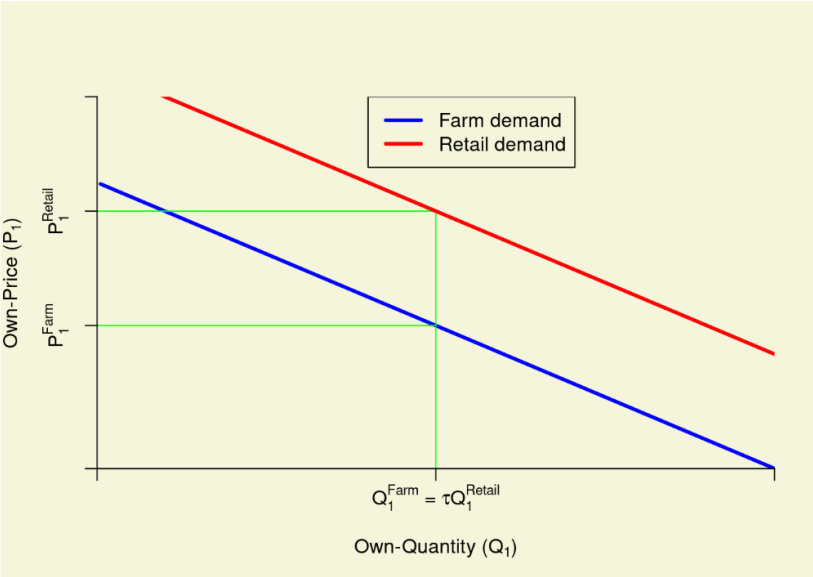


Figure 3.3.1: **Elasticity at different points in the supply chain.**

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3.4: Elasticities of Supply

Once you have learned about elasticities on the demand side of the market, it is easy to translate the same concepts over to the supply side. In this course the convention will be to use the symbol ϕ (the Greek letter phi) to refer to supply elasticities. Again, subscripts will be used in exactly the same fashion as above for demand elasticities. Moreover, the interpretation of supply elasticities is no different than demand elasticities. For example, the own-price elasticity of supply is defined as

$$\phi_{ii} = \frac{\%\Delta Q_i}{\%\Delta P_i}. \tag{3.4.1}$$

The difference is that Q_i is the quantity supplied, making this a supply elasticity as opposed to a demand elasticity.

Ranges for Supply Elasticities

Table 3.4.1 presents some magnitude-based classifications for supply elasticities. Fortunately, there is less to remember about ranges for supply elasticities. The own-price elasticity of supply is always non-negative. This reflects the law of supply. Again, the magnitude of the elasticity shows the responsiveness of quantity supplied to changes in the own-price, and it sometimes makes sense to talk about supply being elastic, unitary elastic, or inelastic. However, the non-negative own-price effect means that revenue to the producing industry always increases as price increases along the supply schedule, regardless of whether supply is responsive (elastic) or unresponsive (inelastic). The sign of the cross-price elasticities will depend on whether the related product in question is a competing product or whether it is a joint product. Finally, economic theory dictates that input price elasticities will be non-positive. If the price of an input used in production increases, the marginal cost of production increases. As explained in Chapter 2, this causes the market supply curve to shift inwards.

Table 3.4.1: Classifications based on magnitude of elasticity of supply

Type	Range	Implication
Own-price	$\phi_{ii} > 1$	Supply for good i is elastic
Own-price	$\phi_{ii} = 1$	Supply for good i is unitary elastic
Own-price	$0 \leq \phi_{ii} < 1$	Supply for good i is inelastic
Cross-price	$\phi_{ij} > 0, i \neq j$	Good j is a joint product for good i
Cross-price	$\phi_{ij} < 0, i \neq j$	Good j is a competing product for good i
Input price	$\phi_{iW} \leq 0$	Input price elasticities are non-positive

Calculating Supply Elasticities

The point and arc formulas presented in Table 3.4.2 are nearly identical to those learned for above for the case of demand. The only difference is that quantities supplied are being used in the computations instead of quantities demanded. Again, it is important to emphasize the "all else held constant" provision when using an arc formula. For example, if you are computing an own-price elasticity of supply using the arc formula, you must be confident that the values of any other variables that could shift supply have not changed.

Table 3.4.2. Point and arc formulas for supply elasticities

Type	Point Formula	Arc Formula
Own-price elasticity	$\phi_{ii} = \frac{\Delta Q_i}{\Delta P_i} \times \frac{P_i}{Q_i}$	$\phi_{ii} = \frac{Q_i^1 - Q_i^0}{P_i^1 - P_i^0} \times \frac{P_i^1 + P_i^0}{Q_i^1 + Q_i^0}$
Cross-price elasticity	$\phi_{ij} = \frac{\Delta Q_i}{\Delta P_j} \times \frac{P_j}{Q_i}, i \neq j$	$\phi_{ij} = \frac{Q_i^1 - Q_i^0}{P_j^1 - P_j^0} \times \frac{P_j^1 + P_j^0}{Q_i^1 + Q_i^0}, i \neq j$
Input-price elasticity	$\phi_{iW} = \frac{\Delta Q_i}{\Delta W} \times \frac{W}{Q_i}$	$\phi_{iW} = \frac{Q_i^1 - Q_i^0}{W^1 - W^0} \times \frac{W^1 + W^0}{Q_i^1 + Q_i^0}$

Type	Point Formula	Arc Formula
Elasticity for other supply shift variable Z	$\phi_{iZ} = \frac{\Delta Q_i}{\Delta Z} \times \frac{Z}{Q_i}$	$\varepsilon_{iZ} = \frac{Q_i^1 - Q_i^0}{Z^1 - Z^0} \times \frac{Z^1 + Z^0}{Q_i^1 + Q_i^0}$

Special Cases for Supply Elasticities

It will sometimes be useful to assume that supply is perfectly elastic or that supply is perfectly inelastic. An inverse supply curve with a slope of zero (a horizontal line) corresponds to perfectly elastic supply. What this means is that any quantity can be purchased at the prevailing market price. At first look, this makes absolutely no sense. However, this assumption is appropriate in certain contexts, usually in the case of a buyer who faces a perfectly elastic supply for a product or service. For example, trucking is an important service provided to blackberry marketers. The popularity of blackberries has grown in recent years, so more blackberries are being grown and shipped. The assumption that the blackberry industry faces a perfectly elastic supply for trucking is probably reasonable. Although blackberries shipments have grown, blackberries account for a tiny portion of trucking volume. The fact that more blackberries now need to be shipped has probably not materially affected freight rates. In other words, blackberry marketers can ship all they want at the going rates. As a matter of fact, this assumptions was reflected earlier in Figure 1. By drawing the farm and retail demand schedules parallel to each other, the implicit assumption was that firms in this industry faced a perfectly elastic supply of marketing inputs, the inputs needed to get products from the farm to the consumer.

An inverse supply curve with an infinite slope (a vertical line) corresponds to perfectly inelastic supply. This means that regardless of the price, the quantity supplied is fixed. This assumption may be reasonable in some short to intermediate run contexts in agriculture, especially when we are dealing with fresh and non-storable commodities coupled with production lags. However, it is very important to be careful with this assumption. Just because there is a fixed stock of a certain product does not mean that the supply for that product is perfectly inelastic. Consider, for example, the supply of van Gogh paintings. Van Gogh died in 1890. Consequently, there will never be another van Gogh painting, unless some heretofore unknown paintings turn up in a vault somewhere. Nevertheless, that does not mean the supply of van Gogh paintings is perfectly inelastic. As the prices of van Gogh paintings rise, art collectors and museums are more likely to offer the van Gogh paintings in their collections up for sale and we would expect more Van Gogh paintings to be placed on the market at higher prices and less at lower.

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3.5: Concluding Comments

To this point in the course, you have learned important concepts related to the demand and supply side of the market. The elasticities covered in this chapter reinforce these concepts. Moreover, they allow questions such as those posed in the introductory section to the chapter to be answered with much more precision. Problem sets 2 and 3 represent plausible business decisions that can be answered with elasticities. In problem set 2, you are asked whether you should increase price by a given amount. In problem set 3, you will need to use an advertising elasticity to determine whether to increase advertising expenditures. Later, you will learn that provided you have a precise estimates of demand elasticities, you can answer these types of question much more accurately. In fact, if you have a good estimate of the elasticity of demand facing the firm, you can calculate the actual price that maximizes profits. This will be addressed further in Chapter 7.

In the next chapter, you will put elasticities to work in earnest. Elasticities will be used in models of equilibrium to understand and estimate how markets respond to shocks to demand or supply. You know about demand and you know about supply. It is time to put them together to understand markets. This is the topic of Chapter 4.

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3.6: Problem Sets

Problem Set 1: Use the Point Formula for Demand Elasticities.

Exercise 3.6.1

Given the following:

The demand equation is:$Q_1 = 150 - 2P_1 - 1.5P_2 + 0.1M$

$P_1 = 20$

$P_2 = 30$

$M = 100$

Calculate$\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.2

Given the following:

The demand equation is:$Q_1 = 75 - 2.5P_1 - 0.5P_2 + 0.5M$

$P_1 = 30$

$P_2 = 40$

$M = 200$

Calculate$\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.3

Given the following:

The demand equation is:$Q_1 = 150 - 3P_1 + 0.5P_2 - 0.5M$

$P_1 = 40$

$P_2 = 50$

$M = 300$

Calculate$\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.4

Given the following:

The demand equation is:$Q_1 = 100 - 2P_1 + 1.5P_2 - 0.2M$

$P_1 = 50$

$P_2 = 40$

$M = 200$

Calculate$\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.5

Given the following:

The demand equation is:$Q_1 = 90 - 2.5P_1 - 0.5P_2 + 0.5M$

$P_1 = 30$

$P_2 = 40$

$M = 200$

Calculate$\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.6

Given the following:

The demand equation is: $Q_1 = 170 - 2.5P_1 - 1.5P_2 + 0.1M$

$P_1 = 40$

$P_2 = 30$

$M = 100$

Calculate $\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.7

Given the following:

The demand equation is: $Q_1 = 100 - 3P_1 - 0.5P_2 + 0.5M$

$P_1 = 40$

$P_2 = 20$

$M = 300$

Calculate $\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.8

Given the following:

The demand equation is: $Q_1 = 200 - 2P_1 + 0.5P_2 - 0.1M$

$P_1 = 20$

$P_2 = 10$

$M = 200$

Calculate$\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.9

Given the following:

The demand equation is:$Q_1 = 200 - 2.5P_1 + 1.5P_2 - 0.5M$

$P_1 = 10$

$P_2 = 20$

$M = 100$

Calculate$\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Exercise 3.6.10

Given the following:

The demand equation is:$Q_1 = 60 - 3P_1 + 1P_2 + 0.1M$

$P_1 = 20$

$P_2 = 30$

$M = 300$

Calculate$\varepsilon_{11}, \varepsilon_{12}, \varepsilon_{1M}$

Is demand for Good 1 inelastic, unitary elastic, or elastic?

Is Good 2 a substitute or complement to good 1?

Is Good 1 inferior, a normal necessity, or a normal luxury?

Answer available at the end of this section.

Problem Set 2: Use Elasticities to Determine Whether to Increase Price.

Exercise 3.6.1

Given the following:

Your current quantity is 1000 units.

Your current price is 25 dollars.

Your average variable cost is 15 dollars per unit.

You face an own-price demand elasticity of -3.

What will happen to profit above variable cost if you raise your price by 2 dollars?

Answer available at the end of this section.

Exercise 3.6.2

Given the following:

Your current quantity is 1100 units.

Your current price is 40 dollars.

Your average variable cost is 36 dollars per unit.

You face an own-price demand elasticity of -4.

What will happen to profit above variable cost if you raise your price by 1 dollars?

Answer available at the end of this section.

Exercise 3.6.3

Given the following:

Your current quantity is 1120 units.

Your current price is 50 dollars.

Your average variable cost is 40 dollars per unit.

You face an own-price demand elasticity of -5.

What will happen to profit above variable cost if you raise your price by 2 dollars?

Answer available at the end of this section.

Exercise 3.6.4

Given the following:

Your current quantity is 1200 units.

Your current price is 20 dollars.

Your average variable cost is 16 dollars per unit.

You face an own-price demand elasticity of -4.

What will happen to profit above variable cost if you raise your price by 1 dollars?

Answer available at the end of this section.

Exercise 3.6.5

Given the following:

Your current quantity is 1300 units.

Your current price is 50 dollars.

Your average variable cost is 40 dollars per unit.

You face an own-price demand elasticity of -1.5.

What will happen to profit above variable cost if you raise your price by 1 dollars?

Answer available at the end of this section.

Exercise 3.6.6

Given the following:

Your current quantity is 1200 units.

Your current price is 20 dollars.

Your average variable cost is 16 dollars per unit.

You face an own-price demand elasticity of -0.75.

What will happen to profit above variable cost if you raise your price by 2 dollars?

Answer available at the end of this section.

Exercise 3.6.7

Given the following:

Your current quantity is 1120 units.

Your current price is 50 dollars.

Your average variable cost is 46 dollars per unit.

You face an own-price demand elasticity of -1.

What will happen to profit above variable cost if you raise your price by 1 dollars?

Answer available at the end of this section.

Exercise 3.6.8

Given the following:

Your current quantity is 1200 units.

Your current price is 25 dollars.

Your average variable cost is 21 dollars per unit.

You face an own-price demand elasticity of -5.

What will happen to profit above variable cost if you raise your price by 1 dollars?

Answer available at the end of this section.

Exercise 3.6.9

Given the following:

Your current quantity is 1050 units.

Your current price is 50 dollars.

Your average variable cost is 40 dollars per unit.

You face an own-price demand elasticity of -5.5.

What will happen to profit above variable cost if you raise your price by 2 dollars?

Answer available at the end of this section.

Exercise 3.6.10

Given the following:

Your current quantity is 1000 units.

Your current price is 25 dollars.

Your average variable cost is 21 dollars per unit.

You face an own-price demand elasticity of -4.5.

What will happen to profit above variable cost if you raise your price by 1 dollars?

Answer available at the end of this section.

Problem Set 3: Use Elasticities to Determine Whether to Increase Advertising.

Exercise 3.6.1

Given the following:

Your current quantity is 1000 units.

Your price is 25 dollars.

Your average variable cost (AVC) is 15 dollars per unit.

Your elasticity of demand with respect to advertising is 0.4.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 200 dollars?

Answer available at the end of this section.

Exercise 3.6.2

Given the following:

Your current quantity is 2000 units.

Your price is 40 dollars.

Your average variable cost (AVC) is 36 dollars per unit.

Your elasticity of demand with respect to advertising is 0.5.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 300 dollars?

Answer available at the end of this section.

Exercise 3.6.3

Given the following:

Your current quantity is 1500 units.

Your price is 50 dollars.

Your average variable cost (AVC) is 40 dollars per unit.

Your elasticity of demand with respect to advertising is 0.6.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 400 dollars?

Answer available at the end of this section.

Exercise 3.6.4

Given the following:

Your current quantity is 1200 units.

Your price is 20 dollars.

Your average variable cost (AVC) is 16 dollars per unit.

Your elasticity of demand with respect to advertising is 0.5.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 250 dollars?

Answer available at the end of this section.

Exercise 3.6.5

Given the following:

Your current quantity is 1300 units.

Your price is 50 dollars.

Your average variable cost (AVC) is 40 dollars per unit.

Your elasticity of demand with respect to advertising is 1.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 200 dollars?

Answer available at the end of this section.

Exercise 3.6.6

Given the following:

Your current quantity is 2000 units.

Your price is 20 dollars.

Your average variable cost (AVC) is 16 dollars per unit.

Your elasticity of demand with respect to advertising is 1.5.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 300 dollars?

Answer available at the end of this section.

Exercise 3.6.7

Given the following:

Your current quantity is 1500 units.

Your price is 50 dollars.

Your average variable cost (AVC) is 46 dollars per unit.

Your elasticity of demand with respect to advertising is 0.4.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 400 dollars?

Answer available at the end of this section.

Exercise 3.6.8

Given the following:

Your current quantity is 1200 units.

Your price is 25 dollars.

Your average variable cost (AVC) is 21 dollars per unit.

Your elasticity of demand with respect to advertising is 0.5.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 250 dollars?

Answer available at the end of this section.

Exercise 3.6.9

Given the following:

Your current quantity is 2000 units.

Your price is 50 dollars.

Your average variable cost (AVC) is 40 dollars per unit.

Your elasticity of demand with respect to advertising is 2.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 200 dollars?

Answer available at the end of this section.

Exercise 3.6.10

Given the following:

Your current quantity is 1000 units.

Your price is 25 dollars.

Your average variable cost (AVC) is 21 dollars per unit.

Your elasticity of demand with respect to advertising is 1.5.

Your current advertising expenditure is $5,000 and is your only fixed cost.

What will happen to profit if you increase advertising by 300 dollars?

Answer available at the end of this section.

Problem Set 4: Short-Run and Long-Run Elasticities.

Exercise 3.6.1

Given the following:

The short run demand equation is:

$\text{The short run demand equation is:} Q_1^{(t)} = 100 - 2P_1 + 0.5Q_1^{(t-1)}$

$P_1 = 35$

$Q_1^{(t-1)} = 60$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Exercise 3.6.2

Given the following:

$\text{The short run demand equation is:} Q_1^{(t)} = 100 - 3P_1 + 0.6Q_1^{(t-1)}$

$P_1 = 20$

$Q_1^{(t-1)} = 100$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Exercise 3.6.3

Given the following:

The short run demand equation is:$Q_1^{(t)} = 150 - 4P_1 + 0.75Q_1^{(t-1)}$

$P_1 = 20$

$Q_1^{(t-1)} = 280$

Answer available at the end of this section.

Exercise 3.6.4

Given the following:

The short run demand equation is:$Q_1^{(t)} = 250 - 4P_1 + 0.8Q_1^{(t-1)}$

$P_1 = 40$

$Q_1^{(t-1)} = 450$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Exercise 3.6.5

Given the following:

The short run demand equation is:$Q_1^{(t)} = 120 - 2P_1 + 0.6Q_1^{(t-1)}$

$P_1 = 40$

$Q_1^{(t-1)} = 100$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Exercise 3.6.6

Given the following:

The short run demand equation is:$Q_1^{(t)} = 150 - 3P_1 + 0.8Q_1^{(t-1)}$

$P_1 = 30$

$Q_1^{(t-1)} = 300$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Exercise 3.6.7

Given the following:

The short run demand equation is:$Q_1^{(t)} = 200 - 3P_1 + 0.75Q_1^{(t-1)}$

$P_1 = 45$

$Q_1^{(t-1)} = 260$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Exercise 3.6.8

Given the following:

The short run demand equation is:$Q_1^{(t)} = 80 - 2P_1 + 0.6Q_1^{(t-1)}$

$P_1 = 30$

$Q_1^{(t-1)} = 50$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Exercise 3.6.9

Given the following:

The short run demand equation is:$Q_1^{(t)} = 120 - 3P_1 + 0.5Q_1^{(t-1)}$

$P_1 = 30$

$Q_1^{(t-1)} = 60$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Exercise 3.6.10

Given the following:

The short run demand equation is:$Q_1^{(t)} = 100 - 2P_1 + 0.5Q_1^{(t-1)}$

$P_1 = 40$

$Q_1^{(t-1)} = 40$

What is the habit parameter?

What is the long-run demand equation?

What is the short-run own-price elasticity of demand?

What is the long-run own-price elasticity of demand?

When is demand more elastic, in the short- or long-run?

Answer available at the end of this section.

Problem Set 5: Multiple Choice.

Exercise 3.6.1

1. **When is demand unitary elastic?**

a) When the income elasticity is 1.

b) When the own-price elasticity of demand is -1.

c) When demand is totally unresponsive (inverse demand is a vertical line).

d) All of the above.

Answer available at the end of this section.

Exercise 3.6.2

2. **If price goes up by 4 percent and quantity demanded falls by 2 percent then**

a) This is a substitute good.

b) This good has an elastic demand.

c) This good is an inferior good.

d) This good has an inelastic demand.

Answer available at the end of this section.

Exercise 3.6.3

3. **Suppose that the own-price elasticity of demand is -1. Which statement is true?**

a) Profits are maximized.

b) Revenue is maximized.

c) Consumer surplus is maximized.

d) All of the above.

Answer available at the end of this section.

Exercise 3.6.4

4. **Suppose the own-price elasticity of demand is -0.75. Which statement is true?**

a) An increase in price will decrease revenue.

b) An increase in price will increase revenue.

c) The good in question is a substitute in consumption.

d) The good in question is an inferior good.

Answer available at the end of this section.

Exercise 3.6.5

5. **Which of the following elasticity numbers is consistent with a normal good?**

a) An income elasticity of demand that is -0.5.

b) An income elasticity of demand that is 0.5.

c) An own-price elasticity of 0.28.

d) Both a and c.

Answer available at the end of this section.

Exercise 3.6.6

6. **If an increase in income causes an increase in demand, then we know that**

a) The good in question is a normal luxury good.

b) The good in question is a normal necessity good.

c) The good in question is a normal good but we can't tell whether it is classified as a necessity or a luxury without further information.

d) The good in question violates the law of demand.

Answer available at the end of this section.

Exercise 3.6.7

7. **Which demand elasticity number tells you that two products are substitutes in consumption?**

a) A cross-price elasticity of -0.5.

b) A cross-price elasticity of 0.5.

c) An income elasticity of 1.5.

d) An own-price elasticity of -0.75.

Answer available at the end of this section.

Exercise 3.6.8

8. **One problem with using the arc elasticity formula to compute an own-price elasticity is:**

a) It is very hard to compute because you need lots of data points.

b) Actually, there are no problems with using the arc formula to compute elasticities.

c) One must assume that all other factors that affect demand, other than own price, remain the same.

d) If demand has not shifted, the arc formula will often return a positive value for the own-price elasticity.

Answer available at the end of this section.

Exercise 3.6.9

9. **Given that a firm has some control over the price it charges (it is not a price taker) and it faces a positive marginal cost, which case would be consistent with profit maximization?**

a) It sets its price to make demand inelastic.

b) It sets its price to make demand elastic.

c) It sets its price to make demand unitary elastic.

d) It sets its price so that both demand and supply are in the inelastic range.

Answer available at the end of this section.

Exercise 3.6.10

10. **As described in class, the supply schedule for van Gogh paintings:**

a) Is perfectly inelastic.

b) Is downward sloping.

c) Maybe quite inelastic but is probably not perfectly inelastic.

d) Is a horizontal line.

e) Choices a and d only.

Answer available at the end of this section.

Exercise 3.6.11

11. **Other things equal, in the long run**

a) Demand is less elastic than in the short run.

b) Supply is less elastic than in the short run.

c) Demand is more elastic than in the short run.

d) Both demand and supply are less elastic than in the short run.

Answer available at the end of this section.

Exercise 3.6.12

12. **Which best describes the concept of elasticity?**

a) The responsiveness of demand or supply to own-price or some other shift variable.

b) The idea that demand schedules always slope downwards.

c) The idea that consumer surplus is the area under the demand schedule.

d) The idea that supply schedules always have non-negative slopes.

Answer available at the end of this section.

Answers

Exercise 3.6.1

$\varepsilon_{11} = -0.53$
$\varepsilon_{12} = -0.6$
$\varepsilon_{1M} = 0.13$
Inelastic
Complement
Normal necessity

Exercise 3.6.2

$\varepsilon_{11} = -0.94$
$\varepsilon_{12} = -0.25$
$\varepsilon_{1M} = 1.25$
Inelastic
Complement
Normal luxury

Exercise 3.6.3

$\varepsilon_{11} = -4.8$
$\varepsilon_{12} = 1$
$\varepsilon_{1M} = -1.2$
Elastic
Substitute
Inferior

Exercise 3.6.4

$\varepsilon_{11} = -5$
$\varepsilon_{12} = 3$
$\varepsilon_{1M} = -2$
Elastic
Substitute
Inferior

Exercise 3.6.5

$\varepsilon_{11} = -0.79$
$\varepsilon_{12} = -0.21$
$\varepsilon_{1M} = 1.05$
Inelastic
Complement
Normal luxury

Exercise 3.6.6

$\varepsilon_{11} = -2.86$
$\varepsilon_{12} = -1.29$
$\varepsilon_{1M} = 0.29$
Elastic
Complement
Normal necessity

Exercise 3.6.7

Answers:
$\varepsilon_{11} = -1$
$\varepsilon_{12} = -0.08$
$\varepsilon_{1M} = 1.25$
Unitary elastic
Complement
Normal luxury

Exercise 3.6.8

$\varepsilon_{11} = -0.28$
$\varepsilon_{12} = -0.03$
$\varepsilon_{1M} = -0.14$
Inelastic
Substitute
Inferior

Exercise 3.6.9
$\varepsilon_{11} = -0.16$
$\varepsilon_{12} = -0.19$
$\varepsilon_{1M} = -0.32$
Inelastic
Substitute
Inferior

Exercise 3.6.10
$\varepsilon_{11} = -1$
$\varepsilon_{12} = -0.5$
$\varepsilon_{1M} = -0.5$
Unitary elastic
Substitute
Normal necessity

Exercise 3.6.1
Your current profit above variable cost is 10000 dollars.
Your price will change by 8 percent.
Your new quantity is 760 units.
If you raise price, the profit above variable cost will be 9120 dollars.

Exercise 3.6.2
Your current profit above variable cost is 4400 dollars.
Your price will change by 2.5 percent.
Your new quantity is 990 units.
If you raise price, the profit above variable cost will be 4950 dollars.

Exercise 3.6.3
Your current profit above variable cost is 11200 dollars.
Your price will change by 4 percent.
Your new quantity is 896 units.
If you raise price, the profit above variable cost will be 10752 dollars.

Exercise 3.6.4
Your current profit above variable cost is 4800 dollars.
Your price will change by 5 percent.
Your new quantity is 960 units.
If you raise price, the profit above variable cost will be 4800 dollars.

Exercise 3.6.5
Your current profit above variable cost is 13000 dollars.
Your price will change by 2 percent.
Your new quantity is 1261 units.
If you raise price, the profit above variable cost will be 13871 dollars.

Exercise 3.6.6
Your current profit above variable cost is 4800 dollars.
Your price will change by 10 percent.
Your new quantity is 1110 units.
If you raise price, the profit above variable cost will be 6660 dollars.

Exercise 3.6.7
Your current profit above variable cost is 4480 dollars.
Your price will change by 2 percent.
Your new quantity is 1097.6 units.
If you raise price, the profit above variable cost will be 5488 dollars.

Exercise 3.6.8
Your current profit above variable cost is 4800 dollars.
Your price will change by 4 percent.
Your new quantity is 960 units.
If you raise price, the profit above variable cost will be 4800 dollars.

Exercise 3.6.9

Your current profit above variable cost is 10500 dollars.
Your price will change by 4 percent.
Your new quantity is 819 units.
If you raise price, the profit above variable cost will be 9828 dollars.

Exercise 3.6.10

Your current profit above variable cost is 4000 dollars.
Your price will change by 4 percent.
Your new quantity is 820 units.
If you raise price, the profit above variable cost will be 4100 dollars.

Exercise 3.6.1

Your current profit is 5000 dollars.
Your advertising will change by 4 percent.
Your new quantity is 1016 units.
Profit will go down to 4960 dollars (after subtracting the increse in advertising).

Exercise 3.6.2

Your current profit is 3000 dollars.
Your advertising will change by 6 percent.
Your new quantity is 2060 units.
Profit will go down to 2940 dollars (after subtracting the increse in advertising).

Exercise 3.6.3

Your current profit is 10000 dollars.
Your advertising will change by 8 percent.
Your new quantity is 1572 units.
Profit will go up to 10320 dollars (after subtracting the increse in advertising).

Exercise 3.6.4

Your current profit is -200 dollars.
Your advertising will change by 5 percent.
Your new quantity is 1230 units.
Profit will go down to -330 dollars (after subtracting the increse in advertising).

Exercise 3.6.5

Your current profit is 8000 dollars.
Your advertising will change by 4 percent.
Your new quantity is 1352 units.
Profit will go up to 8320 dollars (after subtracting the increse in advertising).

Exercise 3.6.6

Your current profit is 3000 dollars.
Your advertising will change by 6 percent.
Your new quantity is 2180 units.
Profit will go up to 3420 dollars (after subtracting the increse in advertising).

Exercise 3.6.7

Your current profit is 1000 dollars.
Your advertising will change by 8 percent.
Your new quantity is 1548 units.
Profit will go down to 792 dollars (after subtracting the increse in advertising).

Exercise 3.6.8

Your current profit is -200 dollars.
Your advertising will change by 5 percent.
Your new quantity is 1230 units.
Profit will go down to -330 dollars (after subtracting the increse in advertising).

Exercise 3.6.9

Your current profit is 15000 dollars.
Your advertising will change by 4 percent.
Your new quantity is 2160 units.
Profit will go up to 16400 dollars (after subtracting the increse in advertising).

Exercise 3.6.10

Your current profit is -1000 dollars.
Your advertising will change by 6 percent.
Your new quantity is 1090 units.
Profit will go up to -940 dollars (after subtracting the increse in advertising).

Exercise 3.6.1

Habit parameter : $\gamma = 0.5$

$Q_1^{LR} = 200 - 4P_1$

$\varepsilon_{11}^{SR} = -1.17$

$\varepsilon_{11}^{LR} = -2.33$

In the long-run.

Exercise 3.6.2

Habit parameter : $\gamma = 0.6$

$Q_1^{LR} = 250 - 7.5P_1$

$\varepsilon_{11}^{SR} = -0.6$

$\varepsilon_{11}^{LR} = -1.5$

In the long-run.

Exercise 3.6.3

Habit parameter : $\gamma = 0.75$

$Q_1^{LR} = 600 - 16P_1$

$\varepsilon_{11}^{SR} = -0.29$

$\varepsilon_{11}^{LR} = -1.14$

In the long-run.

Exercise 3.6.4

Habit parameter : $\gamma = 0.8$

$Q_1^{LR} = 1250 - 20P_1$

$\varepsilon_{11}^{SR} = -0.36$

$\varepsilon_{11}^{LR} = -1.78$

In the long-run.

Exercise 3.6.5

Habit parameter : $\gamma = 0.6$

$Q_1^{LR} = 300 - 5P_1$

$\varepsilon_{11}^{SR} = -0.8$

$\varepsilon_{11}^{LR} = -2$

In the long-run.

Exercise 3.6.6

Habit parameter : $\gamma = 0.8$

$Q_1^{LR} = 750 - 15P_1$

$\varepsilon_{11}^{SR} = -0.3$

$\varepsilon_{11}^{LR} = -1.5$

In the long-run.

Exercise 3.6.7

Habit parameter : $\gamma = 0.75$

$Q_1^{LR} = 800 - 12P_1$

$\varepsilon_{11}^{SR} = -0.52$

$\varepsilon_{11}^{LR} = -2.08$

In the long-run.

Exercise 3.6.8

Habit parameter : $\gamma = 0.6$

$Q_1^{LR} = 200 - 5P_1$

$\varepsilon_{11}^{SR} = -1.2$

$\varepsilon_{11}^{LR} = -3$

In the long-run.

Exercise 3.6.9

Habit parameter : $\gamma = 0.5$

$Q_1^{LR} = 240 - 6P_1$

$\varepsilon_{11}^{SR} = -1.5$

$\varepsilon_{11}^{LR} = -3$

In the long-run.

Exercise 3.6.10

Habit parameter : $\gamma = 0.5$

$Q_1^{LR} = 200 - 4P_1$

$\varepsilon_{11}^{SR} = -2$

$\varepsilon_{11}^{LR} = -4$

In the long-run.

Exercise 3.6.1
b

Exercise 3.6.2
d

Exercise 3.6.3
b

Exercise 3.6.4
b

Exercise 3.6.5
b

Exercise 3.6.6
c

Exercise 3.6.7
b

Exercise 3.6.8
c

Exercise 3.6.9
b

Exercise 3.6.10
c

Exercise 3.6.11
c

Exercise 3.6.12
a

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4: MARKET EQUILIBRIUM AND MODELING

Learning Objectives

- Identify an equilibrium in a single market given a supply equation and a demand equation.
- Distinguish between exogenous and endogenous variables.
- Predict the impact of a change in an exogenous variable on the equilibrium price and quantity in a single market.
- Use elasticities to model the impact of an exogenous shock on a market equilibrium.
- Calculate exogenous demand and supply shocks using elasticities. Use these shocks to model changes to an equilibrium.
- Distinguish between partial equilibrium models and general equilibrium models.
- Explain feedback from one market to another within a general equilibrium model.

In this chapter you will use material learned earlier in the course to be better understand price determination and the behavior of markets. The chapter starts with a general overview of an equilibrium for a single market and then moves on to a basic framework for predicting the effect of a shock to either the demand or supply side of the market on the equilibrium price and quantity. In most real-world modeling exercises, elasticities are used to characterize an equilibrium in percentage change form. These models are often called “equilibrium displacement models” and are the topic of the second section of the chapter. Again, the emphasis will first be on a single market to keep things simple. The third and fourth sections of the chapter extend the framework to examine the effects of a shock on multiple markets simultaneously. This provides a more realistic treatment of actual markets because a shock to one market will generally reverberate through other related markets. Feedback from these related markets will amplify or diminish the effect in the market experiencing the initial shock. The specific learning objectives for this chapter are as follows:

4.1: Market Equilibrium

4.2: Using Elasticities to Model an Equilibrium

4.3: Markets - Supply and Demand

4.4: Partial vs. General Equilibrium Models

4.5: Finding Solutions in Equilibrium Models with Multiple Markets

4.6: Concluding Comments

4.7: References

4.8: Problem Sets

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4.1: Market Equilibrium

In a market, demand and supply come together to determine the price and quantity of a product. A market is said to be in equilibrium when the prevailing price causes the quantity supplied to equal the quantity demanded. The term equilibrium suggests a point of stability. Because supply equals demand at an equilibrium, there is no reason for consumers to bid prices up through unmet requests for the product nor is their a reason for producers to bid prices down because of untaken offers of the product. Price is, in this respect, stable.

Consider an example involving a single market. Suppose that the demand for good 1 is given by

$$Q_1^D = 100 - \frac{1}{2}P_1 + D,$$

where Q_1^D is quantity demanded, P_1 is price, and D is a demand shock. D can be positive, negative, or zero.

Next, suppose that supply for good 1 is given by

$$Q_1^S = -20 + P_1 + S,$$

where Q_1^S is quantity supplied and S is a supply shock. Again, S can be positive, negative, or zero.

To find the equilibrium price, set $Q_1^S = Q_1^D$ and solve for P_1 as follows:

$$-20 + P_1 + S = 100 - \frac{1}{2}P_1 + D \Rightarrow P_1 = 80 + \frac{2}{3}(D - S).$$

Next, substitute this solution for P_1 into the supply or the demand equation. If the solution for P_1 is correct, you will get the same quantity regardless of which equation you use:

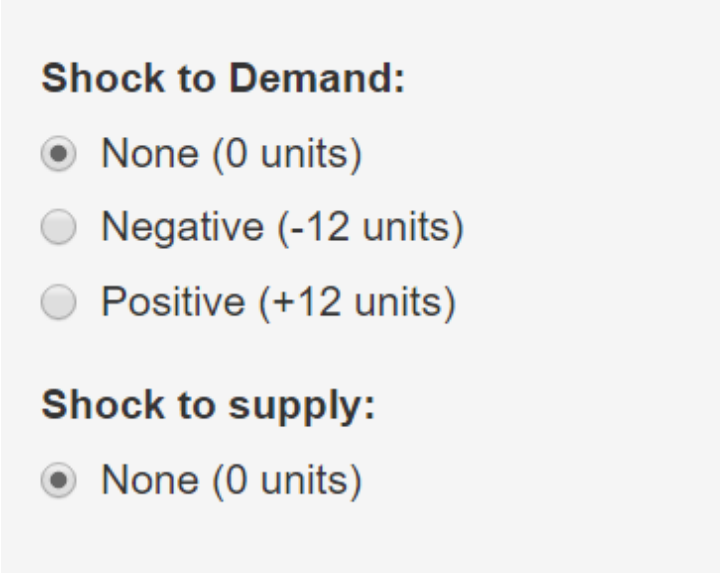
$$Q_1^S = -20 + 80 + \frac{2(D-S)}{3} + S = 60 + \frac{2D+S}{3}.$$

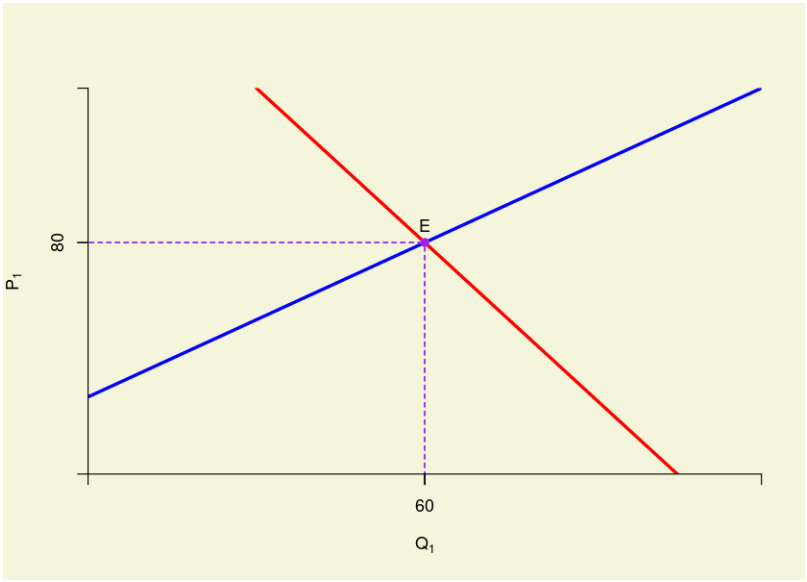
$$Q_1^D = 100 - \frac{1}{2}(80 + \frac{2(D-S)}{3}) + X = 60 + \frac{2D+S}{3}.$$

An equilibrium based on this example is depicted below in Demonstrations $4.1.1$ and $4.1.2$. Note that when there is no demand or supply shock ($D = S = 0$), $P_1^E = 80 \ and \ Q_1^E = 60$. This is the initial equilibrium depicted in the demonstrations. Use Demonstration $4.1.1$ to add a positive shock to demand. When you do this, the demand schedule shifts to the right by 12 units. This disrupts the equilibrium. At the current price of $80, only 60 units are supplied but now 72 units would be demanded. Since demand now exceeds supply, the price will be bid up until a new equilibrium price of $88 is reached which causes the new demand schedule to equate with the supply schedule at a new equilibrium quantity of 68 units. Thus, the initial shock of positive 12 units ultimately resulted in an 8 unit increase in the equilibrium quantity after the market price adjusted to a new equilibrium price.

Reset the demand shock in Demonstration $4.1.1$ to be zero. You will return to the original equilibrium of $P_1^E = 80 \ and \ Q_1^E = 60$. Now use the demonstration to apply a negative shock to demand. This causes demand to shift to the left by 12 units. At the current price of $80, only 48 units would be demanded after the shock, but suppliers will continue to offer 60 units on the market. Because supply now exceeds demand, the price will be bid down until the market reaches a new equilibrium price of $72 and a new equilibrium quantity of 52 units. Again the initial shock of negative 12 units ultimately resulted in an 8 unit decrease in the equilibrium quantity after the market price reached a new equilibrium.

Demonstration $4.1.1$. An Equilibrium and equilibrium adjustment resulting from a demand shock.





Demonstration 4.1.2, is similar except that it allows you to consider the effect of positive or negative shocks to supply as opposed to demand. Spend some time with demonstration 4.1.2 to visualize the effects of a positive or negative supply shock. As you do, note that a shock disrupts the equilibrium so that supply no longer equals demand. As a result, prices are bid up or down as necessary until a new equilibrium price is determined that matches demand to the new supply schedule. Pay attention to the direction of the quantity and price change in response to the positive and negative supply shocks.

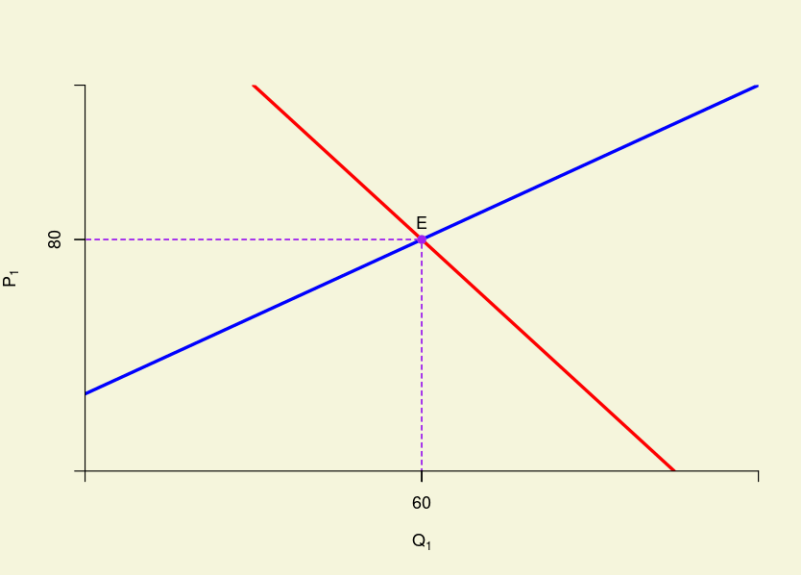
Demonstration 4.1.2. An equilibrium and equilibrium adjustment resulting from a supply shock.

Shock to Supply:

- (•) None (0 units)
- ( ) Negative (-12 units)
- ( ) Positive (+12 units)

Shock to Demand:

- (•) None (0 units)



Exogenous and Endogenous Variables in an Equilibrium Model

In the above example, an equilibrium was found by solving a system of equations. In the case of one market, there are two equations (one supply equation and one demand equation) and two unknowns (the equilibrium price and the equilibrium quantity). These unknown variables are called ***endogenous*** variables. They are given this name because they are determined inside the system of equations. The etymology of the prefix "endo" is from a Greek word meaning "within." In general, the number of endogenous variables in the system will be equal to the number of demand and supply equations. For example, in a model of two markets, there are four equations (two pairs of demand and supply equations) and four endogenous variables (an equilibrium price and quantity in each of the two markets).

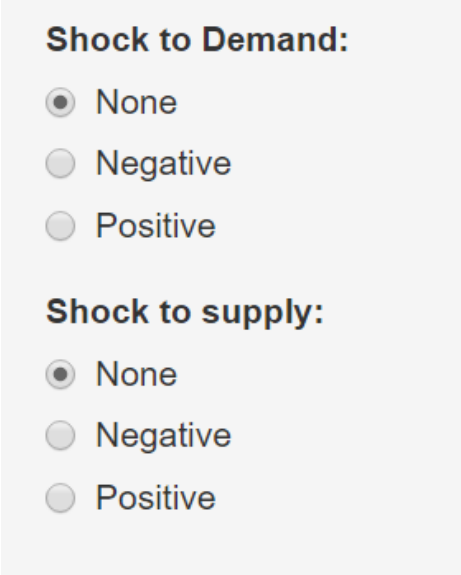
Exogenous variables affect the equilibrium but are determined outside of the system of equations. As you might have guessed, the prefix "exo" also has its origin in a Greek word meaning "outside." In terms of the demand or supply schedules, a change in an exogenous variable causes one or more of the schedules to shift. In the example above, there were two exogenous variables: D and S. There is no upper limit on the number of exogenous variables that can be included in the system. Exogenous variables will be a subset of those designated in chapters 1 and 2 as demand or supply shift variables. However the term "shifter" and "exogenous" are not synonymous. To be truly exogenous, the shift variable needs to be unaffected by the markets being analyzed in the model. Otherwise, it is not truly exogenous. For example, one could argue that beef and pork are substitutes. If this is true, the price of pork shifts the demand for beef. Nevertheless, it would problematic to assume that the price of pork is exogenous

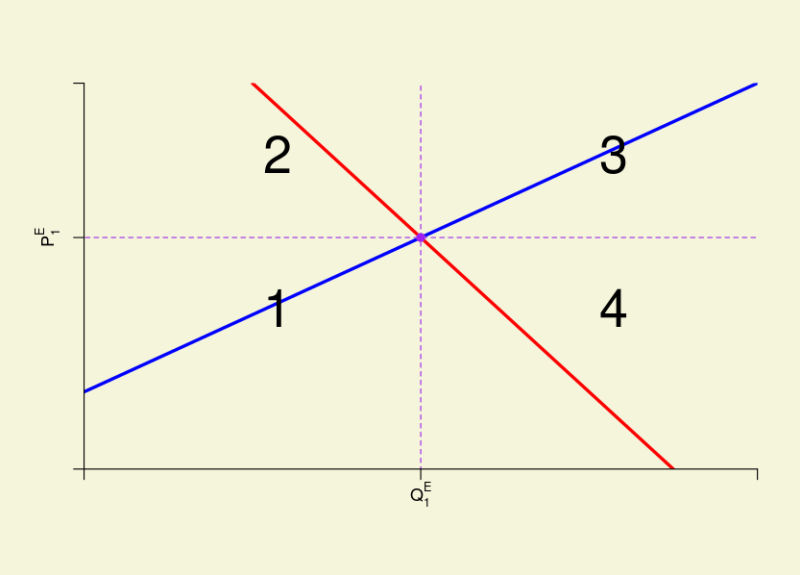
because the price of beef also shifts the demand for pork. In this case, an accurate model would need to encompass the markets for both beef and pork, in which case the prices and quantities of beef and pork would all be endogenous variables in the model.

In many contexts, a change in average consumer income, another demand shift variable, could be treated as exogenous. This is fine so long as it is reasonable to assert that income is dictated by macroeconomic forces that are minimally affected by the market being analyzed. However, there will be cases where income should not be considered exogenous. In fact, income is endogenous in one of the consumer models that will be presented in Chapter 5. In this model, income is determined by the consumer's allocation of time spent in leisure activities, in the labor force, and in household production. Similarly, in some cases, the supply side of the market will be small enough to not materially affect the price of an input. In such cases, it may be reasonable to assume that input prices are exogenous variables within the model. In others, it will be necessary to formally incorporate input markets into the model and input prices will be endogenous.

A Basic Framework for Identifying the Cause of an Equilibrium Change

Demonstration 4.1.3. A basic framework for identifying the cause of an equilibrium change.





In regions 1 and 3 of Demonstration 4.1.3, you can conclude with certainty that demand has shifted. If the new equilibrium lies to the southwest of the initial equilibrium (the region denoted as 1), then demand has decreased (shifted to the left). If the new

equilibrium lies to the northeast of the initial equilibrium (the region denoted as 3), then demand has increased (shifted to the right). If a new equilibrium lies in regions 1 or 3, conclusive statements cannot be made about a supply shift. Supply might have shifted but one cannot be sure. To help you see this, use the demonstration to add a negative shock to demand and a positive shock to supply. The new equilibrium point lies in region 1 even though supply has also shifted. Now set the supply shock back to "none". The resulting equilibrium is still in region 1. In region 1 all you can say with certainty is that demand has decreased. Supply may or may not have shifted. No conclusive statement can be made about supply if you are in region 1.

In regions 2 and 4 of Demonstration 4.1.3, you know that supply has shifted. If the new equilibrium lies to the northwest of the initial equilibrium (the region denoted as 2), then a conclusive statement can be made that supply has decreased (shifted to the left). If the new equilibrium lies to the southeast of the initial equilibrium (the region denoted as 4), then a conclusive statement can be made that supply has increased (shifted to the right). Again, demand may or may not have shifted if a new equilibrium is observed in regions 2 or 4. However, there is no way for a new equilibrium to be in regions 2 or 4 without there having been a supply shift.

In Demonstration 4.1.3, you can see the demand and supply schedules. However, the conclusions above can be inferred from this basic framework even if you could not. The framework requires only that the laws of demand and supply apply to the market being examined. Use Demonstration 4.1.3 to verify the conclusions summarized in Table 4.1.1. Because you are given example demand and supply schedules in Demonstration 4.1.3, you may question why some of the directions are marked as ambiguous in the table. For example, a positive demand shock and negative supply shock results in a slight increase in equilibrium quantity given the example schedules in the demonstration. However, another set of example schedules could have been provided that would have shown a decrease in quantity. Note that the ambiguous cases in table 4.1.1 happen when demand and supply change simultaneously and when the impact of the demand and supply changes on price or quantity offset one another. The actual change in these ambiguous cases depends on the magnitude of the supply shock relative to the demand shock and, as you will see momentarily, on the elasticity of demand and supply.

Table 4.1.1. Effects of demand and supply shocks on a market equilibrium

Supply Shock	Demand Shock	Effect on Eq. Price	Effect on Eq. Quantity
+	None	↓	↑
–	None	↑	↓
None	+	↑	↑
None	–	↓	↓
+	+	Ambiguous	↑
+	–	↓	Ambiguous
–	+	↑	Ambiguous
–	–	Ambiguous	↓

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4.2: Using Elasticities to Model an Equilibrium

Recall from Chapter 3, that elasticities are expressed as ratios of percentages. Consequently, to use elasticities to model a market equilibrium, the exogenous demand and supply shocks must also be expressed in percentages. With this in mind, let $\%\Delta S_i$ and $\%\Delta D_i$ be the percentage exogenous shock to demand and supply in market i, respectively. The demand and supply side of the markets can be expressed in change form as follows:

$$\%\Delta Q_i^D = \varepsilon_{ii}\%\Delta P_i + \%\Delta D_i,$$

and

$$\%\Delta Q_i^S = \phi_{ii}\%\Delta P_i + \%\Delta S_i.$$

The convention introduced in Chapter 3 is being followed here, where ϕ and ε are used for supply and demand elasticities, respectively. When there is a change from one market equilibrium to another, it must be true that the change in the equilibrium quantity supplied is equal to the change in equilibrium quantity demanded. Thus, it is possible find the percentage change in equilibrium price that would result from the demand and supply shocks by setting $\%\Delta Q_i^S = \%\Delta Q_i^D$ and solving for $\%\Delta P_i$. Doing this provides

$$\%\Delta P_i^E = \frac{\%\Delta D_i - \%\Delta S_i}{\phi_{ii} - \varepsilon_{ii}}. \tag{4.2.1}$$

Substituting Equation $4.2.1$ back into $\%\Delta Q_i^S$ or $\%\Delta Q_i^D$ provides the percentage change in equilibrium quantity:

$$\%\Delta Q_i^E = \frac{\phi_{ii}\%\Delta D_i - \varepsilon_{ii}\%\Delta S_i}{\phi_{ii} - \varepsilon_{ii}}. \tag{4.2.2}$$

Use of elasticities in modeling equilibria has some clear advantages. First, there is no need to assume that demand and supply are linear. The equilibrium model is a system of equations that is linear in the elasticities even if the underlying supply or demand equations are non-linear. Second, while it is true that equilibrium models in elasticity form provide percentage changes in equilibrium price and quantity, the prevailing equilibrium price and quantity are commonly known. Thus, percentage impacts from these models contain the information needed to assess the economic effects of an exogenous shock on the market. Third, the approach described below can accommodate any number of exogenous shocks and these shocks can occur simultaneously. Finally, the modeling approaches of this section can be extended to real-world situations involving numerous inter-related markets.

Using Elasticities of Supply or Demand from Exogenous Shift Variables

Recall from Chapter 3, that the general definition of an elasticity enables it to be used to forecast a quantity change. This means that if you have the elasticity of demand or supply with respect to an exogenous variable, it can be used to predict a shock to demand or supply as follows:

$$\%\Delta S_i = \phi_{iZ}\%\Delta Z$$

and

$$\%\Delta D_i = \varepsilon_{iX}\%\Delta X.$$

Thus, one way to obtain exogenous supply or demand shocks, $\%\Delta S_i$ or $\%\Delta D_i$, is to use projected changes in exogenous variables into demand/supply shocks using the elasticities for these exogenous variables.

Convert Potential Quantity Shocks to Percentages

Unfortunately, some shocks do correspond to exogenous variables for which you have elasticity estimates. In these cases it may be feasible to estimate the supply or demand shock in terms of units and then convert those units into a percentage of market

quantity. For instance, in the early 2000's, there was an outbreak of Hoof and Mouth Disease (HMD) in the United Kingdom. According to the BBC, the outbreak resulted in the destruction of more than six million sheep, cattle, and pigs (Bates 2016). The last confirmed case of HMD in the United States was 1929, but HMD is endemic in parts of the world and there is always a risk that it could again become a problem in the United States as well (USDA-APHIS 2013a). In fact, the USDA has an entire agency, The Animal Plant Health Inspection Service, that works closely with Customs and Border Protection to prevent the introduction of HMD and other diseases or pests that could harm US Agriculture (USDA-APHIS 2013b).

Paarlberg, Lee, and Seitzinger (2002) considered the potential effects of an HMD outbreak on meat, poultry and dairy markets in the US. They used supply shocks of -5 percent for beef cattle and milk production, -2 percent for swine production, and -9 percent for lamb and sheep production. These estimates were based on actual livestock reductions observed in the UK outbreak. They also considered demand shocks to account for potential taste changes away from red meats and to account for the fact that discovery of HMD in the US would result in closure of export markets for livestock products. The point to be made here is that in many settings, such as a possible HMD outbreak, modelers may be able to come up with reasonable estimates for supply and demand shocks that can be used for $\%\Delta S$ and/or $\%\Delta D$ and then assess the effect on an equilibrium. A more involved analysis of the potential US market response to an HMD outbreak is provided in Paarlberg et al. (2008). This study provides background on the markets being examined and includes an appendix containing baselines and elasticities used in the equilibrium models. Moreover, the study measures market equilibrium responses to HMD outbreaks of differing levels of severity.

In the Paarlberg, Lee, and Seitzinger (2002) and Paarlberg et al. (2008) studies, the exogenous event was an HMD outbreak and the analyses examined how equilibrium prices and quantities would respond to this event given existing estimates of market elasticities. It is worth pointing out that these authors included markets for feedstuffs in their models. This is because an adjustment to livestock markets would have ramifications on markets for feedstuffs, which would then ripple back into the markets for livestock products. For this reason, it was important to include feedstuff prices and quantities as endogenous variables in the model.

Use Own-Price Elasticities to Convert Changes in Costs or Willingness to Pay Into Quantity Shocks

In other cases, the exogenous shock that needs to be modeled may not have an elasticity nor be easily represented in terms of a percentage of current market quantity. However, if you can estimate the effect as a percentage of the current equilibrium price you can use own-price elasticities to find the shock. This is because an increase in cost is analogous to price decrease for producers. Similarly, an improvement in a quality attribute valued by consumers is analogous to a price decrease for the consumer.

A Supply Shock Problem

Let us consider a supply shock problem. Suppose new biosecurity regulations are proposed to prevent spread of HMD on feedlot operations. Suppose further that the fed cattle market is at an initial equilibrium with a price of $1.25 per pound. It is estimated that it will cost producers $0.03 per pound to comply with the regulations. How will this affect market equilibrium? You know that the regulations will raise costs and this will shift the supply curve to the left resulting in a new equilibrium with a higher price and low quantity (see Table 1 above). The question is, how much higher and lower? To find out, let us first note that the $0.03 cost increase is 2.4 percent (0.03/1.25 = 0.024) of the current market price. Consequently, the costs resulting from the regulation are analogous to a 2.4 percent reduction in the price that producers receive. Suppose that farm-level supply and demand elasticities are as follows: $\phi_{11} = 2$ and $\varepsilon_{11} = -0.8$. The increase in per-unit costs translates into a supply shock of $\%\Delta S = 2(-2.4) = -4.8\%$. You can now use Equation $4.2.1$ to predict the equilibrium price response as follows:

$$\%\Delta P_1^E = \frac{0-(-4.8)}{2-(-0.8)} \approx 1.71.$$

From Equation $4.2.2$, you get the equilibrium quantity response to be

$$\%\Delta Q_1^E = \frac{(2)(0)-(-0.8)(-4.8)}{2-(-0.8)} \approx -1.37.$$

A Demand Shock Problem

Suppose that you have access to a study showing that high protein diet fads are growing in popularity and that within a year,

consumers will, on average, be willing to pay 3 percent more for chicken. If this study is correct, how would it affect the equilibrium price and quantity of chicken? The study suggests that consumer preferences for chicken with strengthen. Thus, you would expect demand to shift outwards, and the equilibrium price and quantity should rise (see Table 1). The question is by how much? Since consumers are projected to obtain 3 percent more value from chicken, this is analogous to a 3 percent reduction in the price that consumers pay. Suppose that retail level supply and demand elasticities for chicken are as follows: $\phi_{11} = 1.75 \ and \ \varepsilon_{11} = -1.1$. The demand shock is $\%\Delta D = -1.1(-3) = 3.3\%$. Using Equation $4.2.1$, the effect on the equilibrium price is

$$\%\Delta P_1^E = \frac{3.3 - 0}{1.75 - (-1.1)} \approx 1.16.$$

From Equation $4.2.2$, you get the equilibrium quantity response to be

$$\%\Delta Q_1^E = \frac{(1.75)(3.3) - (-1.1)(0)}{1.75 - (-1.1)} \approx 2.03.$$

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4.3: Markets - Supply and Demand

In the previous section, supply and demand were introduced and explored separately. In what follows, the interaction of supply and demand will be presented. The market mechanism is a useful and powerful analytical tool. The market model can be used to explain and forecast movements in prices and quantities of goods and services. The market impacts of current events, government programs and policies, and technological changes can all be evaluated and understood using supply and demand analysis. Markets are the foundation of all economics!

A market equilibrium can be found at the intersection of supply and demand curves, as illustrated for the wheat market in Figure $4.3.1$. An equilibrium is defined as, "a point from which there is no tendency to change." Wheat is traded in units of metric tons (MT), or 1000 kilograms, equal to approximately 2,204.6 pounds.

Equilibrium = a point from which there is no tendency to change.

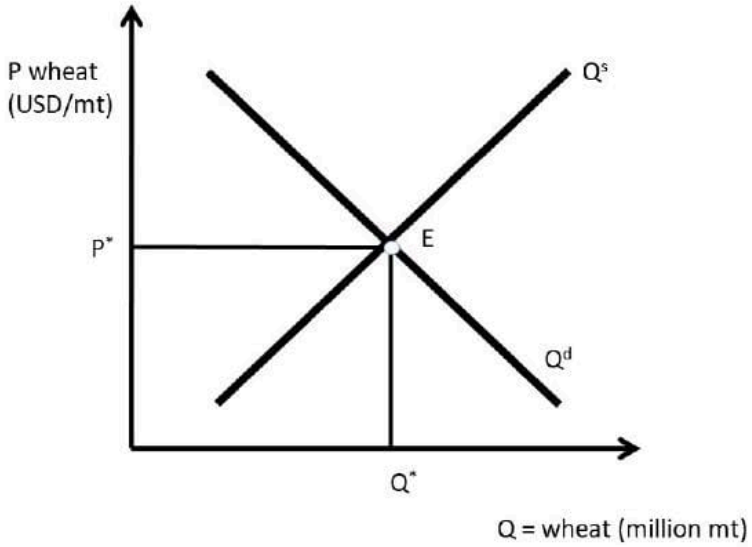


Figure $4.3.1$: Wheat Market

Point E is the only equilibrium in the wheat market shown in Figure $4.3.1$. At any other price, market forces would come into play, and bring the price back to the equilibrium market price, P^*. At any price higher than P^*, such as P' in Figure $4.3.2$, producers would increase the quantity supplied to Q_1 million metric tons of wheat, and consumers would decrease the quantity demanded to Q_0 million metric tons of wheat. A surplus would result, since quantity supplied is greater than quantity demanded $(Q_1 > Q_0)$.

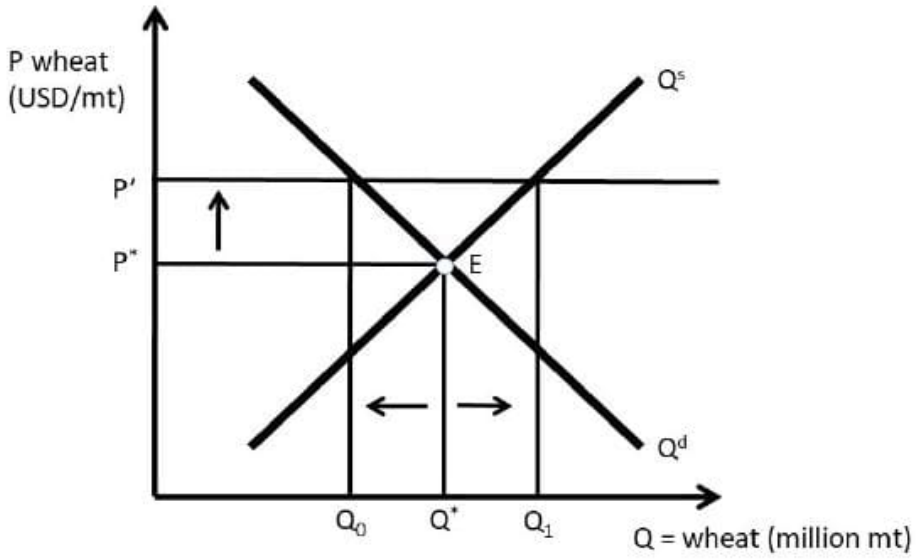


Figure 4.3.2: Wheat Market Surplus

A wheat surplus such as the one shown in Figure 4.3.2 would bring market forces into play since $Q^s \neq Q^d$. Wheat producers would lower the price of wheat in order to sell it. It would be preferable to earn a lower price than to let the surplus go unsold. Consumers would increase the quantity demanded along Q^d and producers decrease the quantity supplied along Q^s until the equilibrium point E was reached. In this way, any price higher than the market equilibrium price will be temporary, as the resulting surplus will bring the price back down to the equilibrium price P^*.

Market forces also come into play at prices lower than the equilibrium market price, as shown in Figure 4.3.3. At the lower price P'', producers reduce the quantity supplied along Q^s to Q_0, and consumers increase the quantity demanded to Q_1. A shortage occurs, since the quantity demanded is greater than the quantity supplied $Q_1 > Q_2$. The shortage will bring market forces into play, as consumers will bid up the price in order to purchase more wheat and producers will produce more wheat along Q^s. This process will continue until the market price returns to the equilibrium market price, P^*.

The market mechanism that results in an equilibrium price and quantity performs a truly amazing function in the economy. Markets are self-regulating, since no government intervention or coercion is needed to achieve desirable outcomes. If there is a drought, the price of wheat will rise, causing more resources to be devoted to wheat production, which is desirable, since wheat is in short supply during a drought. If good weather causes a surplus, the price will fall, causing wheat producers to shift resources out of wheat and into more profitable opportunities. In this fashion, the market mechanism allows voluntary trades between willing parties to allocate resources to the highest return. Efficiency of resource use and high incomes are a feature of market-based economies.

Although markets provide huge benefits to society, not everyone wins from free market economies, and market changes over time. Price increases help producers, but hurt consumers. Technological change has provided lowered food prices enormously over time, but has led to farm and ranch consolidation, and the large migration of farmers and their families out of rural regions and into urban areas.

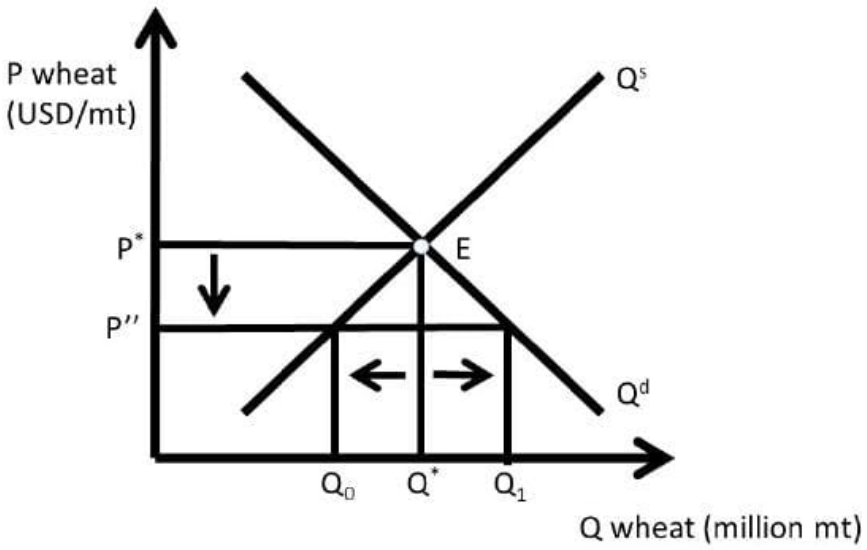


Figure 4.3.3: Wheat Market Shortage

The market graphs of supply and demand are based on the assumption of perfectly competitive markets. Perfect competition is an ideal state, different from actual market conditions in the real world. Once again, economists simplify the complex real world in order to understand it. We will begin with the extreme pure case of perfect competition, and later introduce realism into our analysis.

Competitive Market Properties

A competitive market has four properties:

1. homogeneous product,
2. numerous buyers and sellers,
3. freedom of entry and exit, and
4. perfect information.

The first property of perfect competition is a homogeneous product. This means that the consumer can not distinguish any differences in the good, no matter which firm produced it. Wheat is an example, as it is not possible to determine which farmer produced the wheat. A John Deere tractor is an example of a nonhomogeneous good, since the brand is displayed on the machine, not to mention the company's well known green paint and deer logo.

The assumption of numerous buyers and sellers means something specific. The word, "numerous" refers to an industry so large that each individual firm can not affect the price. Each firm is so small relative to the industry that it is a price taker.

Freedom of entry and exit means that there are no legal, financial, or regulatory barriers to entering the market. A wheat market allows anyone to produce and sell wheat. Attorneys and physicians, however, do not have freedom of entry. To practice law or medicine, a license is required.

Perfect information is an assumption about industries where all firms have access to information about all input and output prices, and all technologies. There are no trade secrets or patented technologies in a perfectly competitive industry. These four properties of perfect competition are stringent, and do not reflect real-world industries and markets. Our study of market structures in this course will examine each of these properties, and use them to define industries where these properties do not hold. Competitive markets have a number of attractive properties.

Outcomes of Competitive Markets

Competitive markets result in desirable outcomes for economies. A competitive market maximizes social welfare, or the total amount of well-being in a market. Competitive markets use voluntary exchange, or mutually beneficial trades, to achieve this

result. In a market-based economy, no one is forced, or coerced, to do anything that they do not want to do. In this way, all trades are mutually beneficial: a producer or consumer would never make a trade unless it made him or her better off. This idea will be a theme throughout this course: free markets and free trade lead to superior economic outcomes.

It should be emphasized that free markets and free trade are not perfect, since there are negative features associated with markets and capitalism. Income inequality is an example. Markets do not solve all of society's problems, but they do create conditions for higher levels of income and wealth than other economic organizations, such as a command economy (as found in a communist or fascist nation). There are winners and losers to market changes. An example is free trade. Free trade lowers prices for consumers, but often causes hardships for producers in importing nations. Similarly, open borders allow immigrants to improve their conditions and earnings by moving from low-income nations to high-income nations such as the United States (US) or the European Union (EU). Workers in the US and the EU will face competition from a larger labor supply, causing reductions in wages and salaries. A simple example of markets is an increase in the price of corn. Corn producers are made better off, but livestock producers, the major buyers of corn, are made worse off. Thus, the market shifts that allow prosperity also create winners and losers in a free market economy.

Supply and Demand Shift Examples

Given our knowledge of markets and the market mechanism, current events and policies can be better understood.

Demand Increase

China was a command economy until 1986. At that time, the government introduced the Household Responsibility System, which allowed farmers to earn income based on how much agricultural output they produced. The new policy worked very well, and China moved from being a net food importer to a net food exporter. Soon, the policy was extended to all industries, and China was on its way to a market-based economy. The result has been a truly unprecedented increase in income. China has gone from a low income nation to a middle income nation, and the rates of economic growth are higher than any nation in history. And, these growth rates are for the world's most populous nation: 1.4 billion people (for comparison, the United States (USA) has approximately 326 million people).

This historical income growth in China has been good for US farmers and ranchers. As incomes increase, consumers shift out of grain-based diets such as rice and wheat, and into meat. There has been a large increase in beef consumption in China as incomes increased. This is an increase in the demand for US beef, as shown in Figure $4.3.4$. The units for beef are hundredweight (cwt), or one hundred pounds. This is called an increase in demand (do you remember why this is not an increase in quantity demanded?). The outward shift in demand results in a movement from equilibrium E_0 to E_1. The movement along the supply curve for beef is called an increase in quantity supplied. The equilibrium market price increases from P_0 to P_1, and the equilibrium market quantity increases from Q_0 to Q_1. An increase in demand results in higher prices and higher quantities. As a result, the best way to increase profitability for a firm is to increase demand.

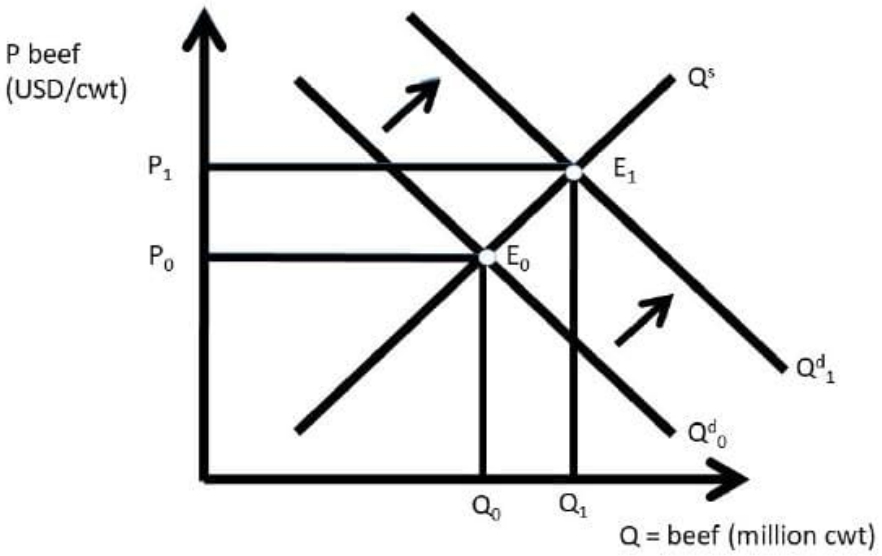


Figure 4.3.4: Increase in China Income Impact on US Beef Market

Interestingly, income growth in China is beneficial to not only US beef producers, who face an increased demand for beef, but also for grain farmers in the USA. The major input into the production of beef is corn, sorghum (also called milo), and soybeans. These grains are fed to cattle in feedlots. Seven pounds of grain are required to produce one pound of beef. Therefore, any increase in the global demand for beef will result in an increase in demand for beef, and a large increase in the demand for feed grains.

Demand Decrease

In the United States, the demand for beef offals (tripe, tongue, heart, liver, etc.) has decreased in the past few decades. As incomes increase, consumers shift out of these goods and into more expensive meat products such as hamburger and steaks. The demand for offals has decreased as a result, as in Figure 4.3.5. This is a decrease in demand (shift inward), and a decrease in quantity supplied (movement along the supply curve). The outcome is a decrease in the equilibrium market price and quantity of beef offals.

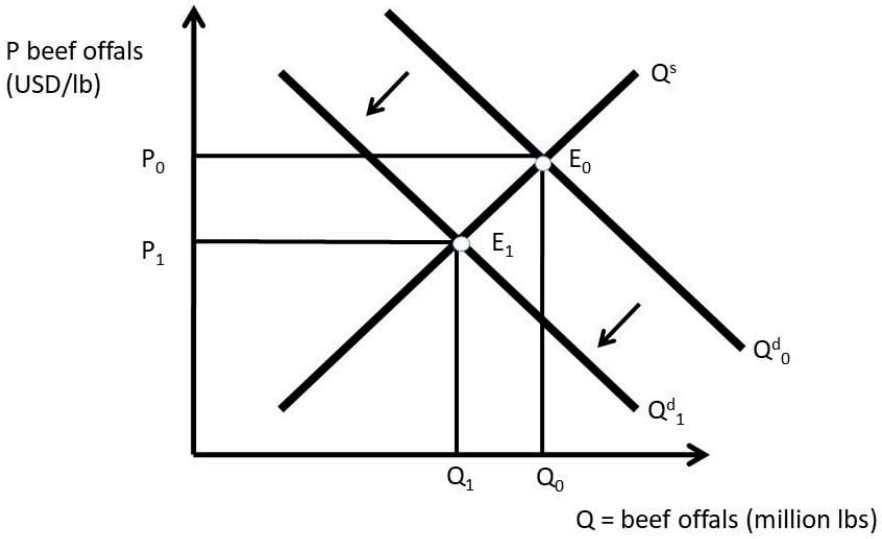


Figure 4.3.5: Increase in US Income Impact on US Beef Offal Market

Supply Decrease

A large share of citrus fruit in the US is grown in Florida and California. If there is bad weather in either State, the market for oranges, lemons, limes, and grapefruit is affected. An early freeze can damage the citrus fruit, resulting in a decrease in supply (Figure 4.3.6).

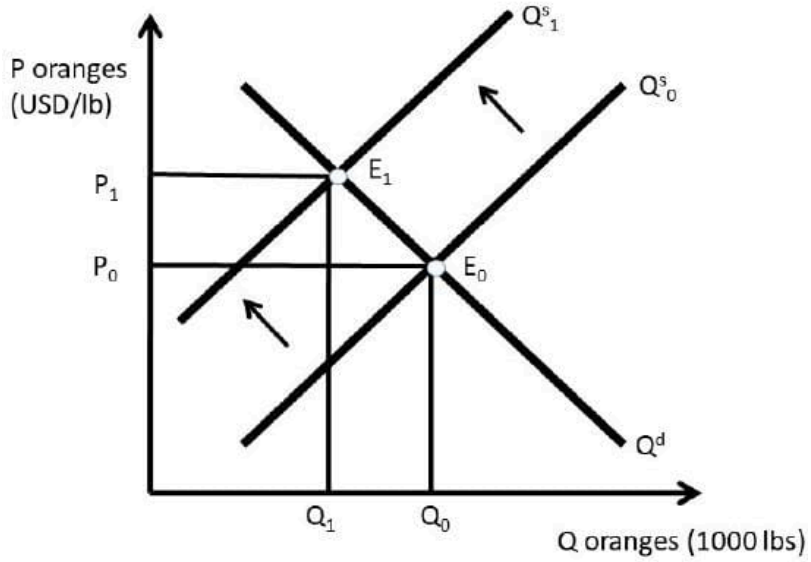


Figure 4.3.6: Frost Damage Impact on US Orange Market

The supply decrease is a shift in the supply curve to the left, resulting in a movement along the demand curve: a decrease in quantity demanded. The equilibrium price increases, and the equilibrium quantity decreases.

Supply Increase

Technological change is a constant in global agriculture. Science and technology has provided more output from the same levels of inputs for many decades, and especially since 1950. Biotechnology in field crops has been a recent enhancement in the world food supply. Biotechnology is also referred to as genetically modified organisms (GMOs). Although GMOs are often in the news media as a potential health risk or environmental risk, they have been produced and consumed in the US for many years, with no documented health issues. However, the herbicide glyphosate has been determined to be a carcinogen in recent studies. Glyphosate is the ingredient in “RoundUp,” a widely used herbicide in corn and soybean production. Genetically modified corn and soybeans are resistant to this herbicide, so it has been used extensively since the introduction of GM crops. Biotechnology has increased the availability of food enormously, and is considered the largest technological change in the history of agriculture. The impact of biotechnology is shown in Figure 4.3.7.

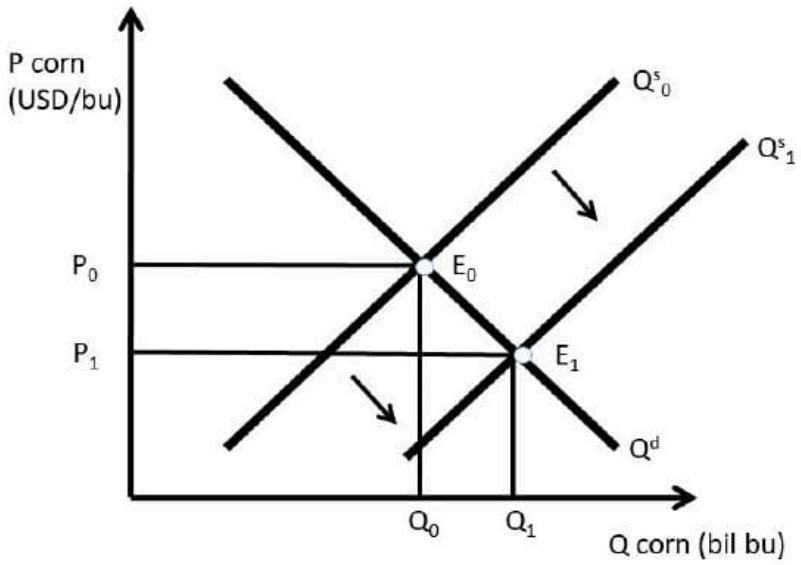


Figure 4.3.7: Biotechnology Impact on Corn Market

Biotechnology results in an increase in supply, the rightward shift in the supply curve. This supply shift results in a movement along the demand curve, an increase in quantity demanded. The equilibrium quantity increases, and the equilibrium price decreases. It may seem that the decrease in price is bad for corn producers. However, in a global economy, this keeps the US competitive in global grain markets. Since a large fraction of US grain crops are exported, this provides additional income to the corn industry.

Mathematics of Supply and Demand

The above market analyses are qualitative, or non-numerical. Numbers can be added to the supply and demand graphs to provide quantitative results. The numbers used here are simple, but can be replaced with actual estimates of supply and demand to yield important and interesting quantitative results to market events.

As an example, consider the phone market. Let the inverse demand for phones be given by Equation 4.3.1. The equation is called, "inverse" because the independent variable (P) appears on the left-hand side and the dependent variable (Q^d) appears on the right hand side. Traditionally, the independent variable (x) is on the right, and the dependent variable (y) is on the left. We use inverse supply and demand equations for easier graphing, since P is on the vertical axis, typically used for the dependent variable (can you remember why these graphs are backwards?).

$$P = 100–2Q^d \tag{4.3.1}$$

In the inverse demand equation, P is the price of phones in USD/unit, and Q is the quantity of phones in millions. The inverse supply equation is given in Equation 4.3.2.

$$P = 20 + 2Q^s \tag{4.3.2}$$

These examples of inverse supply and demand functions are called "price-dependent" for ease of graphing. The equations can be quickly and easily inverted to "quantity-dependent" form. To do this, use simple algebra to isolate Q^d or Q^s on the left-hand side of the equations.

To find equilibrium, set $Q^s = Q^d = Q^e$. This is the point where the market "clears," and supply is equal to demand. By inspection of the market graph (Figure 4.3.8), there is only one price where this can occur: the equilibrium price: P^e.

$$\begin{aligned} P &= 100–2Q^e = 20 + 2Q^e \\ 80 &= 4Q^e \\ Q^e &= 20 \end{aligned}$$

To find the equilibrium price, plug Q^e into the inverse demand equation:

$$P^e = 100–2Q^e = 100–2 * 20 = 100–40 = 60. \tag{4.3.3}$$

This result can be checked by plugging $Q^e = 20$ into the inverse supply equation:

$$P^e = 20 + 2Q^e = 20 + 2 * 20 = 20 + 40 = 60 \tag{4.3.4}$$

The equilibrium price and quantity of phones are:

$$P^e = \text{ USD } 60/\text{phones, and } Q^e = 20 \text{ million phones.} \tag{4.3.5}$$

Notice that these equilibrium values have both labels (phones) and units.

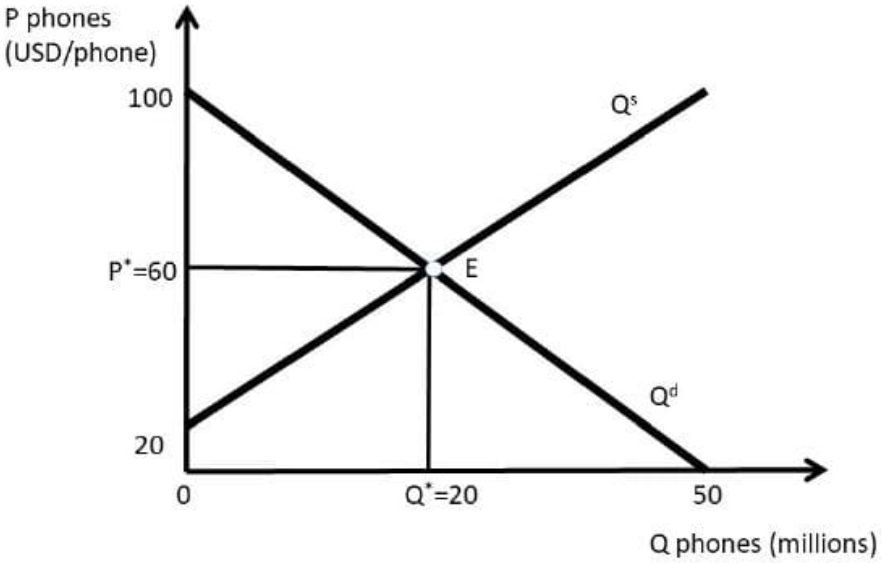


Figure 4.3.8: Phone Market Equilibrium

We will be using quantitative market analysis throughout the rest of the course. If you have any questions about how to graph the functions, or how to solve for equilibrium price and quantity, be sure to review the material in this chapter carefully. We will be using these graphs throughout our study of market structures!

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4.4: Partial vs. General Equilibrium Models

So far, the impact of an exogenous shock has been considered for only one market. In many (if not most) cases, this is not a very good assumption. For instance, a shock to the pork market would be expected to have an impact on the beef and poultry markets because these products are substitutes for pork. Moreover, as shown in the Paarlberg, Lee, and Seitzinger (2002) and Paarlberg et al. (2008) studies on HMD mentioned above, something that affects livestock markets would likely affect markets for grain and other feedstuffs. Thus, an initial shock to the pork market will impact related product and input markets. You should account for feedback between these related markets as they adjust to a new equilibrium.

As additional markets are added into an equilibrium analysis framework, the problem becomes more complex. It may not be feasible to model all the related markets. In some cases, the best an analyst can do is assess a single market in isolation. This is called a partial equilibrium model. In a partial equilibrium model, you are ignoring feedback that may result from related markets.

General equilibrium models differ from partial equilibrium models in that they incorporate related markets or economic sectors into the analysis. In a general equilibrium model, feedback from other markets is considered to account for the fact that exogenous shocks occurring in other markets have implications for the market in question.

Classification of a model as a partial equilibrium or general equilibrium can vary a bit in the literature. Specifically, you will sometimes see a model described as partial equilibrium model even though multiple markets are included in the analysis. For example, Paarlberg, Lee, and Seitzinger (2002) and Paarlberg et al. (2008) classify their analyses as a partial equilibrium model, even though their models included markets for meat, dairy, livestock, and feedstuffs. This is because they restrict their focus to a tightly linked group of markets and do not examine the ramifications of an HMD outbreak on other sectors of the economy.

Normally, in a general equilibrium model, the equilibrium quantities and prices in all markets are endogenous. For instance, if you are modeling three related markets, there would be six endogenous variables: three equilibrium prices and three equilibrium quantities. Exogenous variables in a general equilibrium model again reflect any variable outside the system that shifts demand or supply in one or more markets. Note that when markets are related in consumption or production, the price in Market 2 will shift demand or supply in Market 1 and *vice versa*. However, prices are not exogenous because they are part of the equilibrium and are determined within the system of supply and demand equations that represent all markets included in the model. For this reason, the term “exogenous variable” is much better to use than the term “shift variable” within the context of an equilibrium model. The former implies that the value of the variable is determined outside the system. The latter just implies that the value of the variable causes a shift in one or more of the demand or supply schedules but does not indicate whether the value is determined internally or externally.

Feedback Between Markets in a General Equilibrium Model

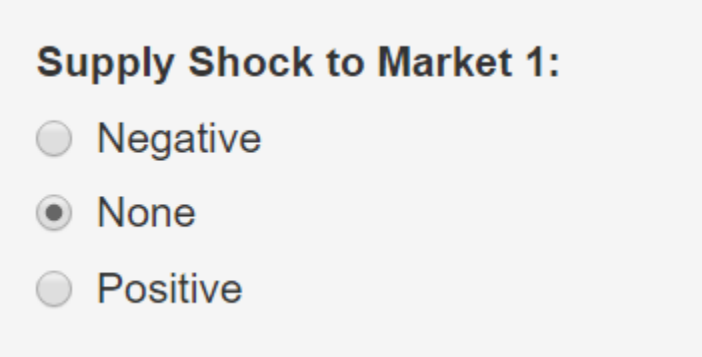
To help you visualize feedback between markets, let us consider two markets that are related in demand but are unrelated in supply. This means the goods are either substitutes or complements to one another on the demand side of the market but are neither competing products or joint products on the supply side. Demonstration 4 depicts this situation for the case of substitutes in consumption. Use the demonstration to create a positive supply shock to Market 1. Now let us step through what happened:

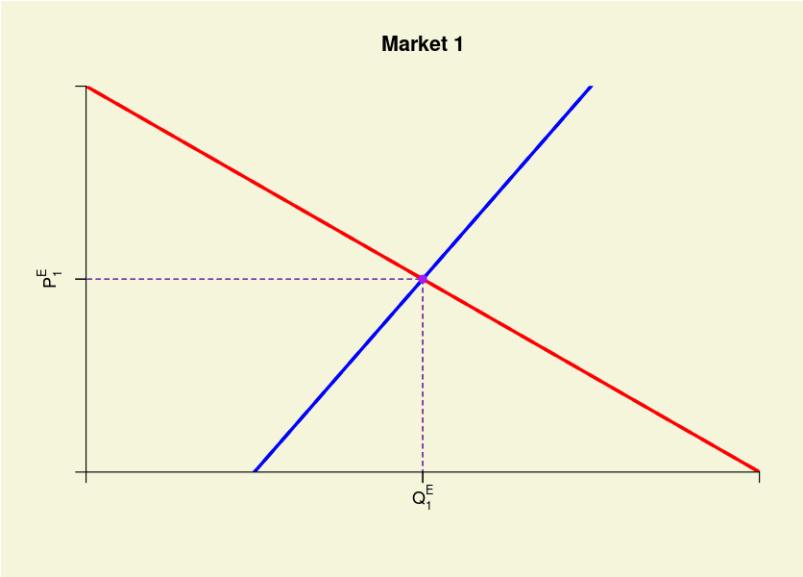
1. The positive supply shock to Market 1 causes a decrease in the equilibrium price and an increase in the equilibrium quantity as predicted in Table 1.
2. Because Products 1 and 2 are substitutes in consumption, the lower price in Market 1 causes a leftward demand shift in Market 2, resulting in a lower price in Market 2 as well.
3. The lower price in Market 2 feeds back into Market 1. Because the price in Market 2 is now lower and good 2 is a substitute for good 1, this causes the demand in Market 1 to shift inward and the price in Market 1 to falls further.

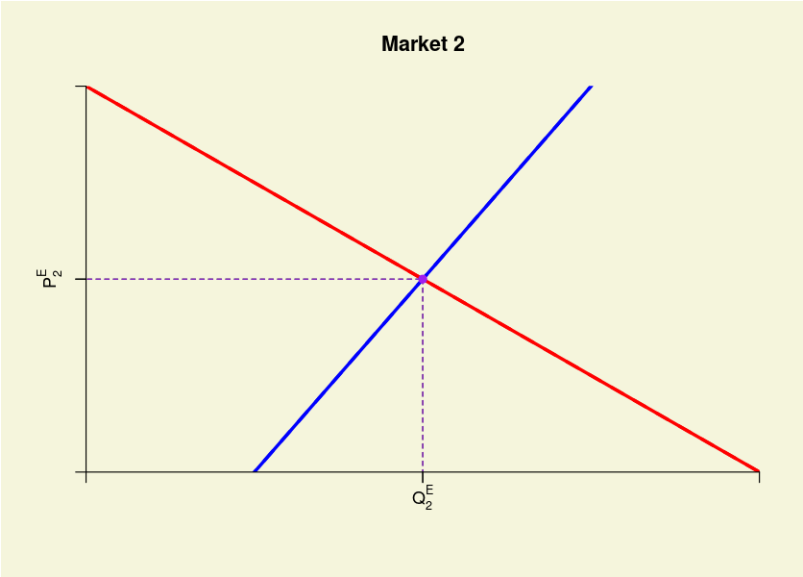
A couple of points are worth mentioning here. First, it should be clear that partial equilibrium models may over or understate the true impact of a shock. In the case just examined, feedback from Market 2 amplified the actual effect of the shock to Market 1. In other words, a partial equilibrium model that only included Market 1 would understate the price effect of positive supply shock. Second, in stepping through this example, adjustments to Markets 1 and 2 were presented as a sequential process, as steps 1-3. This was mainly to reinforce the intuition of feedback from Market 2 into Market 1. In reality, steps 1-3 occur simultaneously and the feedback is bidirectional as the markets in the system adjust to the new equilibria.

Take a moment to step through Demonstration 4.4.1 a second time. This time, create a negative supply shock to Market 1. Notice that prices in both markets increase and feedback from Market 2 to Market 1 again amplifies the price change in Market 1 over what would be observed in a partial equilibrium model.

Demonstration 4.4.1. Feedback between two markets that are substitutes in consumption but unrelated in supply





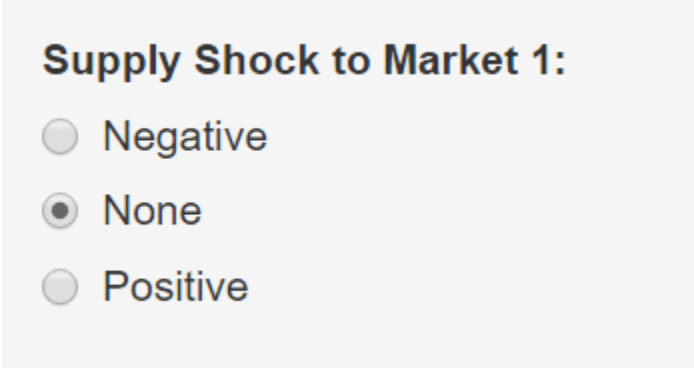


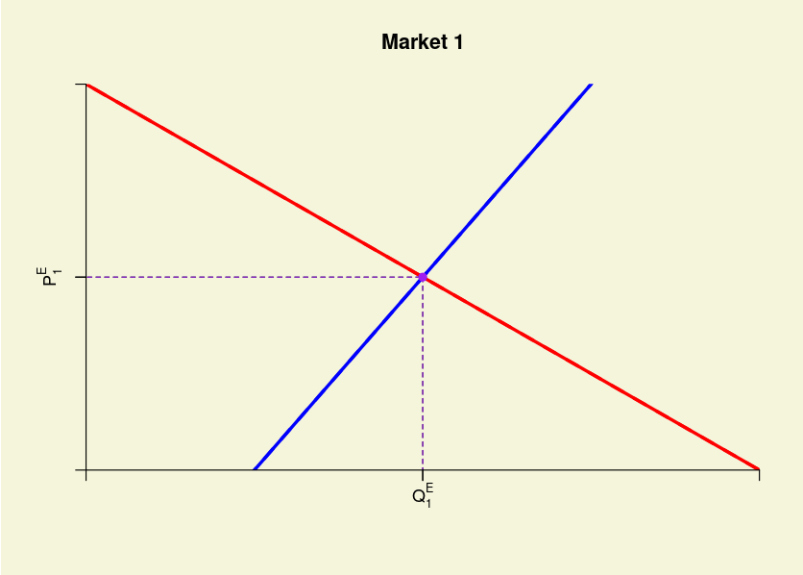
Demonstration ({4{.}4{.}\eatSpaces{2} \endSpaces}\) provides an example for the case of complements in consumption. Use demonstration 5 to add a positive supply shock to Market 1. Again, you see that feedback from Market 2 amplifies the resulting change in equilibrium price in Market 1. In this case, however, it is for a different reason. The initial supply shock causes the price in Market 1 to fall. Because good 2 is a complement to good 1, this causes demand in Market 2 to increase and results in a price increase in Market 2, which feeds back into Market 1. Demand in Market 1 decreases as a result of the higher price in Market 2 which amplifies the the price reduction. You can repeat the process for a negative shock to Market 1 to see that the resulting price increase in Market 1 is similarly amplified by feedback from Market 2.

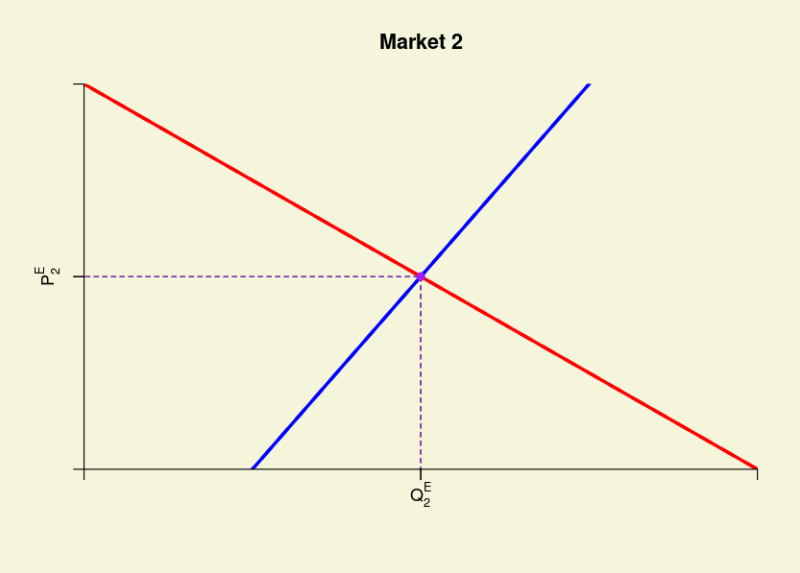
The top panels of Demonstrations ({4{.}4{.}\eatSpaces{1} \endSpaces}\) and ({4{.}4{.}\eatSpaces{2} \endSpaces}\) are very similar. In each case, feedback between the markets amplifies the price change to Market 1. The difference lies in the effects of the initial shock on Market 2. In the case of substitutes, the price change in Market 2 is of the same direction as the price change in Market 1. In the case of complements the price in Market 2 is of the opposite direction to the price change Market 1.

Finally, note that because these markets are unrelated in supply, there is no shift to the supply schedule in Market 2. In fact, this is the only schedule that does not shift as a result of the initial supply shock to Market 1.

Demonstration ({4{.}4{.}\eatSpaces{2} \endSpaces}\). Feedback between two markets that are complements in consumption but unrelated in supply







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4.5: Finding Solutions in Equilibrium Models with Multiple Markets

In a model with a single market, there are two endogenous variables and two equations. You can find a unique solution for $\%\Delta P$ and $\%\Delta Q$. With multiple markets, there will be two equations (one supply equation and one demand equation) for each market. Solving for the endogenous variables becomes a bit messy unless you use matrix algebra. Let us step through the process of putting a two-market model, such as those depicted in Demonstrations 4.4.1 and 4.4.2 above, into matrix format. In the case of two markets there will be four equations.

$$Supply\ in\ Market\ 1: \%\Delta Q_1 = \phi_{11}\%\Delta P_1 + \phi_{12}\%\Delta P_2 + \%\Delta S_1$$

$$Demand\ in\ Market\ 1: \%\Delta Q_1 = \varepsilon_{11}\%\Delta P_1 + \varepsilon_{12}\%\Delta P_2 + \%\Delta D_1$$

$$Supply\ in\ Market\ 2: \%\Delta Q_2 = \phi_{21}\%\Delta P_1 + \phi_{22}\%\Delta P_2 + \%\Delta S_2$$

$$Demand\ in\ Market\ 2: \%\Delta Q_2 = \varepsilon_{21}\%\Delta P_1 + \varepsilon_{22}\%\Delta P_2 + \%\Delta D_2$$

To express these equations in matrix notation, it is first necessary to make sure terms in these equations are arranged appropriately

- First, get all the endogenous variables on the left side of the equations and all the exogenous terms on the right. There are four endogenous variables in this system. They are $\%\Delta Q_1$, $\%\Delta Q_2$, $\%\Delta P_1$, and $\%\Delta P_2$. The exogenous terms are $\%\Delta S_1$, $\%\Delta D_1$, $\%\Delta S_2$, and $\%\Delta D_2$.
- Second, there must be place for each endogenous variable in each equation. As shown above, $\%\Delta Q_1$ appears only in the supply and demand curves for Market 1 and $\%\Delta Q_2$ appears only in the supply and demand equations for Market 2. However, you can add $0 \times \%\Delta Q_1$ to the equations to Market 2 and $0 \times \%\Delta Q_2$ to the equations for Market 1 so that each endogenous variable has a place in each equation.
- Finally, each endogenous variable must appear in the same order in each equation.

An arrangement that meets all of these criteria is as follows.

$$Supply\ in\ Market\ 1: \%\Delta Q_1 + 0 \times \%\Delta Q_2 - \phi_{11}\%\Delta P_1 - \phi_{12}\%\Delta P_2 = \%\Delta S_1$$

$$Demand\ in\ Market\ 1: \%\Delta Q_1 + 0 \times \%\Delta Q_2 - \varepsilon_{11}\%\Delta P_1 - \varepsilon_{12}\%\Delta P_2 = \%\Delta D_1$$

$$Supply\ in\ Market\ 2: 0 \times \%\Delta Q_1 + \%\Delta Q_2 - \phi_{21}\%\Delta P_1 - \phi_{22}\%\Delta P_2 = \%\Delta S_2$$

$$Demand\ in\ Market\ 2: 0 \times \%\Delta Q_1 + \%\Delta Q_2 - \varepsilon_{21}\%\Delta P_1 - \varepsilon_{22}\%\Delta P_2 = \%\Delta D_2$$

Notice that each endogenous variable now appears in each equation. In each equation, $\%\Delta Q_1$ appears first, $\%\Delta Q_2$ appears second $\%\Delta P_1$ appears third, and $\%\Delta P_2$ appears fourth. It does not matter which endogenous variable appears first, second, third, or fourth so long as the order of these variables is uniform across all equations. In other words, the variable that appears first must be first in each equation, the variable that appears second must be second in each equation, and so forth. Finally, it does not matter the order of the equations. For example, you could have arranged these equations so that both supply equations were listed first followed by both demand equations, if that was your preference. This system of equations as arranged above can be expressed in matrix form as shown below.

$$\begin{bmatrix} 1 & 0 & -\phi_{11} & -\phi_{12} \\ 1 & 0 & -\varepsilon_{11} & -\varepsilon_{12} \\ 0 & 1 & -\phi_{21} & -\phi_{22} \\ 0 & 1 & -\varepsilon_{21} & -\varepsilon_{22} \end{bmatrix} \begin{bmatrix} \%\Delta Q_1 \\ \%\Delta Q_2 \\ \%\Delta P_1 \\ \%\Delta P_2 \end{bmatrix} = \begin{bmatrix} \%\Delta S_1 \\ \%\Delta D_1 \\ \%\Delta S_2 \\ \%\Delta D_2 \end{bmatrix}$$

The equations are now in the form $\mathbf{Ax} = \mathbf{b}$, where $\mathbf{A}$ is the matrix containing zeros, ones, and the elasticities of demand and supply; $\mathbf{x}$ is the vector of endogenous variables; and $\mathbf{b}$ is the vector of exogenous shocks. The solution to this system of equations is given by $\mathbf{x} = \mathbf{A}^{-1}\mathbf{b}$. Demonstration $4.5.1$, provides an example of two markets like those in depicted graphically above in Demonstrations 4.4.1 and 4.4.2. The markets in the demonstration are related in demand but not in supply. The demonstration

permits you to examine a supply shock in Market 1. Like the demonstration above, you can see the role of feedback from Market 1 to Market 2 when the supply shock occurs. Take a moment to verify that you understand how the matrices in Demonstration 4.5.1 are constructed given the data provided. Notice also that the effects of the supply shock conform to those you analyzed above in Demonstrations 4.4.1 and 4.4.2.

Demonstration 4.5.1. An exogenous supply shock in a two market system. The markets are related in demand but unrelated in supply.



Given the following:

$$\phi_{11} = 1.3; \phi_{12} = 0; \varepsilon_{11} = -1.2; \varepsilon_{12} = 0.5.$$

$$\varepsilon_{21} = 0; \phi_{22} = 0.9; \varepsilon_{21} = 0.6; \varepsilon_{22} = -1.4.$$

The A matrix is:

$$\mathbf{A} = \begin{bmatrix} 1 & 0 & -\phi_{11} & -\phi_{12} \\ 1 & 0 & -\varepsilon_{11} & -\varepsilon_{12} \\ 0 & 1 & -\phi_{21} & -\phi_{22} \\ 0 & 1 & -\varepsilon_{21} & -varepsilon_{22} \end{bmatrix} = \begin{bmatrix} 1 & 0 & -1.3 & 0 \\ 1 & 0 & 1.2 & -0.5 \\ 0 & 1 & 0 & -0.9 \\ 0 & 1 & -0.6 & 1.4 \end{bmatrix}$$

The b matrix is:

$$\mathbf{b} = \begin{bmatrix} \%\Delta S_1 \\ \%\Delta D_1 \\ \%\Delta S_2 \\ \%\Delta D_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

The solution matrix (x) is:

$$\mathbf{x} = \begin{bmatrix} \%\Delta Q_1 \\ \%\Delta Q_2 \\ \%\Delta P_1 \\ \%\Delta P_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Linear systems of equations can be solved easily with today's computers. For example, R, the software used to develop *An Interactive Text* is an excellent package to solve these kinds of systems. Figure 4.5.1 contains the code needed to replicate the results in Demonstration 4.5.1 within an R session. R is a good choice for this kind of work because it is designed to do matrix operations, is open source, and is widely used across industry, government, and academia. The grey blocks in Figure 4.5.1 are

the commands you would submit to define the matrices or solve the equations. The white blocks show the output that the R commands would generate. Note that the solution in Figure 4.5.1 matches that in Demonstration 4.5.1 for a positive supply shock when the products are substitutes in consumption.

```
## The command below defines and prints the A matrix using the elasticities given in Demonstra
## (case of substitutes).
A<-matrix(c(1, 0, -1.3,    0,
            1, 0,  1.2, -0.5,
            0, 1,    0, -0.9,
            0, 1, -0.6,  1.4),
          nrow=4,byrow=T,
          dimnames=list(c("S1","D1","S2","D2"),c("Q1","Q2","P1","P2"))
          ); A
```

```
##    Q1 Q2   P1   P2
## S1  1  0 -1.3  0.0
## D1  1  0  1.2 -0.5
## S2  0  1  0.0 -0.9
## D2  0  1 -0.6  1.4
```

```
## The command below defines and prints the b vector for a positive 3 percent supply shock to
b<-matrix(c(3,0,0,0),nrow=4,dimnames=list(c("S1","D1","S2","D2"),c("shock")));b
```

```
##    shock
## S1     3
## D1     0
## S2     0
## D2     0
```

```
## The command below finds the solution to the system of equations and rounds it to three deci
x<-round(solve(A,b),digits=3)
## The command below formats the row names and column name of the solution vector and displays
dimnames(x)<-list(c("Q1","Q2","P1","P2"),c("Pct.Change")); x
```

```
##    Pct.Change
## Q1      1.354
## Q2     -0.297
## P1     -1.266
## P2     -0.330
```

Figure 4.5.1: **Using R to find the solution to a two-market equilibrium model.**

Most spreadsheets are also capable of solving these kinds of linear systems. LibreOffice Calc is an open-source spreadsheet program that can take the inverse of a block of cells you define as a matrix and multiply it by a column vector thereby implementing the solution to a market equilibrium model as $\mathbf{x} = \mathbf{A}^{-1}$. The spreadsheet functions needed are *minverse()*, to take the inverse of the $\mathbf{A}$ matrix and *mmult()*, to multiply this inverse by a block of cells containing the exogenous shocks. The *minverse()* and *mmult()* functions (or functions similar to them) are available in spreadsheet programs from commonly used proprietary office suites as well.

Given the power of today's computers, the two-market framework presented above can be expanded to encompass any number of markets. A general system of N markets would be as follows. Once the matrices have been defined, the solution can be found in exactly the same fashion as in the two market case.

$$\begin{bmatrix} 1 & 0 & 0 & \cdots & 0 & -\phi_{11} & -\phi_{12} & \cdots & -\phi_{1N} \\ 1 & 0 & 0 & \cdots & 0 & -\varepsilon_{11} & -\varepsilon_{12} & \cdots & -\varepsilon_{1N} \\ 0 & 1 & 0 & \cdots & 0 & -\phi_{21} & -\phi_{22} & \cdots & -\phi_{2N} \\ 0 & 1 & 0 & \cdots & 0 & -\varepsilon_{21} & -\varepsilon_{22} & -\varepsilon_{2N} & \\ \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \cdots & 1 & -\phi_{N1} & -\phi_{N2} & \cdots & -\phi_{NN} \\ 0 & 0 & 0 & \cdots & 1 & -\varepsilon_{N1} & -\varepsilon_{N2} & \cdots & -\varepsilon_{NN} \end{bmatrix} \begin{bmatrix} \%\Delta Q_1 \\ \%\Delta Q_2 \\ \vdots \\ \%\Delta Q_N \\ \%\Delta P_1 \\ \%\Delta P_2 \\ \vdots \\ \%\Delta P_N \end{bmatrix} = \begin{bmatrix} \%\Delta S_1 \\ \%\Delta D_1 \\ \%\Delta S_2 \\ \%\Delta D_2 \\ \vdots \\ \%\Delta S_N \\ \%\Delta D_N \end{bmatrix}$$

Anymore, computational resources are generally not a limiting factor in analyzing models with many markets. Rather, accurate estimates of the elasticities needed to implement the models can often be challenging. The Food and Agricultural Policy Research Group (FAPRI) maintains models of domestic and international agricultural commodity markets and provides a database of elasticities for agricultural commodities in many regions of the world to use in their modeling efforts. For a time, USDA's Economic Research Service compiled a database of published elasticity estimates. This is no longer an active effort, but the elasticities compiled are available on the agency's website. In some cases, estimates of the needed elasticities will not exist or will be outdated, and it will be necessary to estimate or impute elasticities to use in a modeling problem. The model of fresh berry markets developed by Sobekova (2012) and summarized below illustrates a reasonably simple example of a situation where elasticities had to be developed to parameterize an equilibrium model.

In her MS thesis, Sobekova (2012) estimated the demand elasticities she needed to model markets for fresh berries. She used data from Nielsen on retail berry sales by week across different US cities to estimate own and cross-price elasticities of demand for strawberries, blueberries, blackberries, and raspberries. She did not directly estimate retail-level supply elasticities but was able to develop reasonable estimates of farm-level supply elasticities from earlier work. She then gathered data from USDA's Agricultural Marketing Service on value of fresh berries at shipping-point locations and estimated the an elasticity of price transmission, τ_i, between the farm and retail levels of the market. This allowed her to express retail-level supply elasticities as

$$\phi_i^R = \tau_i \phi_i^F,$$

where superscripts R and F refer to the retail and farm levels, respectively. Elasticities used in her model are presented below in Table 4.5.1.

Table 4.5.1. Elasticities used in Sobekova's (2012) model of the retail berry market

Type of berry	P_{sb}	P_{bb}	P_{bk}	P_{rb}	Farm Supply	Price Transmission	Retail Supply
Strawberries (sb)	-1.26	0.32	0.52	0.39	0.30	0.98	0.29
Blueberries (bb)	0.12	-1.49	0.24	0.20	0.22	0.40	0.09
Blackberries (bk)	0.05	0.06	-1.88	0.06	0.20	0.47	0.09
Raspberries (rb)	0.08	0.10	0.13	-1.66	0.21	0.59	0.12

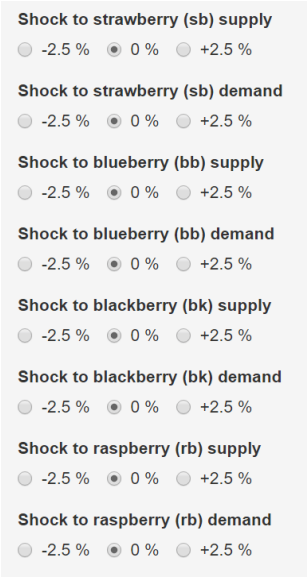
Note: Demand elasticities are in the first four columns of the table and can be interpreted as the the elasticity of retail demand for the product on the row with respect to the price in column.

Notice from the table that the own-price demand elasticities are all in the elastic range. All the cross-price elasticities are positive indicating that consumers view the different types of berries as substitutes. Demonstration 4.5.2 presents the equilibrium model in matrix form. There are eight endogenous variables as shown in the column headings for the A matrix and in the solution vector. These consist of percentage changes in four quantities and four prices, corresponding to each of the four types of berries in the model. You can control exogenous demand or supply shocks using the radio buttons in the left panel of the demonstration. Take a moment to verify how the elasticities in Table 4.5.1 translate into matrix A in Demonstration 4.5.2.

Use Demonstration 4.5.2 to consider the effect of a positive supply shock to one of the markets. Make sure all demand shocks are set to zero, then add a positive supply shock to one and only one of the markets. This will increase revenue to producers in the market experiencing the positive supply shock. You can see this because the positive change in quantity is larger in magnitude than the negative change in price. The impact of the shock on producers in the remaining berry markets is negative. Demand decreases in each market not affected by the shock because the remaining berries are substitutes in demand.

Now consider the effect of a positive demand shock to one of the markets. Make sure all supply shocks are set to zero, then add a positive shock to one and only one of the markets. The impact is biggest on the market experiencing the demand shock but the spillover effects cause an increase in price and quantity in each of the related markets as well. Spend some time with the demonstration by considering other shocks to demand and or supply. if you want to test your knowledge, see if you can replicate this model in a spreadsheet or in R.

Demonstration 4.5.2. Interactive implementation of Sobekova's (2012) model for retail fresh berry markets.



Matrix A

	Qsb	Qbb	Qbk	Qrb	Psb	Pbb	Pbk	Prb
Supply sb	1	0	0	0	-0.29	0.00	0.00	0.00
Demand sb	1	0	0	0	1.26	-0.32	-0.52	-0.39
Supply bb	0	1	0	0	0.00	-0.09	0.00	0.00
Demand bb	0	1	0	0	-0.12	1.49	-0.24	-0.20
Supply bk	0	0	1	0	0.00	0.00	-0.09	0.00
Demand bk	0	0	1	0	-0.05	-0.06	1.88	-0.06
Supply rb	0	0	0	1	0.00	0.00	0.00	-0.12
Demand rb	0	0	0	1	-0.08	-0.10	-0.13	1.66

Vector b

	Pct. Shock
Supply sb	0
Demand sb	0
Supply bb	0
Demand bb	0
Supply bk	0
Demand bk	0
Supply rb	0
Demand rb	0

Solution Vector

	Pct. Change
Qsb	0
Qbb	0
Qbk	0
Qrb	0
Psb	0
Pbb	0
Pbk	0
Prb	0

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4.6: Concluding Comments

This chapter provided an opportunity to put almost everything you have learned up to this point in the course to work. In particular, you have learned how to use elasticities of demand an supply within a modeling framework to predict the effects of an exogenous shock on the market price and quantity. You have also learned how to use elasticities to estimate the exogenous shocks that go into your model. Problems Sets and 1 and 2 below are intended to reinforce these concepts within the context of a single market.

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4.7: References

Bates, C. 2016. “When Foot-and-Mouth Disease Stopped the UK in its Tracks” *BBC News Magazine*. Published online February 17. http://www.bbc.com/news/magazine-35581830

Paarlberg, Philip L., John G. Lee, and Ann H. Seitzinger. 2002. “Potential Revenue Impact of an Outbreak of Foot-and-Mouth Disease in the United States.” *Journal of the American Veterinary Medical Association* 220(7):988-92.

Paarlberg, Philip L., Ann Hillberg Seitzinger, John G. Lee, and Kenneth H. Mathews, Jr. 2008. *Economic Impacts of Foreign Animal Disease*. ERR-57. U.S. Dept. of Agriculture, Econ. Res. Serv. Available at: https://www.ers.usda.gov/webdocs/publications/45980/12163_err57fm_1_.pdf?v=41056

Sobekova, K. 2012. *Market Analysis of Fresh Berries in the United States* University of Arkansas, MS Thesis.

USDA-APHIS. 2013a. “Factsheet: Food-and-Mouth Disease.” Available at: www.aphis.usda.gov/publications/animal_health/2013/fs_fmd_general.pdf

USDA-APHIS. 2013b. “Factsheet: Protecting America From Foot-and-Mouth Disease and Other High-Consequence Livestock Diseases.” Available at: www.aphis.usda.gov/publications/animal_health/2013/fs_fmd_hcd_protection.pdf

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4.8: Problem Sets

Problem Set 1: Use Elasticities for Exogneous Variables to Estimate Shocks and Changes to an Equilibrium. In this problem set you can assume that it is appropriate to treat W and M as exogenous variables.

Exercise 4.8.1

Given the following:

$\phi_{11} = 0.5$

$\phi_{1W} = -0.15$

$\varepsilon_{11} = -1.5$

$\varepsilon_{1M} = -0.5$

$\%\Delta M = 6$

$\%\Delta W = 0$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.2

Given the following:

$\phi_{11} = 1.5$

$\phi_{1W} = -0.25$

$\varepsilon_{11} = -1.75$

$\varepsilon_{1M} = 0.5$

$\%\Delta M = 5$

$\%\Delta W = 3$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.3

Given the following:

$\phi_{11} = 0.5$

$\phi_{1W} = -0.3$

$\varepsilon_{11} = -2$

$\varepsilon_{1M} = -0.4$

$\%\Delta M = 8$

$\%\Delta W = 0$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.4

Given the following:

$\phi_{11} = 2$

$\phi_{1W} = -0.1$

$\varepsilon_{11} = -3$

$\varepsilon_{1M} = 0.3$

$\%\Delta M = 0$

$\%\Delta W = 8$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.5

Given the following:

$\phi_{11} = 0.5$

$\phi_{1W} = -0.2$

$\varepsilon_{11} = -1.5$

$\varepsilon_{1M} = 0.4$

$\%\Delta M = 5$

$\%\Delta W = 4$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.6

Given the following:

$\phi_{11} = 0.25$

$\phi_{1W} = -0.3$

$\varepsilon_{11} = -1.75$

$\varepsilon_{1M} = 0.5$

$\%\Delta M = 0$

$\%\Delta W = 8$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.7

Given the following:

$\phi_{11} = 1$

$\phi_{1W} = -0.5$

$\varepsilon_{11} = -2$

$\varepsilon_{1M} = -0.5$

$\%\Delta M = 5$

$\%\Delta W = 8$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.8

Given the following:

$\phi_{11} = 0.5$

$\phi_{1W} = -0.7$

$\varepsilon_{11} = -3$

$\varepsilon_{1M} = 0.4$

$\%\Delta M = 0$

$\%\Delta W = 2$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.9

Given the following:

$\phi_{11} = 1.5$

$\phi_{1W} = -0.5$

$\varepsilon_{11} = -1.75$

$\varepsilon_{1M} = -0.6$

$\%\Delta M = 5$

$\%\Delta W = 6$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.10

Given the following:

$\phi_{11} = 0.75$

$\phi_{1W} = -0.2$

$\varepsilon_{11} = -1.75$

$\varepsilon_{1M} = -0.4$

$\%\Delta M = 7$

$\%\Delta W = 0$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Problem Set 2: Use Per Unit Cost or Valuation Estimates to Compute Shocks and Changes to an Equilibrium

Exercise 4.8.1

Given the following:

$\phi_{11} = 1.5$

$\varepsilon_{11} = -1$

Per unit change in production cost is 8%

Per unit change in willingness to pay is $= 3\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.2

Given the following:

$\phi_{11} = 1$

$\varepsilon_{11} = -2$

Per unit change in production cost is 0%

Per unit change in willingness to pay is $= -6\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.3

Given the following:

$\phi_{11} = 0.5$

$\varepsilon_{11} = -2$

Per unit change in production cost is 6%

Per unit change in willingness to pay is $= 7\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.4

Given the following:

$\phi_{11} = 2$

$\varepsilon_{11} = -6$

Per unit change in production cost is -2%

Per unit change in willingness to pay is $= -3\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.5

Given the following:

$\phi_{11} = 2$

$\varepsilon_{11} = -3$

Per unit change in production cost is 0%

Per unit change in willingness to pay is $= 5\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.6

Given the following:

$\phi_{11} = 1.5$

$\varepsilon_{11} = -1.75$

Per unit change in production cost is -5%

Per unit change in willingness to pay is $= -5\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.7

Given the following:

$\phi_{11} = 1$

$\varepsilon_{11} = -4$

$\text{Per unit change in production cost is } -4\%$

$\text{Per unit change in willingness to pay is } = 0\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.8

Given the following:

$\phi_{11} = 2$

$\varepsilon_{11} = -3$

$\text{Per unit change in production cost is } -6\%$

$\text{Per unit change in willingness to pay is } = 0\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.9

Given the following:

$\phi_{11} = 1.5$

$\varepsilon_{11} = -1.75$

Per unit change in production cost is 5%

Per unit change in willingness to pay is $= 5\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Exercise 4.8.10

Given the following:

$\phi_{11} = 0.5$

$\varepsilon_{11} = -0.75$

Per unit change in production cost is 6%

Per unit change in willingness to pay is $= -7\%$

What is the supply shock?

What is the demand shock?

What is the change in equilibrium price?

What is the change in equilibrium quantity?

Answer available at the end of this section.

Problem Set 3: Multiple Choice

Exercise 4.8.1

1. **Which best describes a market equilibrium?**

a) A price such that quantity supplied equals quantity demanded.

b) The confluence of exogenous factors that alter conditions within the market in question.

c) Forces that cause changes in price and or quantity in a market.

d) A situation where prices reach what many consider to be reasonable levels. For instance, the market for gasoline has finally returned to an equilibrium after several years of high prices.

Answer available at the end of this section.

Exercise 4.8.2

2. **In equilibrium models, endogenous variables**

a) Are variables that cause shifts in the demand and supply curves.

b) Are prices and quantities in the markets being analyzed.

c) Are non-existent because all variables are exogenous in these models.

d) Are difficult to measure but still affect the equilibrium (e.g., changes in preferences).

Answer available at the end of this section.

Exercise 4.8.3

3. **If you are modeling a market equilibrium and you need to account for feedback from other markets or sectors of the economy then you should be using**

a) A partial equilibrium model.

b) A feedback accountability model.

c) A general equilibrium model.

d) A model that forces cross-price elasticities to be negative.

Answer available at the end of this section.

Exercise 4.8.4

4. **Consider a single market. Which would be most likely to cause an increase in both the equilibrium price and the equilibrium quantity?**

a) A positive supply shock

b) A decrease in consumer incomes, assuming demand is for an inferior good

c) A decrease in consumer incomes, assuming demand is for a normal good

d) A negative supply shock

Answer available at the end of this section.

Use the scenario below to answer questions 5 - 8.

Two products are substitutes in consumption and are unrelated in production. The Ukraine is a major supply source for Product 1. Given the current conflict in Eastern Ukraine, the supply for Product 1 (Market 1) shifts inwards (to the left).

Exercise 4.8.5

5. **Which of the following do you know will happen in Market 1?**

a) Equilibrium quantity in Market 1 will increase

b) Equilibrium price in Market 1 will decrease

c) Equilibrium price in Market 1 will increase

d) Both a and c

Answer available at the end of this section.

Exercise 4.8.6

6. **Which of the following do you know will happen in Market 2?**

a) Nothing because the supply shock was in Market 1.

b) Equilibrium price in Market 2 will increase

c) Equilibrium price in Market 2 will decrease

d) Equilibrium quantity in Market 2 will increase

e) Both b and d.

Answer available at the end of this section.

Exercise 4.8.7

7. **After considering feedback between these two markets. Which, if any, of the following schedules have not shifted once a new equilibrium is reached?**

a) Supply in Market 1

b) Supply in Market 2

c) Demand in Market 1

d) Demand in Market 2

e) All of the above schedules have shifted

Answer available at the end of this section.

Exercise 4.8.8

8. **Which best describes the exogenous shock in this situation?**

a) The conflict that led to the supply shift to Market 1

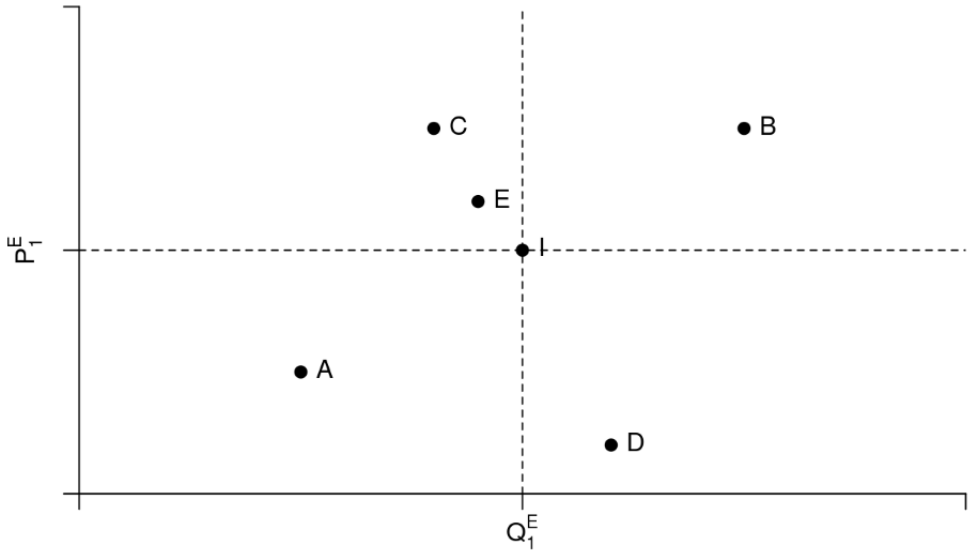
b) The change in equilibrium price in Market 1

c) The feedback from Market 2 into Market 1

d) All of the above.

Answer available at the end of this section.

Use the diagram below to answer questions 9 - 12.



Exercise 4.8.9

1. Point D only
2. Points C, D, and E
3. Points B and A
4. Points C and E
5. None of the points

Answer available at the end of this section.

Exercise 4.8.10

10. **In which cases do you know for certain that demand has increased relative to the original equilibrium at point I?**

a) Point B

b) Points C and E

c) Points B and A

d) Points A

e) None of the points

Answer available at the end of this section.

Exercise 4.8.11

11. **In which cases do you know for certain that supply has decreased relative to the original equilibrium at point I?**

a) Point B

b) Points C and E

c) Points B and A

d) Points A

e) None of the points

Answer available at the end of this section.

Exercise 4.8.12

12. **In which cases do you know for certain that both demand and supply have shifted from the original equilibrium at point I?**

a) Point B

b) Points C and E

c) Points B and A

d) Points A

e) None of the points

Answer available at the end of this section.

Answers

Exercise 4.8.1

Supply Shock : $S = 0$
Demand Shock : $D = -3$
$\%\Delta P_1 = -1.5$
$\%\Delta Q_1 = -0.75$

Exercise 4.8.2

Supply Shock : $S = -0.75$
Demand Shock : $D = 2.5$
$\%\Delta P_1 = 1$
$\%\Delta Q_1 = 0.75$

Exercise 4.8.3

Supply Shock : $S = 0$
Demand Shock : $D = -3.2$
$\%\Delta P_1 = -1.28$
$\%\Delta Q_1 = -0.64$

Exercise 4.8.4

Supply Shock : $S = -0.8$
Demand Shock : $D = 0$
$\%\Delta P_1 = 0.16$
$\%\Delta Q_1 = -0.48$

Exercise 4.8.5

Supply Shock : $S = -0.8$
Demand Shock : $D = 2$
$\%\Delta P_1 = 1.4$
$\%\Delta Q_1 = -0.1$

Exercise 4.8.6

Supply Shock : $S = -2.4$
Demand Shock : $D = 0$
$\%\Delta P_1 = 1.2$

$\%\Delta Q_1 = -2.1$

Exercise 4.8.7

Supply Shock : $S = -4$

Demand Shock : $D = -2.5$

$\%\Delta P_1 = 0.5$

$\%\Delta Q_1 = -3.5$

Exercise 4.8.8

Supply Shock : $S = -1.4$

Demand Shock : $D = 0$

$\%\Delta P_1 = 0.4$

$\%\Delta Q_1 = -1.2$

Exercise 4.8.9

Supply Shock : $S = -3$

Demand Shock : $D = -3$

$\%\Delta P_1 = 0$

$\%\Delta Q_1 = -3$

Exercise 4.8.10

Supply Shock : $S = 0$

Demand Shock : $D = -2.8$

$\%\Delta P_1 = -1.12$

$\%\Delta Q_1 = -0.84$

Exercise 4.8.1

Supply Shock : $S = -12$

Demand Shock : $D = 3$

$\%\Delta P_1 = 6$

$\%\Delta Q_1 = -3$

Exercise 4.8.2

Supply Shock : $S = 0$

Demand Shock : $D = -12$

$\%\Delta P_1 = -4$

$\%\Delta Q_1 = -4$

Exercise 4.8.3

Supply Shock : $S = -3$

Demand Shock : $D = 14$

$\%\Delta P_1 = 6.8$

$\%\Delta Q_1 = 0.4$

Exercise 4.8.4

Supply Shock : $S = 4$

Demand Shock : $D = -18$

$\%\Delta P_1 = -2.75$

$\%\Delta Q_1 = -1.5$

Exercise 4.8.5

Supply Shock : $S = 0$

Demand Shock : $D = 15$

$\%\Delta P_1 = 3$

$\%\Delta Q_1 = 6$

Exercise 4.8.6

Supply Shock : $S = 9$

Demand Shock : $D = -10.5$

$\%\Delta P_1 = -6$

$\%\Delta Q_1 = 0$

Exercise 4.8.7

Supply Shock : $S = 4$

Demand Shock : $D = 0$

$\%\Delta P_1 = -0.8$

$\%\Delta Q_1 = 3.2$

Exercise 4.8.8

Supply Shock : $S = 12$

Demand Shock : $D = 0$

$\%\Delta P_1 = -2.4$

$\%\Delta Q_1 = 7.2$

Exercise 4.8.9

$\text{Supply Shock} : S = -7.5$

$\text{Demand Shock} : D = 8.75$

$\%\Delta P_1 = 5$

$\%\Delta Q_1 = 0$

Exercise 4.8.10

$\text{Supply Shock} : S = -3$

$\text{Demand Shock} : D = -5.25$

$\%\Delta P_1 = -1.8$

$\%\Delta Q_1 = -3.9$

Exercise 4.8.1

a

Exercise 4.8.2

b

Exercise 4.8.3

c

Exercise 4.8.4

b

Exercise 4.8.5

c

Exercise 4.8.6

e

Exercise 4.8.7

b

Exercise 4.8.8

a

Exercise 4.8.9

c

Exercise 4.8.10

a

Exercise 4.8.11

b

Exercise 4.8.12

e

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5: CONSUMER BEHAVIOR IN AGRICULTURE

Learning Objectives

- Explain the main logic of consumer choice theory in terms of preferences and budget sets.
- Graph budget sets and budget frontiers, given price and income data, and explain what happens to the budget set as prices and/or income change.
- Outline the basic assumptions required for well-behaved preferences. Given a specific example, be able to determine whether these assumptions are satisfied.
- Describe the difference between ordinal utility and cardinal utility.
- Graphically derive individual demand functions.
- Diagram efficient consumption frontiers (Lancaster-type budget constraints) and identify products that are and are not competitive.
- Analyze how changes in price, income, and product characteristics affect consumer choice in Lancaster's framework.
- Describe hedonic pricing models and identify characteristics to be included in a hedonic pricing model for a given product.
- Derive the full-time income constraint of Becker's model.
- Use the logic of Becker's model to explain consumer valuation of time-saving (convenience) built into food products.
- Use the logic of Lancaster's and Becker's models to analyze trends in food consumption.

You may have encountered the idea of popular sovereignty in a civics or political science course. This means that the people rule, as opposed to a monarch, dictator, clique of oligarchs, religious authorities, etc. When it comes to the economy, it is often said that consumers are sovereign. Consumer sovereignty is the idea that consumer choices rule the economy. A firm that provides a product or service that better meets consumer wants and needs is likely to succeed and be profitable. A firm that fails to do so will not remain in business very long, or so the theory goes. Evidence that businesses recognize the importance of consumer sovereignty is provided by placards common in many workplaces reminding employees that "the customer is always right." This notion is also encapsulated in the Latin phrase, *De gustibus non disputatum est*, which translates into English as "tastes are not disputable".

Consumer sovereignty helps explain the breadth of production and marketing activities observed in the economy. To illustrate, consider children's breakfast cereals. Lots of money is spent on the packaging and promotion of these products. Even if it can be assumed that these cereals are good for children, a critic might argue that everyone would be better off if an entity was set up to simply take flour from oats, rice, corn, or wheat; add sugar and a binding agent; pellet it; and distribute it to families with children. Children would get the same nutrition regardless of whether there was a friendly looking pirate on the box and a cheap toy inside. The critic could argue that all the money that is spent on promoting these products is wasteful and contributes nothing to the nutritional well-being of children. These resources could instead be better used for a worthwhile cause like cancer research or public education. This critic may have a point, but consumer sovereignty suggests that if parents continue to vote with their purchases in favor of branded breakfast cereals (or if children have the power to influence their parents to do so), breakfast cereal companies will exist to meet this demand.

If consumers are sovereign, then it is probably a good idea to consider models of consumer behavior in a course like this. The aim of this chapter is to provide an overview of some economic theories of the consumer. The first section addresses the neoclassical theory of the consumer. Two extensions of this theory that have particular resonance in food markets are covered next. One is Lancaster's (1966) model, which emphasizes products as delivery mechanisms for characteristics. The other, Becker's (1965) model, theorizes that market-sourced products are inputs for household production activities. All three of three of these models – the Neoclassical model, Lancaster's model, and Becker's model – are based on the idea that consumers are rationale. They know what they want and what is available. Moreover they can make choices that are best for them given what they are able to afford. The primary objectives of this chapter are as follows:

5.1: Neoclassical Consumer Theory

5.2: Lancaster's (1966) Characteristics Model

5.3: Becker's (1965) Household Production Model

5.4: Welfare Economics - Consumer and Producer Surplus
5.5: Concluding Comments
5.6: References
5.7: Problem Sets

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5.1: Neoclassical Consumer Theory

The basic idea behind consumer choice theory is very simple: The consumer seeks to obtain the best bundle of goods and services that he or she possibly can (Varian 1993). This is true of the neoclassical theory covered in this section as well as the extension to the theory to be described below. In deciding what is the best bundle of goods and services, economists generally assume that the consumer has preferences that can be represented by a utility function. The utility function assigns a number to a given bundle of goods and services. A bundle that the consumer likes more is assigned a higher number. A bundle that the consumer likes less is assigned a lower number. A utility function formalizes the idea that consumers have the ability to rank various bundles of goods and services in terms of their desirability.

Preferences represented by a utility function determine the "best" bundle of goods and services. However, think carefully about the fundamental idea that a consumer chooses the best bundle of goods and services that he or she possibly can. The "possibly can" part of the idea is very important. A consumer's best bundle might include several multimillion-dollar homes: one at a ski resort in the Rockies or Alps, one on the north shore of Lake Superior (for summer months), and one in the Virgin Islands (for winter months when not on the ski slopes). Of course, the best bundle would also include a private jet to take the consumer wherever he or she fancied. Very few people could obtain this best bundle. This is because the dollars consumers have to spend is limited by their available income.

We could reformulate our fundamental idea in terms of economic jargon as follows: consumers maximize their utility subject to a budget or income constraint. The utility function determines what is best. The budget or income constraint determines the set of possible bundles that the consumer can obtain.

Budget Sets in the Neoclassical Model

The ***budget set*** contains all combinations of goods that the consumer can afford. In this course, simple budget sets that include only two goods will be used. Such a simplification may not work well in empirical applications using real-world data because each consumer probably has hundreds, if not thousands, of possible goods in their budget set (just think about the wide variety of goods available in any supermarket, department store, or online retailer). However, all models are simplifications, and in terms of understanding consumer choice behavior, a two-good world can get you a long way. With a simple two-good world you can develop an understanding of the essential logic of the consumer choice model. Simplifying the world to only two goods also allows the consumer's choice space to be represented graphically (as in Demonstration 1 below).

Algebraically, the budget set is defined over the quantities of the two goods, Q_1 and Q_2 as all pairs:

$$Q_1, Q_2 : P_1 Q_1 + P_2 Q_2 \leq M,$$

where P_1 and P_2 are prices of goods 1 and and 2, respectively, and M is the consumer's income. The budget set simply states that the amount spent on good 1 plus the amount spent on good 2 must be less than the consumer's income.

The ***budget frontier*** consists of those bundles that completely exhaust the consumer's income. In the expression for the budget set above, replace the inequality with an equal sign and you have those points that comprise the budget frontier. Because Q_2 will be on the vertical axis this expression for Q_2. This is the equation for the budget frontier:

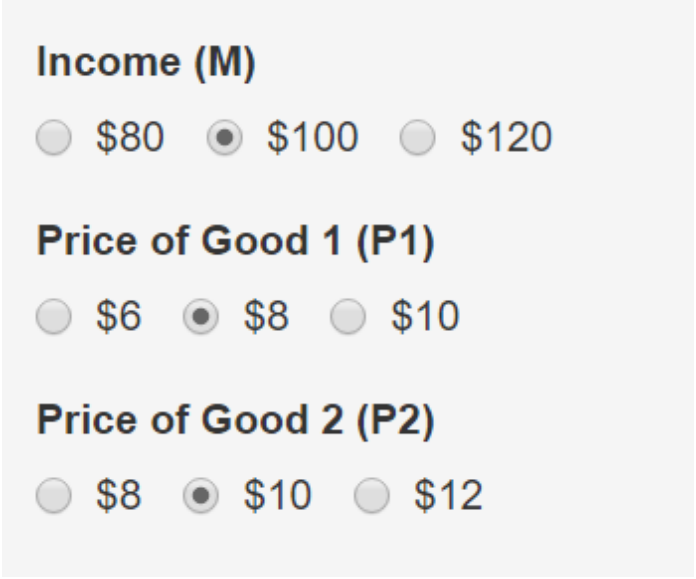
$$Q_2 = \frac{M}{P_2} - \frac{P_1}{P_2} Q_1.$$

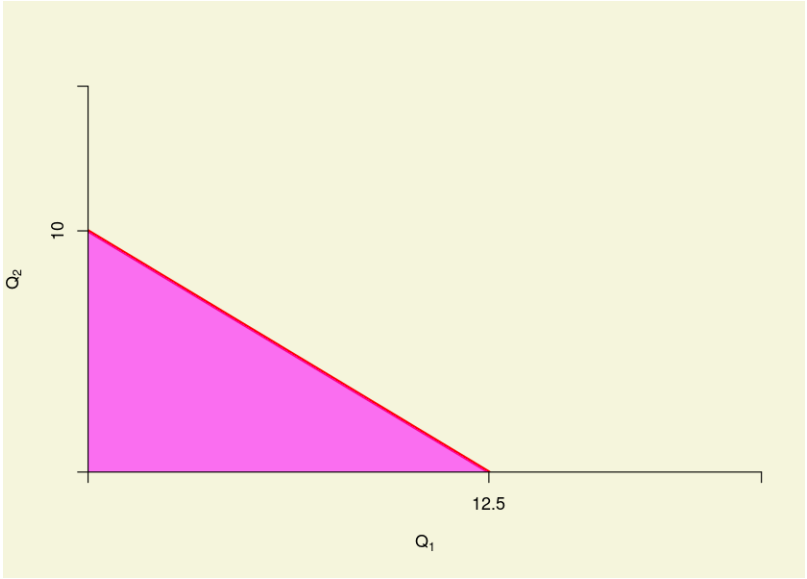
An example budgets set is presented in Demonstration $5.1.1$. Note that this is a line with a vertical intercept of $\frac{M}{P_2}$ and a slope of $-\frac{P_1}{P_2}$

There is an easy way to graph the budget set in a two-good economy. The vertical intercept is where the consumer spends all of his or her income on good 2. You only need to ask how many units of good 2 the consumer could afford if the entire budget went to good 2. The answer is $\frac{M}{P_2}$. The horizontal intercept can similarly be found be asking how many units of good 1 could be obtained if the consumer spend all his/her money on good 1, which is $\frac{M}{P_1}$. Thus if you know M, P_1, and P_2, you can, in a matter of

seconds, graph the consumer's budget frontier. Simply divide M by P_2 to get your vertical intercept, divide M by P_1 to get your horizontal intercept, and connect the dots. It is as easy as that! You now have your frontier. The budget set is comprised of the points on the frontier and the points south and west of the frontier.

Demonstration 5.1.1. The Budget Set





First, use Demonstration 5.1.1 to see what happens to the budget set when P_1 and/or P_2 changes. Start by increasing one of the prices, P_1 or P_2, but not both. The price increase changes the slope of the frontier because the intercept for the axis with the now higher-priced good moves towards the origin. The entire budget set becomes smaller. You will see a triangular area comprised of points that the consumer was able to afford before the price increase but can no longer afford afterwards. Now, go ahead and increase the other price as well. This further contracts the budget set. Finally, set the prices back to their initial values. Repeat the process for a price decrease and note what happens to the budget set. The takeaway here is that price changes affect both the size of the budget set and slope of the budget frontier.

Second, use Demonstration 5.1.1 to evaluate a change in income (M). Decrease the consumer's income in the demonstration and notice that both the vertical and horizontal intercepts contract towards the origin. The budget frontier line makes a parallel shift to the southwest. The entire budget set becomes smaller. Repeat the process for an increase in income and note what happens to the budget set. The conclusion to be drawn is that a change in income affects the size of budget set but not the slope of the budget frontier.

Preferences in the Neoclassical Model

A budget set identifies what bundles are affordable to a consumer. The fundamental idea behind consumer theory is that a consumer will choose the best bundle from this set. Just what this "best" bundle is depends on the consumer's preferences. To facilitate a discussion of preferences, it will be useful to introduce some preference relations that we can use to indicate how the consumer views different bundles. These relations are defined in Table 5.1.1.

Table 1. Preference Relations

Relation	Name	Example	Interpretation
$\approx$	Indifference	$x \approx y$	x is indifferent to y
$\succeq$	Weakly preferred	$x \succeq y$	x is at least as good as y
$\succ$	Strictly preferred	$x \succ y$	x is better than y

Representing Preferences Graphically

In introductory microeconomics, you probably learned about indifference curves (they might also have been called iso-utility curves). Figure 5.1.1 presents indifference curves that represent a consumer's preferences. Each labeled point in Figure 5.1.1 represents a bundle of the two goods. The curves are called indifference curves because they represent bundles that the consumer likes equally well. Unless, you are instructed otherwise, you are to assume that points on indifference curves to the northeast are increasingly preferred. For instance, E is preferred to all labeled bundles on this diagram because it lies on the indifference curve that is furthest northeast. Based on Figure 5.1.1, it is possible to make the following statement about the five labeled bundles:

$$E \succ D \approx C \succ B \approx A.$$

Given the preference relations defined above, the following are also true, although less precise, statements of the preference ordering for the consumer with the preference map in Figure 5.1.1:

$$E \succeq D \succeq C \succeq B \succeq A,$$

and

$$E \succeq C \succeq D \succeq A \succeq B$$

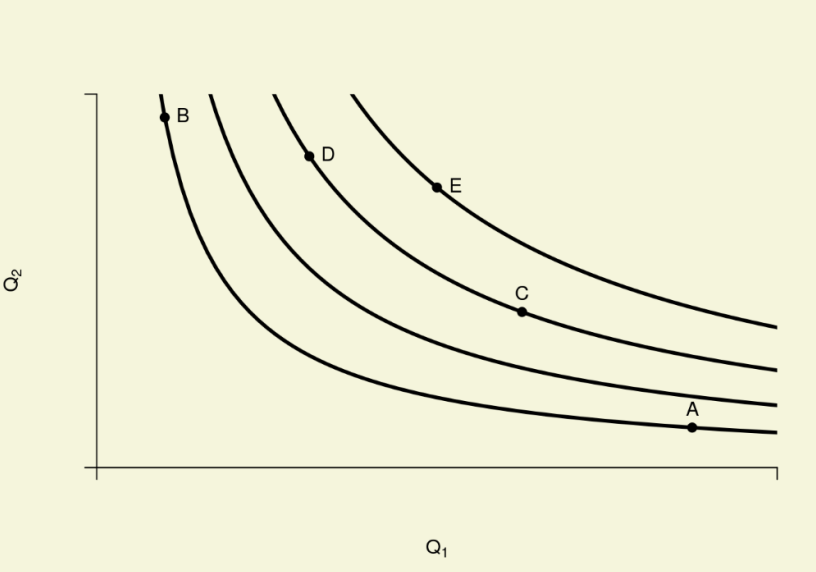


Figure 5.1.1: **Graphical representation of preferences.**

Utility Functions

A preference map, such as that in Figure 5.1.1, is a two-dimensional representation of a utility function. The important thing about a utility function is that it assigns numbers that indicate the consumer's strength of preference for a given bundle. If the consumer likes bundle C more than bundle A, then a utility function would assign a higher number to bundle C and a lower number to bundle A. If the consumer likes bundle B just as much as bundle A, then the utility function would assign the same number to both bundles A and B. There is an important concept here. This concept is that a utility function provides an ***ordinal*** (not ***cardinal***) ranking of preferences. With an ordinal utility function, one does not particularly care about the utility number itself, only that higher numbers are assigned to bundles the consumer likes more, lower numbers to bundles the consumer likes less, and that the same number is assigned to bundles the consumer likes equally well.

Figure 5.1.2 depicts a utility function. The function is in blue tones and shows the level of utility corresponding to different combinations of goods 1 and 2. The horizontal plane in the figure, depicted in green, intersects the utility function at a specified height. The intersection between the plane and function provides all combinations of goods 1 and 2 that provide the consumer with level of utility equal to the height of the plane. If you were to look at the utility function directly from above, you would see that the intersection of the plane with the function maps out an indifference curve. Thus, an indifference curve map, such as that shown in Figure 5.1.1, is actually a two dimensional representation of a three dimensional phenomenon. Each indifference curve depicts a given height on the utility function.

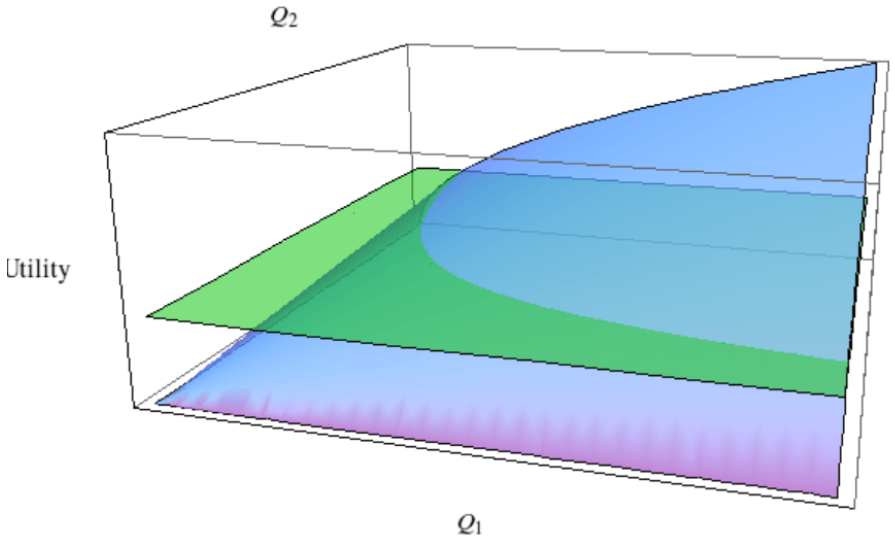


Figure 5.1.2: **An indifference curve depcits the level of utility from a utility function.**

Assumptions About Preferences

There are several assumptions that are commonly made about preferences. These assumptions simplify the consumer's choice problem and also result in individual demand equations that conform to the law of demand.

Preferences are complete. If preferences are complete, it means that the consumer is able to rank bundles. This is not unreasonable assumption in most cases. If you were given a choice between two packages of almonds with one apple (bundle A) or one package of almonds with two apples (bundle B), you could probably indicate which bundle you most preferred or whether you were indifferent between the two.

Preferences are transitive. Transitive preferences simply mean that if $C \succeq B$, and $B \succeq A$, then it must be that $C \succeq A$. Like completeness, transitivity is a fairly straightforward assumption. The transitivity assumption assures that indifference curves will never intersect one another.

That preferences are **reflexive** and **continuous** are additional basic assumptions about preferences which are important to formal mathematical treatment of consumer theory but are of less practical importance in a course like this. The important thing is that if preferences are complete, transitive, reflexive, and continuous; there is an ordering of preferences that can be represented

by a utility function (Varian 1992). It is common to make two additional assumptions about preferences and these are of more practical importance in this course. The first is that preferences are convex and the second is that preferences are monotonic.

Preferences are convex. Convexity is a common assumption made about preferences. Given (1) the consumer likes bundle A exactly as much as bundle B ($A \approx B$), and (2) bundle A is not the same bundle as bundle B ($A \neq B$), preferences are strictly convex if the consumer prefers an average bundle $C = 0.5A + 0.5B$ to either bundle A or B by itself. Convexity implies that consumers like to have variety in their consumption. Another way to say this is that "means are preferred to extremes."

In most cases, convexity is a reasonable assumption. It is actually hard to come up with cases where convexity might not hold. Suppose, for example, that a consumer likes cocktail olives and that the consumer also like chocolate ice cream. However, ice cream does not pair well with olives and so the the consumer does not like to have cocktail olives with his/her ice cream. In this case, you might argue that the consumer would prefer an extreme bundle (all cocktail olives or all ice cream) to a mean bundle (some cocktail olives and some ice cream) and his or her preferences would not be convex. This example is a bit stretched, however. It assumes that that the consumer would somehow be forced to eat cocktail olives and ice cream at the same time. Why could he or she not eat the ice cream now and save the olives for later? Over the course of the day, the consumer may want to have something sweet with lunch (ice cream) and something savory with supper (cocktail olives). Thus, even though he or she does not like cocktail olives and ice cream at the same time, preferences are still convex because the consumer likes a variety of sweet and savory foods over the course of a day.

Preferences are monotonic. The second additional assumption is that preferences are monotonic. Monotonicity simply means that the consumer prefers bundles with more goods to bundles with less. Given two bundles, bundles A and B, monotonicity means the consumer prefers B to A if:

1. B contains at least as much of each good as does A, and
2. B contains strictly more of at least one good than does A.

Is monotonicity a reasonable assumption? At first glance it would seem that it is not because there are some goods where too much of a good becomes a bad. For example, after eating two sandwiches, the consumer could be sick, literally, if forced to eat a third. That said, an argument can be made that monotonicity is a very reasonable assumption for models of the consumer. This is because consumers make market choices only in regions where their preferences are monotonic. For example, if a consumer is waiting in line to purchase a sandwich it is a pretty good assumption that an additional sandwich is something he or she wants and that preferences are monotonic at least with respect to one more sandwich. In short, consumers are only in the market when they want more of a good or when they have monotonic preferences for the good in question. The goal of the consumer model is to provide a reasonable approximation to what occurs in the real world. If, in the real world, consumers are only making choices in regions where monotonicity holds, then it is a reasonable to assume monotonicity for preferences used in the consumer model.

Choice in the Neoclassical Model

Having covered budget sets and preferences in some detail, let us now return to the basic idea of consumer theory: Consumers choose the best bundle of goods and services that they possibly can. The "best" part of the idea is given by preferences. The "possibly can" part of the idea is determined by budget sets. In the parlance of the model, the consumer's problem is to achieve the highest indifference curve possible given the budget set.

Figure $5.1.3$ provides a graphical illustration of the consumer's choice problem. Points A, B, and C are on the frontier of the budget set. At each of these points, the consumer is exhausting all of his/her income. Only point C, however, is optimal. Given convexity, point C is preferred to either A or B. As a result, our utility function places point C on a higher indifference curve. In fact, it is not possible to find a point within the consumer's budget set that is preferred to point C. Thus, point C is the best bundle that the consumer can afford. At point C, the indifference curve is tangent to the budget frontier line.

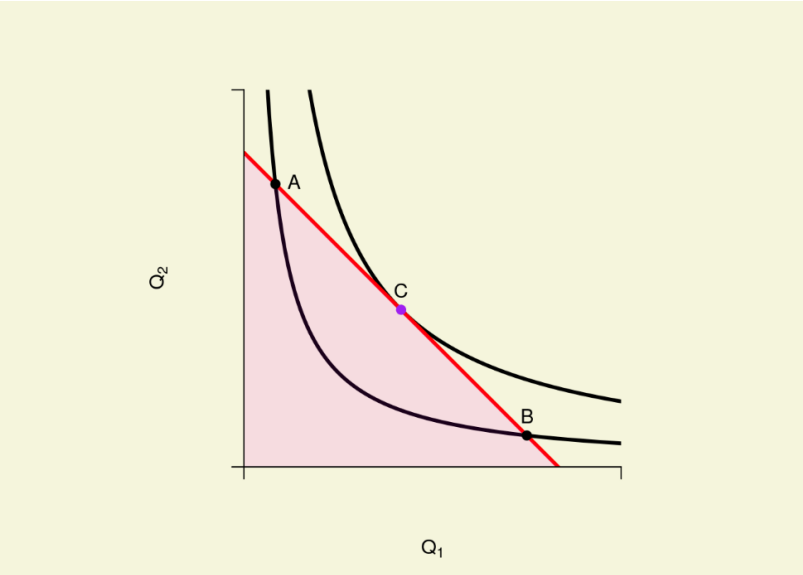


Figure 5.1.3: **Point C is the consumer's optimal choice. If preferences are strictly monotonic and strictly convex, the optimal choice occurs where the indifference curve is tangent to the budget frontier line.**

Again, Figure 5.1.3 is a two-dimensional representation of a three-dimensional phenomenon. Figure 5.1.4, depicts the utility function (blue-toned surface). The yellow-toned vertical plane intersecting the utility function is the budget constraint. The consumer cannot afford points and corresponding levels of utility that lie to the right of this vertical budget plane. The consumer's goal is to reach the highest elevation on the utility function possible. In Figure 5.1.4, this highest level is shown by the purple point. The green-toned horizontal plane is set to the elevation of the affordable point that provides the greatest utility. If the model were to be viewed directly from above, this three-dimensional model would look very similar to the two-dimensional model in Figure 5.1.3. You would see an indifference curve that is created by the intersection of the green horizontal plane and the utility function. This indifference curve would just touch the vertical budget plane at the optimal point.

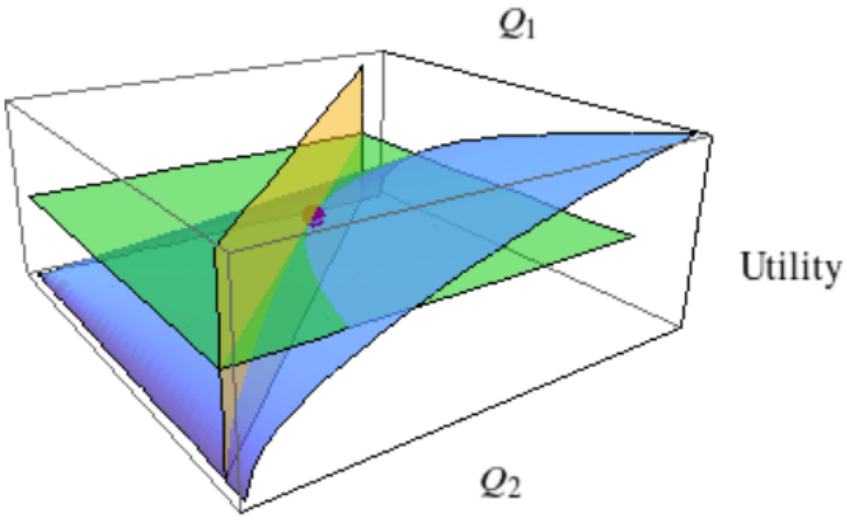


Figure 5.1.4: **The neoclassical choice model in three dimensions.**

Individual Demand Curves

The theory of consumer choice, the idea that the consumers seek the highest point on their utility function given an affordability constraint, can be used to generate demand curves. This is illustrated in Demonstration 5.1.2 below. Notice that as P_1 increases, the consumer's budget set becomes smaller and his or her optimal choice changes to include a smaller amount of Q_1. Conversely as P_1 decreases, the consumer's budget set becomes larger and his or her optimal choice includes a larger amount of Q_1. The

lower panel of the demonstration depicts a mapping of the optimal choices of Q_1 corresponding to different levels of P_1, holding P_2 and M constant. The result is a nice, downward sloping, demand schedule. As you change the value of P_1 in the demonstration, be sure to note the relationship between the choice model in the upper panel and the demand schedule in the lower panel.

Anything aside from own-price that effects the budget sets or the preference map shifts the individual demand curve. For example, in Demonstration $5.1.2$, you can change the level of income. As you do this, notice that the budget set changes and the demand curve shifts. In general, any variable, aside from own-price, that affects the budget set or that effects the preference map will shift the individual's demand schedule.

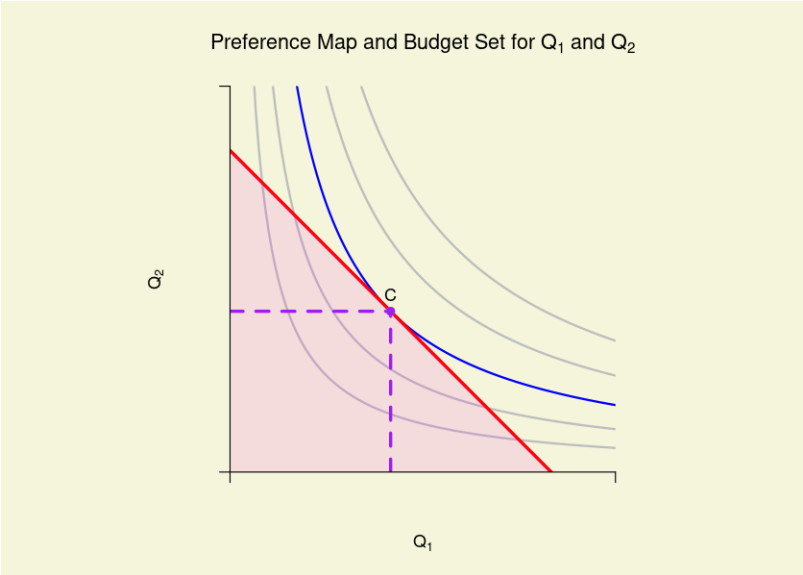
Demonstration $5.1.2$. The Choice Model and the Consumer's Individual Demand Schedule

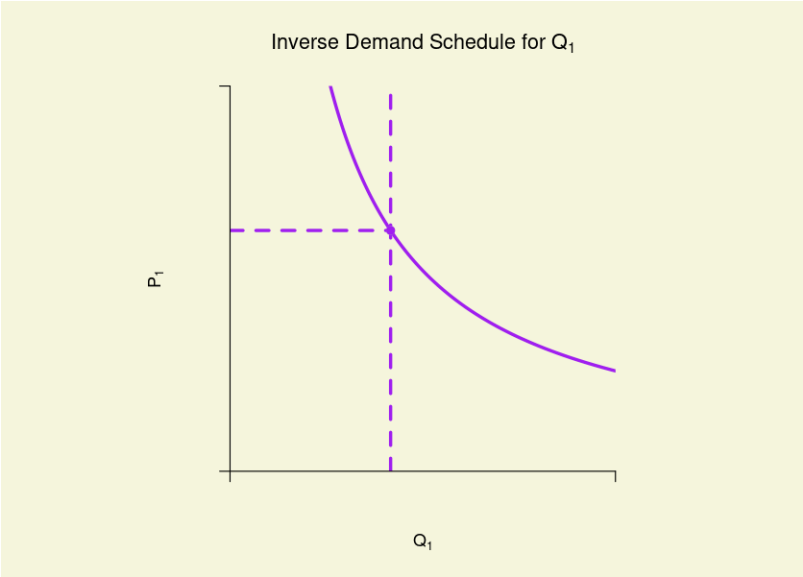
Income (M)

- ○ High
- ◉ Baseline
- ○ Low

Price of Good 1 (P1)

- ○ High
- ○ Moderately High
- ◉ Baseline
- ○ Moderately Low
- ○ Low





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5.2: Lancaster's (1966) Characteristics Model

In the neoclassical model of consumer choice described above, the consumer has preferences that can be represented by a utility function. The solution to the consumer's choice involves a constrained optimization problem wherein the consumer seeks the bundle that returns the highest utility possible given his or her budget set. The benefit of the neoclassical model is that it provides a framework for examining the role of price changes, income changes, and (in some cases) preference changes on consumer behavior. You saw in Demonstration 5.2.2, for example, that given some reasonable assumptions, the solution to the neoclassical choice model results in demand functions that are downward sloping in own-price and that could depend on prices of related substitute and complement goods as well as consumer income.

An alternative formulation of the consumer's choice problem is provided by Lancaster (1966). This model is similar to the neoclassical model in that it relies on the same basic premise: Consumers seek the best bundle of goods given an affordability constraint. However, it differs from the neoclassical model in terms of how preferences and budget sets are formulated.

Preferences in the Lancaster Model

The essential difference in the Lancaster model is that the consumer views a purchased good as a bundle of characteristics. For example, the consumer is not interested in a half gallon of orange juice *per se*. Rather he or she is interested in characteristics such as vitamin C, potassium, a sweet and tart taste sensation, carbohydrates for energy, dietary fiber, etc. The consumer could satisfy the desire for these characteristics through orange juice or through several other products. For example, grapefruit juice might provide similar micro-nutrient characteristics to orange juice but would differ in terms of the taste characteristics provided (less sweet with a slightly bitter aftertaste) and macro-nutrients (perhaps slightly fewer calories). Concord grape juice would lack the tartness of orange juice, provide a taste sensation that is more sweet, would likely contain more calories, provide more or less of certain micro-nutrients, and would provide a mouth-feel different from either orange juice or grapefruit juice. The point to be made here is that orange juice, grapefruit juice, and Concord grape juice are more than just products, they are delivery mechanisms for a variety of characteristics that the consumer may value.

Utility in the Lancaster Model

In Lancaster's model, the consumer has preferences that can be represented by a utility function. However, preferences and utility levels are defined in terms of characteristics of purchased goods and services. A utility function in Lancaster's framework can be defined as follows:

$$U = f(c_{11}, c_{12}, c_{13}, \cdots, c_{1N}, c_{21}, c_{22}, c_{23}, \cdots, c_{2N}, \cdots, c_{M1}, c_{M2}, C_{M3}, \cdots, c_{MN}),$$

where c_{ij} is the amount of the ith characteristic contained in one unit of the jth purchased good, $i = 1, 2, 3, \cdots, M$ and $j = 1, 2, 3, \cdots, N$.

For example, it would be possible to identify and measure characteristics in three juice products: orange juice (Q_1) , grapefruit juice (Q_2), and Concord grape juice (Q_3). Suppose, for simplicity, that consumers care only about two characteristics: sweetness (characteristic 1) and tartness (characteristic 2). In this case, the c_{ij} terms in the consumer's utility function would be interpreted as follows:

- c_{11} = the amount of characteristic 1 (sweetness) in product 1 (orange juice)
- c_{12}= the amount to characteristic 1 (sweetness) in product 2 (grapefruit juice)
- c_{13} = the amount of characteristic 1 (sweetness) in product 3 (Concord grape juice)
- c_{21} = the amount of characteristic 2 (tartness) in product 1 (orange juice)
- c_{22}= the amount characteristic 2 (tartness) in product 2 (grapefruit juice)
- c_{23}= the amount of characteristic 2 (tartness) in product 3 (Concord grape juice)

The formulation of preferences in the Lancaster model clearly has implications for product design and marketing. Within one single product, there can be the opportunity to adjust characteristics being offered to consumers with different tastes. For example, consider ready-to-serve orange juice in the typical supermarket. You will see variations in terms of pulp, whether the product is from concentrate, and whether the product has been fortified with other nutrients not naturally found in orange juice

(e.g., calcium). Basically, food marketers understand that altering the characteristics of a product can make it more attractive to certain consumer segments.

The Lancaster model does assume that the characteristics that are of interest to consumers can be measured. In many cases, this would be straightforward. For example, consider an automobile. Characteristics that might be important to the consumer include horsepower, fuel efficiency, head room, leg room, number of doors, whether the vehicle is four-wheel drive, and so forth. Some characteristics that are important to the consumer such as reliability and smoothness of ride might be more difficult to measure. However, there are third-party entities that provide ratings for experience characteristics like reliability and handling. Moreover, the consumer will generally test drive the vehicle to assess some of these characteristics before purchase. In the case of food products, sensory labs with specialized equipment and trained sensory panelists can provide quantitative measures of characteristics such as texture, firmness, mouth-feel, aftertastes, and other attributes of the product.

Budget Sets in the Lancaster Model

Provided that characteristics can be measured, it is possible to construct a budget constraint for the Lancaster model. Remember that in the Lancaster model, consumers care about characteristics. Purchased goods matter to the consumer only because of the characteristics contained therein. In other words, utility is derived indirectly from purchased goods and services. This being the case, the budget constraint for Lancaster's model needs to reflect the amount of characteristics the consumer can afford.

Figure $5.2.1$ provides a diagram of a Lancaster-type budget set for two characteristics. Following the earlier conventions, let P_1 and P_2 be the prices of products 1 and 2, respectively, and let M be the consumer's budget. Notice that in Figure $5.2.1$, the characteristics are on the vertical and horizontal axis. The consumer cannot buy characteristics directly, but obtains characteristics by purchasing products 1 and 2. Thus, the affordable amounts of products 1 and 2 need to be converted into the characteristics they deliver. In Figure $5.2.1$, each purchased good is a vector extending from the origin. The affordable set of characteristics in Figure $5.2.1$ is contained within the triangular shaped area inside the two product vectors and the red line segment connecting the endpoints of the two vectors. The consumer can obtain any point inside this triangle by buying goods 1 and 2 in the appropriate combination. The ***efficient consumption frontier*** (in red) consists of combinations of products that provide the most characteristics for the consumer's dollar. This efficient consumption frontier is analogous to the budget frontier in the neoclassical model.

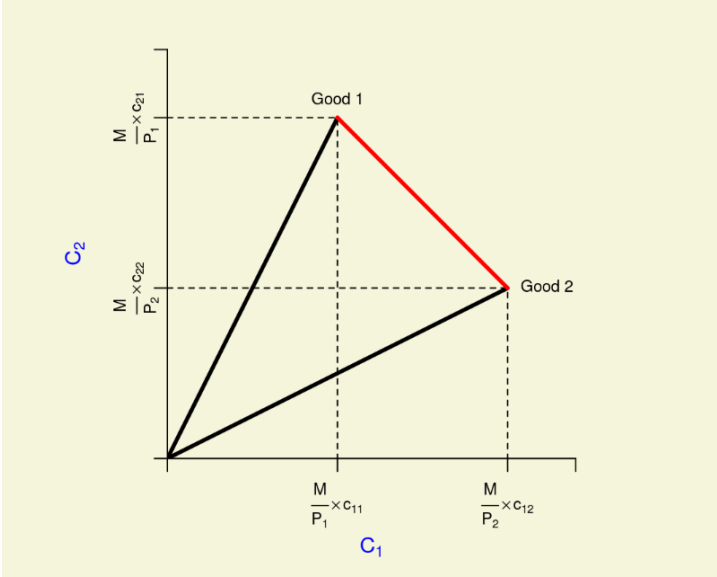


Figure $5.2.1$: **The efficient consumption fronteir (in red) for two characteristics, C_1 and C_2.**

Choice in the Lancaster Model

In the Lancaster Model, the consumer's optimal choice is the bundle of goods that provides the combination of characteristics that provide him or her with the highest level of utility given the affordability constraint. If the consumer has monotonic preferences over the two preferences, this choice will occur somewhere on the efficient consumption frontier. In Figure $5.2.2$, a consumer's indifference curves are imposed over the affordable set, and the optimal choice occurs at point E. In this

particular example, the consumer spends half of his or her budget on good 1 and half on good 2. This happens to occur at a tangency between the line segment constituting the efficient consumption frontier and the consumer's indifference curve. However, optimal choices need not be points of tangency in the Lancaster model even if preferences are monotonic and convex over the characteristics. Had these preferences been drawn differently, the optimal choice could have occurred at one of the product vector endpoints. You will see this in the example that follows.

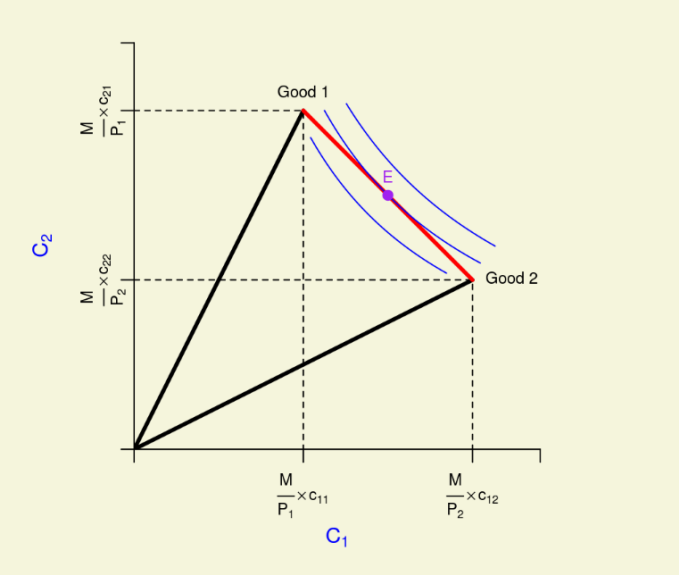


Figure 5.2.2: **Choice in the Lancaster Model. The consumer chooses the combination of characteristics that provide the highest level of utility. Given the consumer with the preferences shown here, the optimal choice occurs at E.**

An Example

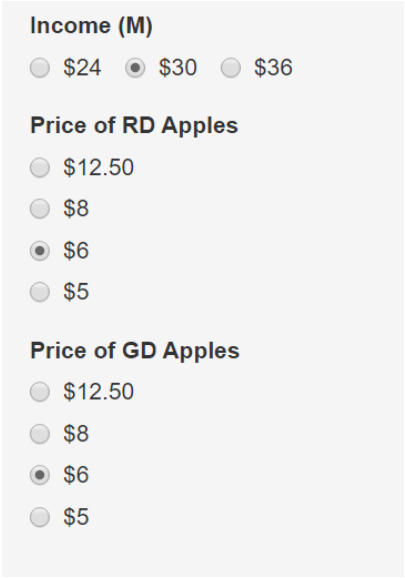
Consider the fictional characteristic and price data for red delicious (RD) and golden delicious (GD) apples as presented in Table 5.2.1. As should be clear from the table, RD apples are sweeter than GD apples but GD apples are crispier than RD apples in this example. Consider a consumer who purchases apples because he or she values the attributes of sweetness and crispiness.

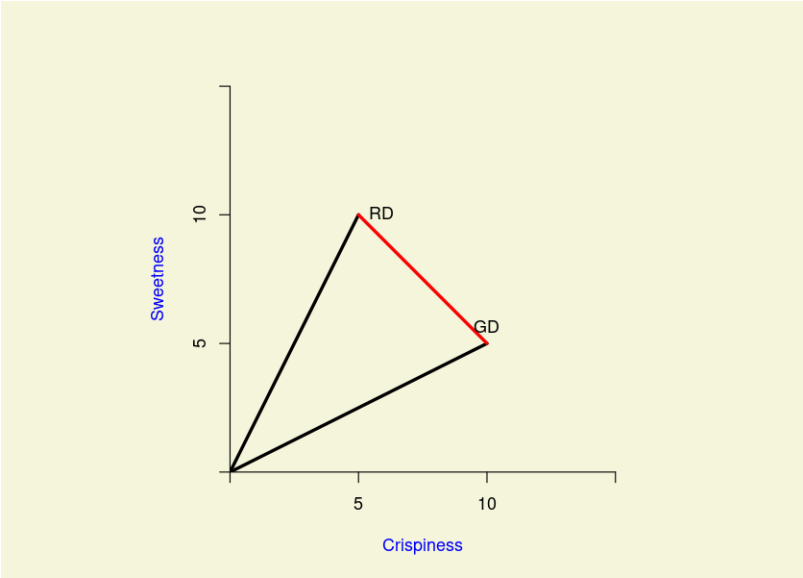
Table 5.2.1. Fictional Characteristic and Price Data for the Apple Example

Characteristic	Red Delicious (RD) Apple	Golden Delicious (GD) Apple
Crispiness	1 unit	2 units
Sweetness	2 units	1 unit

The information in Table 5.2.1 is reflected below in Demonstration 5.2.1. As shown in the demonstration, the price of each type of apple is initially \$6 per unit and the consumer has an initial budget of \$30 that is used to purchase apples ($M = \$30$). If the consumer spends all of the \$30 budget on RD apples, he or she could obtain five RD apples in total. Multiplying this total by the value of the characteristics per apple indicates that these five RD apples would provide a total of five units of crispiness and 10 units of sweetness. Similarly, if the consumer spends all the budget on GD apples, he or she could obtain five GD apples in total, which would provide 10 units of crispiness and five units of sweetness. This sets up the initial values in the demonstration.

Demonstration 5.2.1. Efficient Consumption Frontier for Example of RD and GD Apples





Use Demonstration 5.2.1 to adjust the income and the price of the apples. Make note of the following features from the demonstration:

1. The efficient consumption frontier can collapse to a point if one of the products becomes noncompetitive. To see this, change the RD price to \$5 and set the GD price to \$12.50. In this case, a consumer that cared only about crispiness could still get more crispiness by buying RD apples. RD apples dominate GD apples in terms of both crispiness and sweetness meaning that GD is priced out of the market. Similarly, if you set the RD price to \$12.50 and the GD price to \$5, the efficient consumption frontier collapses to a point that includes only GD apples. GD apples become the most efficient mechanism by which to obtain both sweetness and crispiness and RD is priced out of the market.
2. An increase in price causes the product vector to contract radially towards the origin.
3. A decrease in price causes the product vector to expand radially away from the origin.
4. A change in income causes both vectors to contract or expand proportionately. The efficient consumption frontier shifts in the same direction of the income change. If both products are competitive, the new efficient consumption frontier is parallel to the old.

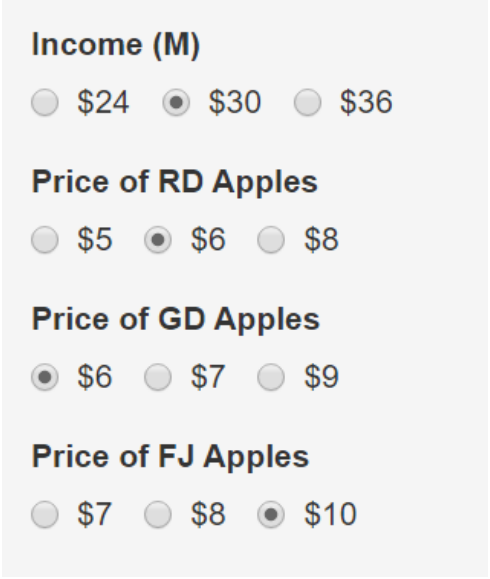
Now let us complicate the example by assuming that Fuji apples have all the sweetness of a RD apple and all the crispiness of a GD apple. The characteristics of the Fuji apple are presented in Table 5.2.2 below. This is clearly a better apple, but let us assume that it is also more costly to grow. In Demonstration 5.2.2, the Fuji apple is priced initially at \$10. Notice that at \$10, the Fuji apple

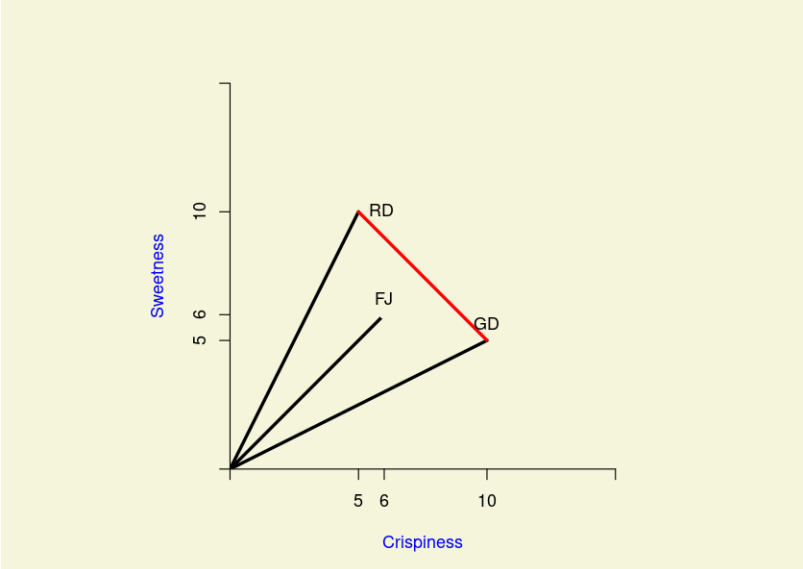
is not on the efficient consumption frontier. Even though it is a better apple in terms of its attributes, it is too costly and is not market feasible at $10. Consumers can obtain more of the characteristics in question by purchasing RD apples, GD apples, or some combination thereof.

Table 5.2.2. Updated Characteristics Table for the Apple Example

Characteristic	Red Delicious (RD) Apple	Golden Delicious (GD) Apple	Fuji (FJ) Apple
Crispiness	1 unit	2 units	2 units
Sweetness	2 units	1 unit	2 units

Demonstration 5.2.2. The Expanded Example





If the price of the Fuji apples is reduced to $8 in Demonstration 5.2.2, it becomes competitive with the other two apples. At an even lower price of $7, Fuji apples start to push out the efficient frontier, causing it to kink. In this case, the Fuji apple becomes the best choice for those consumers who like a balance of crispiness and sweetness. Note that RD and GD apples are still on the frontier when Fuji apples are priced at $7. This is because consumers who have strong preferences for sweetness but not crispiness or strong preferences for crispiness but not sweetness may still find it optimal to purchases bundles with RD or GD apples, respectively.

This is illustrated in Figure 5.2.3 below. Figure 5.2.3, shows indifference curves for three consumers. One consumer has the horizontal indifference curves shown in blue. This consumer cares only about sweetness and nothing about crispiness. His or her utility is maximized by purchasing all RD apples because this provides the largest amount of sweetness. Another consumer has the vertical indifference curves shown in yellow. This consumer cares only about crispiness and nothing about sweetness. He or she maximizes utility by purchasing only GD Apples. The consumer with the typically shaped and strictly convex indifference curves shown in green likes both crispiness and sweetness. He or she maximizes utility by purchasing the Fuji apples.

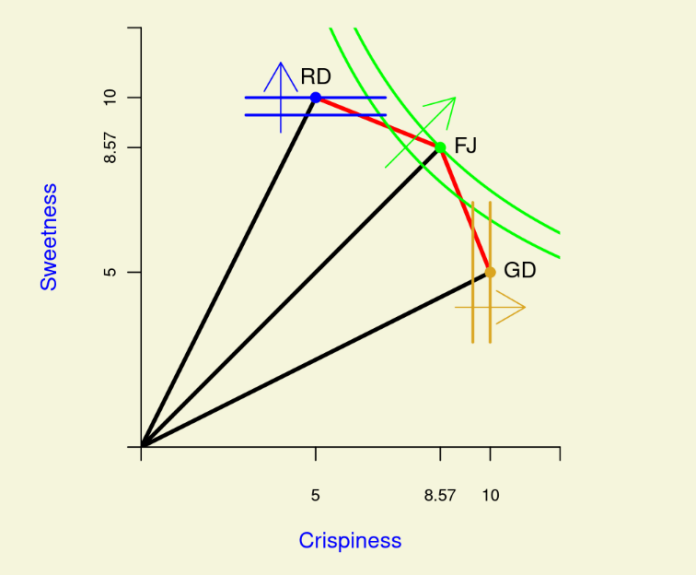


Figure 5.2.3: **Choice by consumers with different preferences shown in blue, green, and yellow. Characteristics reflected in the figure are from Table 5.2.2. Other assumptions are $M = \$30$, $PRD = \$6$, $PGD = \$6$, and $PFJ = \$7$. Arrows point in the direction of increasing preferences.**

Hedonic Pricing Models

In Lancaster's framework, characteristics are the things that matter in the consumer's utility function. The consumer gets characteristics by purchasing goods and services that contain them. When a market price is observed, the price is for a product that probably reflects a number of characteristics. You cannot observe the value of individual characteristics directly. Continuing the automobile example above, the price of the automobile reflects horsepower along with several other characteristics. You may observe that cars with higher horsepower also tend to have higher price tags. This suggests that it should be possible to construct a model to get an estimate of the implicit price for horsepower. Such a model is called a hedonic pricing model. A hedonic pricing model could be specified as follows:

$$p = f(c_1, c_2, \cdots, c_M),$$

where p is price of the product in question and $c_1, c_2, \cdots, C_M$ are levels of different characteristics.

A hedonic pricing model can be used to obtain the implicit marginal value of a characteristic. For example, if p is the price of an automobile and c_1 is horsepower, then $\frac{\Delta p}{\Delta c_1}$ (the slope coefficient for c_1) is the increase in automobile price that one would expect to result from increasing horsepower by a small amount.

As an example, suppose that you were asked to specify a hedonic pricing model for retail strip steaks. You might use something such as

$$p = f(weight,\ thickness,\ color,\ quality,\ freshness)$$

You could measure weight (g) and thickness (cm). There are techniques for quantifying color and quality could be measured in terms of internal marbling and/or through a series of binary (0 or 1) variables to control for USDA quality grade (prime, choice, select, and so forth). These grades take marbling into account. Freshness might be measured in terms of days remaining before the "sale by" date.

A hedonic pricing model provides information about the returns that could be expected by improvements to one or more of the characteristics. In the case of our retail strip steak, it may be possible to increase freshness by using vacuum packaging. Before investing in such a technology, it would be nice to know how much consumers would be willing to pay for this product improvement. Vacuum packaging could darken the color and result in a steak that is purplish rather than a bright red. It is possible that despite enhanced freshness, consumers would pay less for vacuum packed steaks because they view the darker color to be undesirable. A hedonic pricing model could be very useful decision tool in this type of a situation.

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5.3: Becker's (1965) Household Production Model

Another model of consumer behavior is Becker's (1965) household production model. Here, the consumer has a utility function that depends on two things:

1. household produced goods and services, and
2. time spent in leisure activities.

To illustrate the idea of Becker's model, suppose that the household produced good in question is a meal. To be more specific, let us suppose this meal consists of pasta with a marinara sauce. Ultimate utility comes from consuming the meal. However, in order to obtain this utility, the consumer will need to:

1. purchase ingredients from the marketplace,
2. spend time in the kitchen and dining room, and
3. have some knowledge about cooking. This can be called human capital.

A key point of the Becker model is that items the consumer buys at the supermarket provide him or her with no utility *per se*. In other words, Inputs such as a bag of pasta, tomatoes, garlic cloves, and oregano leaves do not satisfy the consumer. Satisfaction is not obtained until these ingredients have been combined with time and human capital to produce a meal.

Almost any human activity could be characterized in terms of the household production model. Even a good night's rest could be viewed as household production. A good night's requires purchased inputs (shelter, a bed, linens, and possibly sleeping pills). It requires an investment in time (normally 6 to 8 hours). Finally, it might require some human capital (the ability to clear one's mind of the pressures of the day and relax into sleep). Similarly a sporting event, like a football game, could be characterized as another household produced good. This requires purchased inputs (tickets, television, cable or satellite subscription, snacks), time (several hours), and human capital (some knowledge of the rules and strategies of the game). The point being made here is that the household production idea is broadly applicable to human activities. However, in actual implementations of the Becker model, activities such as sleep or enjoying sporting events might be lumped into leisure time.

It would be wrong to suppose that only activities within the home would classify as household production and fall within the Becker framework. Suppose that instead of making the pasta dinner in the home kitchen, the consumer decides to purchase it from a restaurant. Utility is ultimately derived from consuming the prepared meal. In this case, the consumer requires purchased goods (transportation to the restaurant and a pasta dinner ordered from the menu). The consumer must also invest time to enjoy the meal. Human capital in the case of a restaurant meal involves knowledge about quality and service of competing restaurants and related products that go along with the meal (e.g., a suitable beverage or appetizer that complements the main course). Even though a restaurant meal is not "homemade", it could easily conceptualize it within the household production model.

The formal elements of the Becker model include a utility function:

$$U = f[(hh\ \ produced\ \ goods),\ \ (leisure\ \ time)]$$

The consumer maximizes utility subject to:

1. A hh production function:

   $$hh\ \ goods = g[(time\ \ in\ \ hh\ \ production),\ \ (market\ \ goods),\ \ (human\ \ capital)]$$

2. Income-use constraint:

$$money\ \ income \geq spending\ \ on\ \ market\ \ goods$$

3. Income-source constraint:

$$money\ \ income = (wage) \times (time\ \ in\ \ labor\ \ force) + (other\ \ income)$$

4. Time-use constraint:

$$total\ time = (time\ in\ hh\ production) + (time\ in\ labor\ force) + (leisure\ time)$$

A main advantage of Becker's model is that it incorporates the value of the consumer's time. The income-use constraint in the Becker model is essentially the same as in the neoclassical model. The consumer cannot spend more on purchased inputs than his or her available income. However, the model differs in that it incorporates where the consumer gets income (the income-source constraint) along with the potential uses for the consumer's time. The income-use, income-source, and time-use constraints can be combined into one overall constraint known as the full time-income constraint below.

$$(wage) \times (total\ time) + (other\ income) \geq (wage) \times (time\ in\ hh\ production) + (wage) \times (leisure\ time) + (spending\ on\ market\ goods)$$

The left side of the full time-income constraint represents income potential. The right side of the full time-income constraint represents how income potential is used.

A key insight from Becker's model for food marketing is that time spent in the kitchen has a very real cost. Many consumers are spending more time in the workforce to generate income. They are using this income to save time in household production by buying goods that require minimal preparation. Senauer, Asp, and Kinsey (1991) make a distinction between time-intensive goods and expenditure-intensive goods. A cake from the bakery costs more money than a couple of cups of flour, vegetable oil, eggs, and a bit of baking powder and cocoa. However, when you consider the opportunity cost of making a cake from scratch, the bakery cake might be the cheapest way to obtain this good. In this example, the bakery cake is an expenditure-intensive good while the raw ingredients to make a cake from scratch are time-intensive goods.

One of the best examples of Becker's model in action is the growth in food-away-from-home expenditures (the overwhelming majority of which is accounted for by food consumed at restaurants) relative to growth in food purchased for at-home consumption. Figure 5.3.1 shows these data from 1970 through 2014. In 2014 food-away from home expenditures actually surpassed food-at-home expenditures. Insights from Becker's model are also reflected in the product assortments contained in supermarkets. New or recently renovated supermarkets tend to have larger deli and prepared food sections.

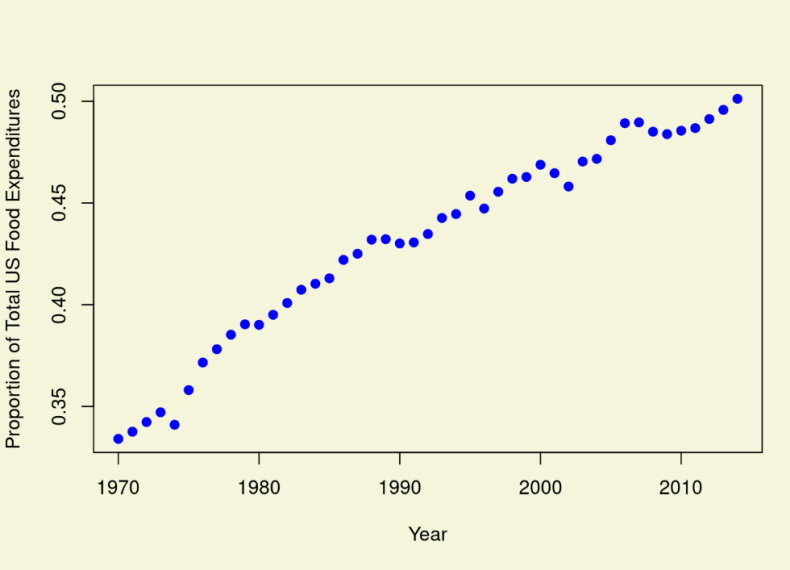


Figure 5.3.1: **Food-away-from-home share of total US food expenditures 1970 through 2014. Source: USDA Economic Research Service.**

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5.4: Welfare Economics - Consumer and Producer Surplus

Introduction to Elasticities

An **elasticity** is a measure of responsiveness.

Elasticity = How responsive one variable is to a change in another variable.

An elasticity (E), or responsiveness, is measured by the percentage change of each variable. The change in a variable is the ending value (X_1) minus the initial value (X_0), or $\Delta X = X_1 – X_0$. A percentage change in a variable is defined as the change in the variable divided by the initial value of the variable:

$$\%\Delta X = \frac{\Delta X}{X_0}. \tag{5.4.1}$$

Using this formula, Equation 5.4.2 shows the responsiveness of Y to a change in X:

$$E = \frac{\%\Delta Y}{\%\Delta X} = \frac{(\Delta Y/Y)}{(\Delta X/X)} = \left(\frac{\Delta Y}{\Delta X}\right)\left(\frac{X}{Y}\right). \tag{5.4.2}$$

Elasticities can be calculated for any two variables. Elasticities are widely used in economics to measure how responsive producers and consumers are to changes in prices, income, and other economic variables. Elasticities have a very desirable property: they do not have units. Since the two variables are measured in percentage changes, the units of each variable are cancelled, and the resulting elasticity has no units. This allows elasticities to be compared to each other, when prices and quantities cannot be directly compared. For example, the quantity of apples cannot be directly compared to the quantity of orange juice, since they are in different units. However, the elasticities of oranges and apples can be compared directly, since there are no units for elasticities.

Own Price Elasticity of Demand: E_d

The **own-price elasticity of demand** (most often called simply the “price elasticity of demand” or the “elasticity of demand”) measures the responsiveness of consumers to a change in price, as shown in Equation 5.4.3:

$$E_d = \frac{\%\Delta Q^d}{\%\Delta P} = \left(\frac{\Delta Q^d}{\Delta P}\right)\left(\frac{P}{Q^d}\right). \tag{5.4.3}$$

Own Price Elasticity of Demand = the percentage change in quantity demanded given a one percent change in the good’s own price, *ceteris paribus*.

The own-price elasticity of demand is the most important thing that a business firm can know. The price elasticity informs the business about how a change in price will affect the quantity demanded. If consumers are responsive to price changes, the firm may think twice before raising the price and losing customers to the competition. On the other hand, if consumers are relatively unresponsive to price changes, the firm may increase the price, and most customers will continue to purchase the good at the higher price. Food is an example of an inelastic good, since we all need to eat.

The price elasticity of demand (E_d) depends on the availability of substitutes. If there are no substitutes for a good (food, toilet paper, toothpaste), the good is called, “price inelastic.” Consumers will purchase the good even at a high price. If substitutes are available, the good is considered to be “price elastic:” a higher price will cause customers to decrease consumption of the good by buying the substitute good. Green shirts are an example: if the price of green shirts is increased, consumers will shift purchases to blue shirts, or shirts of a different color.

The price elasticity of demand is the most critical aspect of a business firm, since it provides the most crucial information about customers! Knowledge of the price elasticity of demand provides information to a business firm on how consumers would react to price changes, allowing the firm to identify the profit-maximizing price to charge consumers.

Price Elasticity of Demand Example

Suppose that the price of wheat is equal to USD 4/bu of wheat, and increases to USD 6/bu. Due to the higher price, suppose that wheat millers reduce their purchases of wheat from 10 million bushels (m bu) to 8 million bushels. The price elasticity of demand for wheat can be calculated using Equation 5.4.4. By convention, the initial values of P and Q^d are used in the elasticity calculation for the variables P and Q^d.

$$E_d = \frac{\%\Delta Q^d}{\%\Delta P} = \frac{(\Delta Q^d/\Delta P)}{(P/Q^d)} = \left(\frac{\text{8-10 m bu}}{\text{6-4 USD/mt}}\right) \cdot \left(\frac{\text{4 USD/bu}}{\text{10 m bu}}\right) \tag{5.4.4}$$

Notice that the units cancel: there are (m bu) in both the numerator and denominator, and (USD/bu) also appears in both numerator and denominator. This allows the math to be greatly simplified:

$$E_d = \left(\frac{-2}{2}\right) \cdot \left(\frac{4}{10}\right) = \frac{-1}{0.4} = -0.4 \tag{5.4.5}$$

The price elasticity of demand is always negative, due to the Law of Demand. By convention, economists take the absolute value to make E_d positive. For example, in this case, $E_d = -0.4$, then $\mid E_d \mid = 0.4$. The own price elasticity of demand provides important information about the wheat market: how responsive wheat buyers are to a change in price. To interpret the elasticity, it means that for a one percent increase in price, the quantity demanded of wheat will decrease by 0.4 percent. This is a relatively inelastic response, since the change in quantity demanded is smaller than the price change.

Elasticities are classified into three categories, based on consumer responsiveness to a one percent change in price.

Price elastic	$\mid E_d \mid > 1$
Price inelastic	$\mid E_d \mid < 1$
Unitary elastic	$\mid E_d \mid = 1$

Goods that are price elastic have substitutes available, and the percentage change in quantity demanded will decrease more than the percentage increase change in price ($\%\Delta Q^d > \%\Delta P$, therefore $\mid E_d \mid > 1$). A price inelastic good, on the other hand, will have a smaller percentage change in quantity demanded than the percentage increase in price ($\%\Delta Q^d < \%\Delta P$, therefore $\mid E_d \mid < 1$). For unitary elastic goods, the percentage change in quantity demanded is equal to the percentage change in price ($\%\Delta Q^d = \%\Delta P$, therefore $\mid E_d \mid = 1$).

Elastic and Inelastic Demand Examples

To compare elastic and inelastic demands, think of a student who would like to purchase a pack of cigarettes during a late night study session for an exam. If the student arrives at the convenience store to find that the price of Marlboros, her usual brand, has doubled, she could switch to many other brands: Lucky Strikes, Winstons, etc. The demand for Marlboro cigarettes is price elastic (left panel, Figure 5.4.1). The price elasticity of demand depends on the availability of substitutes. An elastic demand will have a relatively flat slope, since a small change in price results in a relatively larger change in quantity demanded.

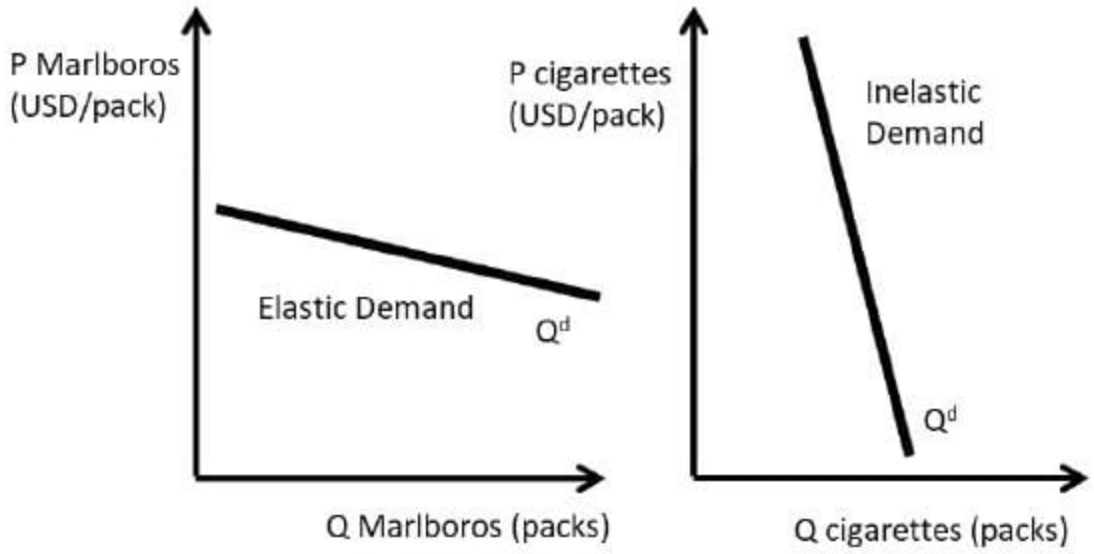


Figure 5.4.1: Price Elasticity of Demand for Marlboros and Cigarettes

On the other hand, if the convenience store increases the price of all cigarettes, the student will pay for a pack, since there are no substitutes for all cigarettes (right panel, Figure 5.4.1). More narrowly defined goods will have larger absolute values of own price elasticities, since there are more substitutes for narrowly defined goods. For example, apples are more price elastic than all fruit, and green shirts are more price elastic than all shirts. An inelastic good will have a steep slope, since the change in quantity demanded is small relative to the change in price.

Figure 5.4.2 shows a range of own price elasticities, from perfectly inelastic to perfectly elastic.

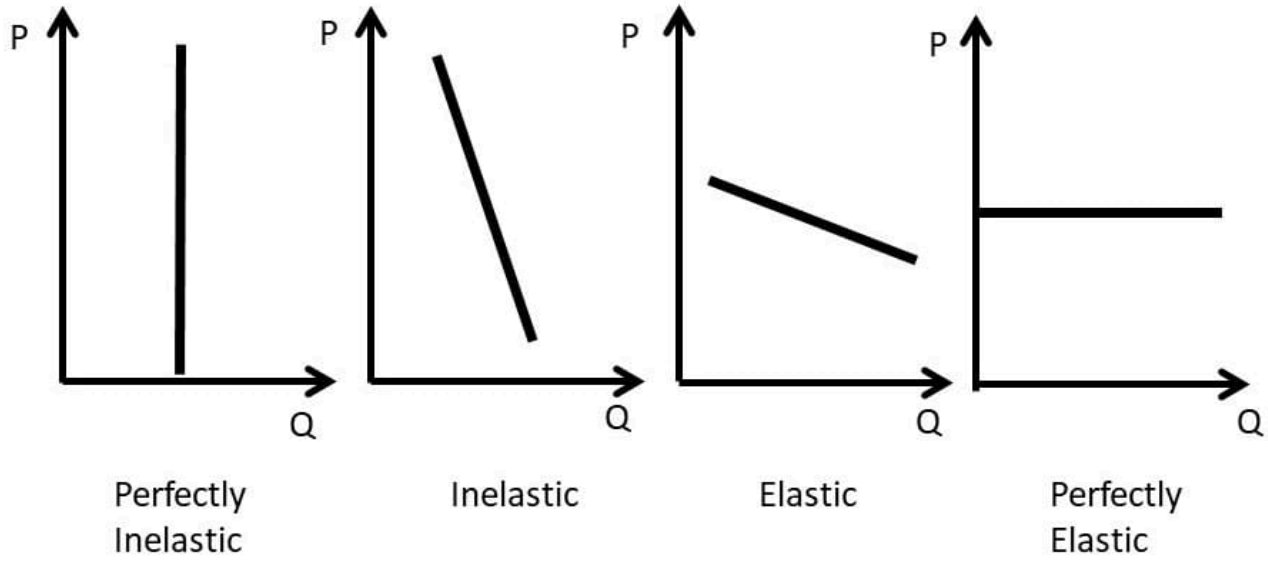


Figure 5.4.2: Price Elasticity of Demand

A good that is perfectly inelastic is one that consumers purchase no matter what the price is. Within a certain range of prices, this could be food or electricity. In this case, quantity demanded is completely unresponsive to changes in price: $\mid E_d \mid = 0$. An inelastic demand is one where the percentage change in price is larger than the percentage change in quantity demanded: $\%\Delta Q^d < \%\Delta P$, and $\mid E_d \mid < 1$. Goods that are price inelastic are characterized by consumers being unresponsive to price changes. Goods that are price elastic exhibit relatively high levels of consumer responsiveness to price movements. For elastic goods, the percentage change in quantity demanded is larger than the percentage change in price: $\%\Delta Q^d > \%\Delta P$, and $\mid E_d \mid > 1$. A perfectly elastic good is characterized by a horizontal demand curve. In this case, if the price of the good is increased even one cent, all customers decrease purchases of the good to zero. An individual wheat farmer's crop is an example. If the farmer tries to raise the price by one cent more than the prevailing market price, no consumers would purchase her wheat. There are a large number of perfect

substitutes available from other wheat farmers, so the price elasticity is infinite, and the good is called, “perfectly elastic.”

Own Price Elasticity of Supply: E_s

Producer responsiveness to a change in price is measured with the **own price elasticity of supply**, often called the price elasticity of supply, or the elasticity of supply (E_S). The formula for the price elasticity of supply is given in Equation 5.4.6:

$$E_s = \frac{\%\Delta Q^s}{\%\Delta P}. \tag{5.4.6}$$

Own Price Elasticity of Supply = the percentage change in quantity supplied given a one percent change in the good's own price, *ceteris paribus*.

The own price elasticity of supply is always positive, because of the Law of Supply: there is a direct, positive relationship between the quantity supplied of a good and the good's own price, *ceteris paribus*. Similar to the price elasticity of demand, the price elasticity of supply is categorized into three elasticity classifications.

$$\begin{array}{ll} \text{Price elastic} & E_s > 1 \\ \text{Price inelastic} & E_s < 1 \\ \text{Unitary elastic} & E_s = 1 \end{array}$$

A good with an elastic supply is one where the percentage change in quantity supplied is greater than the percentage change in price: $\%\Delta Q^s > \%\Delta P$, and $E_s > 1$. Since E_s is always positive, the absolute value is not necessary (redundant). A good with an inelastic supply has a smaller percentage change in quantity supplied, given a percent change in price: $\%\Delta Q^s <$, and $E_s < 1$. A good with unitary elasticity of supply has equal percent changes in quantity supplied and price: $\%\Delta Q^s = \%\Delta P$, and $E_s = 1$. Figure 5.4.3 illustrates the different categories of the own price elasticity of supply.

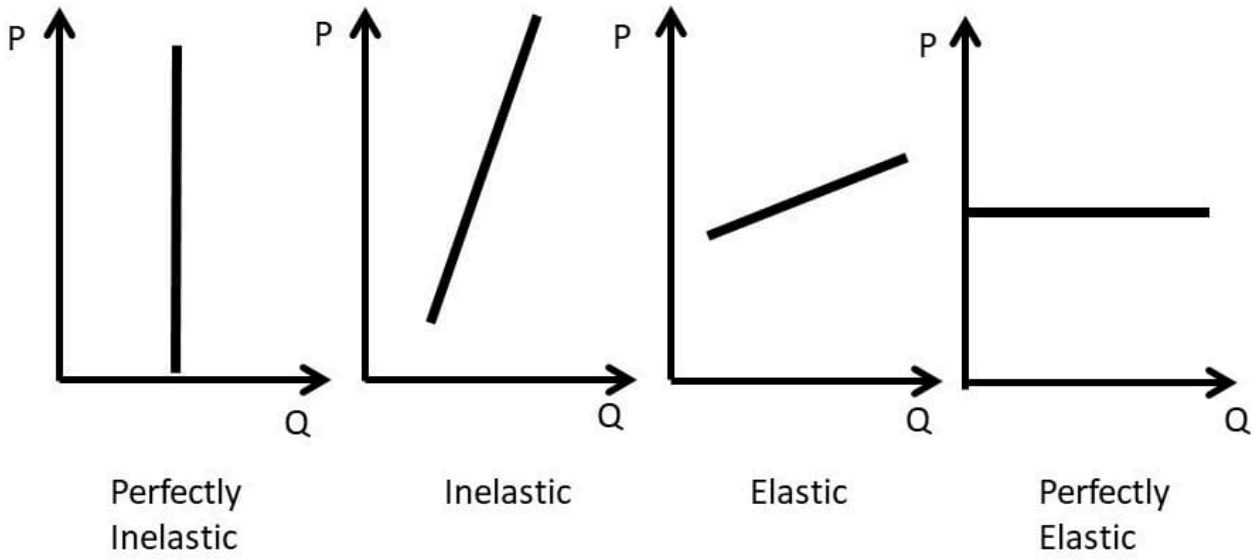


Figure 5.4.3: Price Elasticity of Supply

Income Elasticity: E_i

The **income elasticity** (E_i) measures how consumers of a good respond to a one percent increase in income (I), as shown in Equation /ref{1.11}:

$$E_i = \frac{\%\Delta Q^d}{\%\Delta I}. \tag{5.4.7}$$

The income elasticity is defined in a similar way as the price elasticities.

Income Elasticity = the percentage change in demand given a one percent change in income, *ceteris paribus*.

Income elasticities are also categorized into responsiveness classifications. A **normal good** is one that increases with an increase in income $(E_i > 0)$. There are two subcategories of normal goods: necessities and luxury goods. Notice that necessity goods and luxury goods are normal goods. They represent subgroups of the normal category, since E_i is positive in both cases.

Normal Good	$E_i > 0$
Necessity Good	$0 < E_i < 1$
Luxury Good	$E_i > 1$
Inferior Good	$E_i < 1$

The graphs of the relationship between income and demand are called, "Engel Curves," named for Ernst Engel (1821-1896), a German statistician who first investigated the impact of income on consumption.

A necessity good is a normal good that has a positive, but small, increase in demand given a one percent increase in income. Food is an example, since consumers increase the consumption of food with an increase in income, but the total amount of food consumed reaches an upper limit. This is shown in Figure 5.4.4, left panel.

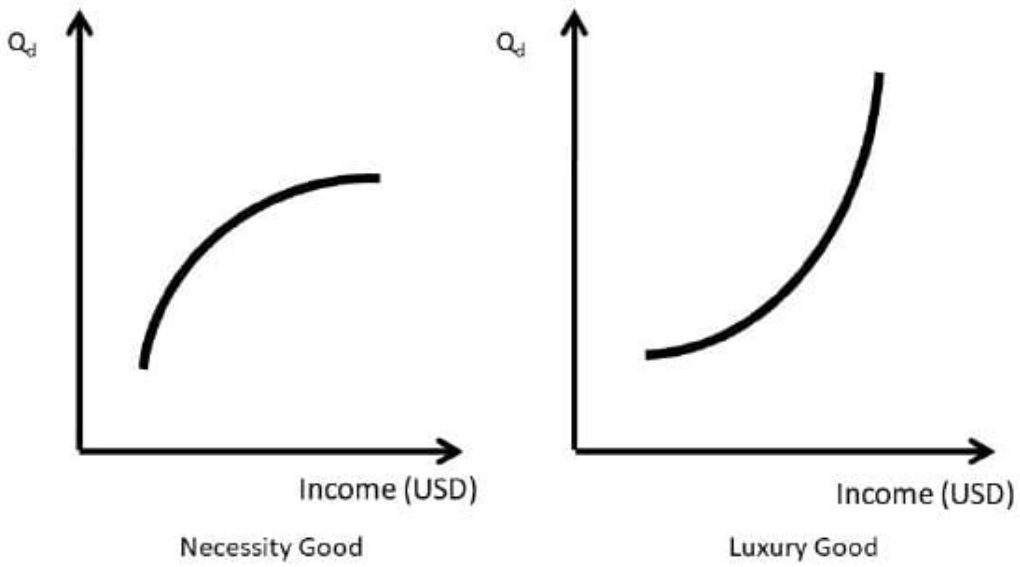


Figure 5.4.4: Engel Curves for Necessity Goods and Luxury Goods

A luxury good is one that has increasing demand as income increases, as shown in the right panel of Figure 5.4.4. Good such as boats, golf club memberships, and expensive clothing are examples of luxury goods. Inferior goods (Figure 5.4.5) are characterized by lower levels of consumption as income increases: ramen noodles and used clothes are examples.



Figure 5.4.5: Engel Curve for an Inferior Good

It is important to point out that a good can be a normal good at low income levels, and an inferior good at higher income levels. Hamburger (ground beef) is an example. At low levels of income, hamburger consumption might increase when income rises (Figure 5.4.6). However, at higher levels of income, consumers might shift out of ground beef and into more expensive meats such as steak. Figure 5.4.6 shows that the same good can be both a normal good and an inferior good, at different levels of income.

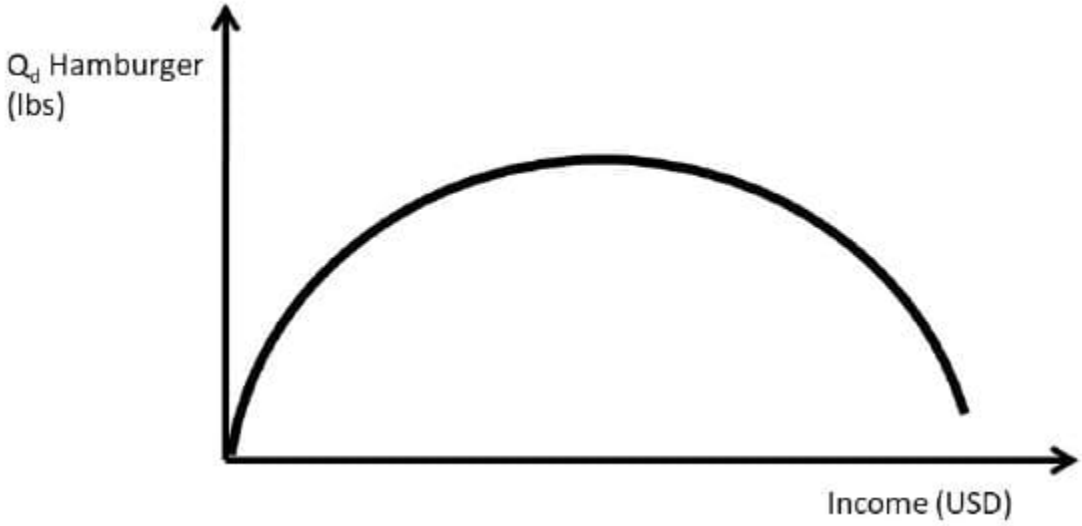


Figure 5.4.6: Engel Curve for Hamburger: A Necessity Good and An Inferior Good

Cross Price Elasticity of Demand: E_{dxy}

The **cross price elasticity of demand** measures the responsiveness of demand for one good with respect to a change in the price of another good.

$$E_{dxy} = \frac{\%\Delta Q_y^d}{\%\Delta P_x} \tag{5.4.8}$$

Cross Price Elasticity of Demand = the percentage change in the demand of one good given a one percent change in a related good's price, *ceteris paribus*.

The cross price elasticity is important for two categories of related goods: **substitutes** and **complements in consumption**.

Substitutes in consumption will have a positive cross price elasticity of demand, since consumers will decrease purchases of the good that has the price increase, and buy more substitute goods. Complements in consumption are goods that are consumed together, like macaroni and cheese. If the price of macaroni increases, then consumption of both macaroni and cheese decreases.

$$\begin{aligned}
&\text{Substitutes in Consumption} && E_{dxy} = \frac{\%\Delta Q_y^d}{\%\Delta P_x} > 0 \\
&\text{Complements in Consumption} && E_{dxy} = \frac{\%\Delta Q_y^d}{\%\Delta P_x} < 0 \\
&\text{Unrelated Goods in Consumption} && E_{dxy} = \frac{\%\Delta Q_y^d}{\%\Delta P_x} = 0
\end{aligned}$$

Unrelated goods have a cross price elasticity of demand equal to zero. This is because a change in the price of a good has no effect on the quantity demanded of an unrelated good.

Cross Price Elasticity of Supply: E_{sxy}

The **cross price elasticity of supply** captures the responsiveness of the supply of one good, given a change in the price of another good.

$$E_{sxy} = \frac{\%\Delta Q_y^s}{\%\Delta P_x} \tag{5.4.9}$$

Cross Price Elasticity of Supply = the percentage change in the supply of one good given a one percent change in a related good's price, *ceteris paribus*.

Substitutes in production are goods that are produced "either/or," such as corn and soybeans. The same resources (land, machinery, labor, etc.) could be used to produce either corn or soybeans, but the two crops can not be grown on the same land at the same time. The cross price elasticity of supply of substitutes in production is negative. If the price of corn increases, for example, then producers will devote more land to corn and less to soybeans.

$$\begin{aligned}
&\text{Substitutes in Production} && E_{sxy} = \frac{\%\Delta Q_y^s}{\%\Delta P_x} < 0 \\
&\text{Complements in Production} && E_{sxy} = \frac{\%\Delta Q_y^s}{\%\Delta P_x} > 0 \\
&\text{Unrelated Goods in Production} && E_{sxy} = \frac{\%\Delta Q_y^s}{\%\Delta P_x} = 0
\end{aligned}$$

Complements in production are goods that are produced together, such as beef and leather. Complements in production have a positive cross price elasticity: if the price of beef increases, both more beef and more leather will be supplied to the market. Unrelated goods in production have a cross price elasticity of supply equal to zero, since the price of an unrelated good has no impact on the demand of the other unrelated good.

Price Elasticities and Time

The magnitude of the price elasticity of supply measures how easy it is for the firm to adjust to price changes. In the immediate run (a short time period), the firm can not adjust the production process, so the supply is typically perfectly inelastic. In the short run, a time period when some inputs are fixed and some inputs are variable, the firm may be able to adjust some inputs, so supply is inelastic, but not perfectly inelastic. In the long run, all inputs are variable, and the firm can make adjustments to the production process. In this case, supply is elastic. As more time passes, the price elasticity of supply increases.

This relationship also holds for the price elasticity of demand. If the price of a good increases in the immediate run, there is little consumers can do other than purchase the good. Air travelers who have an emergency that they need to attend to will pay a high price of an airline ticket on the same day of the flight. As time passes, there are more options available to the consumer, and the price elasticity of demand becomes more elastic with the passage of time.

Elasticity of Demand along a Linear Demand Curve

Interestingly, the elasticity of demand changes along a linear demand curve. This is due to the calculation of the own price elasticity of demand as percentage change in quantity demanded caused by a percentage change in the price of the good. In Figure 5.4.7, the slope of the demand function is constant: it does not change over the entire demand curve.

For example, suppose that the inverse demand function is given by: $P = 10–Q^d$, where P is the price of the good and Q^d is the quantity demanded. In this case, the vertical intercept (y-intercept) is equal to 10, and the slope is equal to negative one. It should be emphasized that, in this case, the slope is constant and equal to minus one for the entire demand curve.

The elasticity of demand, however, changes in value quite dramatically from the y-intercept to the x-intercept. It changes from a value of zero on the x-axis to a value of negative infinity on the y-axis. The cause is the calculation of percentage change.

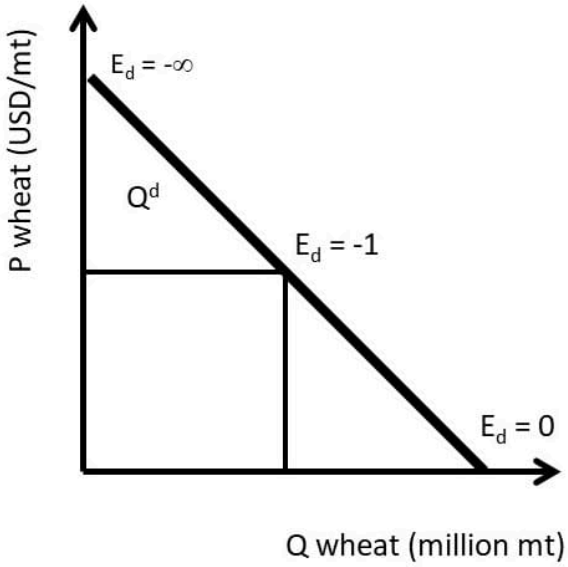


Figure 5.4.7: The Price Elasticity of Demand along a Linear Demand Curve

Consider an example of a mouse and an elephant. If both gain one pound, the weight gain is identical, but the percentage change is vastly different. Suppose that the mouse weighs one-tenth of a pound, the elephant weighs 10,000 pounds, and the total weight gain for both the mouse and the elephant is one pound. The percentage weight gain is $\%\Delta WG = \frac{\Delta WG}{WG_0}$, where ΔWG is the change in weight, and WG_0 is the initial weight gain. For the mouse,

$$\%\Delta WG \text{ mouse } = \frac{\Delta WG}{WG_0} = \frac{1 \text{ lb}}{0.1 \text{ lbs}} = 10 = 1000 \text{ percent!} \tag{5.4.10}$$

For the elephant,

$$\%\Delta WG \text{ elephant} = \frac{\Delta WG}{WG_0} = \frac{1 \text{ lb}}{10,000 \text{ lbs}} = 0.0001 = 0.01 \text{ percent!} \tag{5.4.11}$$

The take home message of the story is that the total weight gain was identical for both the elephant and the mouse (one pound), whereas the percentage weight gain was enormously different.

This is also true of the elasticity of demand along the linear demand curve. Consider the point where the linear demand curve crosses the x-axis. At this point, the price is equal to zero. Suppose that we raised the price by one unit to find out how responsive consumers are to an increase in price. The price elasticity of demand is:

$$E_d = \frac{\%\Delta Q^d}{\%\Delta P}. \tag{5.4.12}$$

At the x-intercept, the percentage change in price $(\%\Delta P)$ is equal to $dfrac\Delta PP = \frac{1}{0} =$ infinity. The elasticity of demand is equal

to the percentage change in quantity demanded $(\%\Delta Q)$ divided by the percentage change in price $(\%\Delta P =$ infinity). Thus, $E_d = 0$ at the x-intercept, since dividing any number by infinity is equal to zero.

How responsive are consumers to a change in price at the vertical axis? At the y-intercept, the percentage change in quantity demanded $(\%\Delta Q_d)$ is equal to $\frac{\Delta Q_d}{Q_d} = \frac{1}{0} =$ infinity. Therefore, the elasticity of demand is equal to the percentage change in quantity demanded $(\%\Delta Q =$ infinity) divided by the percentage change in price $(\%\Delta P)$. Thus, $\mid E_d \mid =$ infinity at the y-intercept.

At the midpoint, the price elasticity of demand is equal to negative one.

$$E_d = \frac{\%\Delta Q^d}{\%\Delta P} = \left(\frac{\Delta Q^d}{\Delta P}\right)\left(\frac{P}{Q^d}\right) = -1 \tag{5.4.13}$$

At the midpoint, the slope of the demand curve is equal to minus one $(\frac{\Delta Q^d}{\Delta P} = 1)$, and the price is equal to the quantity demanded $(P = Q^d)$. Therefore the own price elasticity of demand at the midpoint of a linear demand curve is equal to minus one $\left(\frac{\Delta Q^d}{\Delta P}\right)\left(\frac{P}{Q_d}\right) = -1$.

A valuable lesson is learned in this example: be careful to distinguish between the slope of a demand curve and the elasticity of demand. When interpreting graphs, the slope is not a good determinant of elasticity, since a graph could be drawn steep or shallow depending on the units. The elasticity is related to the slope, but it is not equal to the slope!

Agricultural Policy Example of Elasticity of Demand

The impact of agricultural policies depends critically on the elasticity of demand. It was claimed earlier that the price elasticity of demand is the most important thing that a business firm can know. This section provides evidence of the importance of the price elasticity of demand. The own price elasticity of demand for food is inelastic in a domestic economy with no trade. Everyone must eat, and the caloric intake will not be greatly influenced by the price of food.

This changes enormously in a global economy. In an open economy that has international trade, there are many overseas customers for food exports, and many competing nations that export food. For example, the US is a major wheat exporter. Other wheat exporting nations include: Canada, Australia, Argentina, the European Union (EU), and many of the former Soviet nations in Eastern Europe such as Ukraine. In this case, the US faces a highly elastic demand for wheat in the global economy: if the US increased the price of wheat above the world price, wheat importers would shift purchases from the US to other wheat exporters. A global economy changes the effectiveness of price policies enormously.

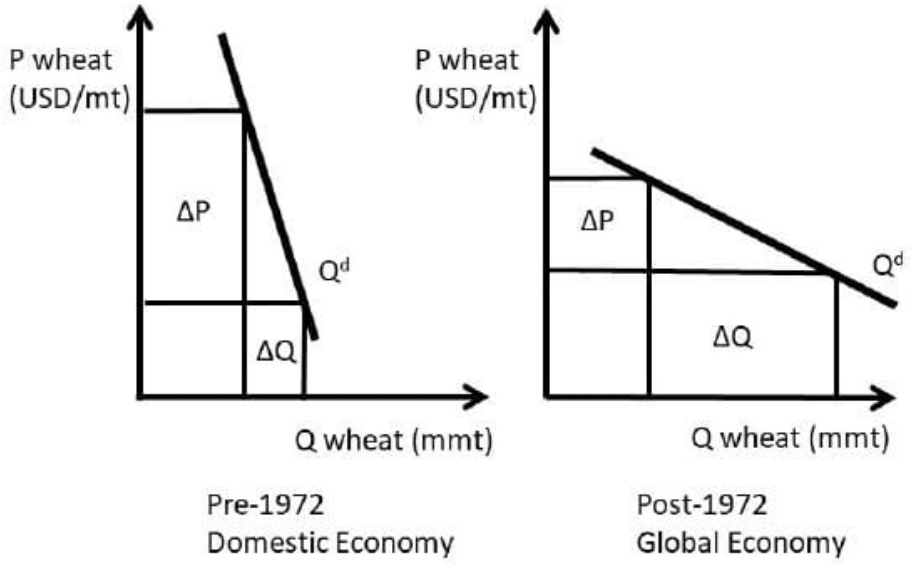


Figure 5.4.8: Price Elasticity and Price Policies

Prior to 1972, the United States agricultural sector could be characterized as a domestic economy, with less food and agricultural

trade. In this case, the demand for food was primarily domestic, and thus relatively inelastic (Figure 5.4.8, left panel).

Starting in 1933, agricultural price supports increased the price of wheat above the market equilibrium level. This policy worked well, as long as the surplus was eliminated. One way to eliminate the surplus was through acreage restrictions, which limited the number of acres planted to wheat (ΔQ in the left panel of Figure 5.4.8). Acreage limitations and production quotas were used to decrease the quantity of wheat in the market. These policies worked well prior to 1972, since the US agricultural economy was primarily domestic, characterized by an inelastic demand curve. The decrease in quantity led to a larger increase in price ($\Delta P > \Delta Q^d$), given the inelastic demand in a domestic economy.

In 1972, major changes in international exchange rate policies, together with poor weather in Asia, led to the globalization of US food and agricultural markets. A larger percentage of the US wheat crop was exported, and the inelastic demand that prevailed prior to 1972 became more elastic in the globalized environment (right panel, Figure 5.4.8). Although the wheat market became globalized, the policies did not. During the 1980s, the US maintained price supports and production controls in the seven basic commodities (defined by the USDA as: wheat, corn, sorghum, sugar, cotton, rice, and tobacco). These policies were counterproductive, as they priced the grain out of the world market. The US attempted to increase the market share of wheat trade, only to find that the US price was higher than the other major wheat exporters.

Figure 5.4.8 shows why the policies implemented in 1933 were hurting more than they were helping. Production controls were decreasing the quantity of wheat. In the domestic economy (left panel of Figure 5.4.8, pre-1970), this achieved the objectives of the policies: wheat producer were made better off, since the increase in price was greater than the decrease in quantity. This all changed in the globalized world after 1972 (right panel of Figure 5.4.8, post 1972). With an elastic demand, the decrease in quantity did not result in large price increases. Price supports raised the US price above the world price of wheat. These policies were not working, and in 1996, they were changed to make the US grain industry more competitive in the global market. Today, a large fraction of all grain produced in the US is exported.

In summary, policies intended to help producers have greatly divergent outcomes, depending on the price elasticity of demand. In a domestic economy, the demand for food and agricultural products is typically inelastic. In this case, production controls and price supports will achieve the policy goal of helping producers: the price increases will be larger than the quantity decreases (left panel, Figure 5.4.8). In a global economy, the demand for food and agricultural goods is elastic: there are many nations that export grains (right panel, Figure 5.4.8). In this case the policy that helps producers the most is technological change, which will shift the supply curve to the right. With an elastic demand, the increase in quantity is larger than the decrease in price.

This is the same strategy that Walmart utilizes: everyday low prices. Sam Walton found that the increase in sales due to low prices more than offset the decrease in price ($\Delta Q^d > \Delta P$). This is true in any market characterized by an elastic demand. Since most consumer goods in the United States have many substitutes, Walton's lower-price strategy led to Walmart becoming the most successful retailer in the history of the world.

Calculation of Market Supply and Demand Elasticities

In Section 1.3.4 above, inverse supply and demand curves were used to calculate the equilibrium price and quantity of phones.

The inverse demand and supply functions were:

$$P = 100–2Q^d \tag{5.4.14}$$

$$P = 20 + 2Q^s \tag{5.4.15}$$

Where P is the price of phones in USD/unit, and Q is the quantity of phones in millions. By setting the two equations equal to each other, the intersection of the inverse supply and demand curves was found, yielding the equilibrium market price and quantity:

$$P^e = \text{ USD } 60/\text{phones}, \tag{5.4.16}$$

and

$$Q^e = 20 \text{ million phones}. \tag{5.4.17}$$

The graph of the phone market is replicated in Figure 5.4.9.

To calculate the own price elasticities of supply and demand, simple calculus provides an easy solution. Recall the definition of

the own price elasticity of demand:

$$E_d = \frac{\%\Delta Q^d}{\%\Delta P} = \left(\frac{\Delta Q_d}{\Delta P}\right)\left(\frac{P}{Q_d}\right) = \left(\frac{\partial Q_d}{\partial P}\right)\left(\frac{P}{Q_d}\right) \tag{5.4.18}$$

The delta sign (Δ) refers to a small change in a variable. This is the same as the derivative sign, "∂." The difference is that the derivative indicates in infinitesimally small change, whereas the delta sign is a discrete change, which is the same idea, just larger. Therefore, the delta signs can be replaced with the derivative signs in the equation that defines the price elasticity of demand. For example, the slope of a function is $\frac{\Delta y}{\Delta x}$. The slope of the function at a given point on the function is $\frac{\partial y}{\partial x}$.

The last expression in the equation shows that to calculate E_d, use the derivative of quantity with respect to price, and the levels of P and Q. At the equilibrium point, the equilibrium levels of P and Q are known. To find the derivative, begin by taking the derivative of the inverse demand equation (Equation 5.4.14).

$$\frac{\partial P}{\partial Q^d} = -2 \tag{5.4.19}$$

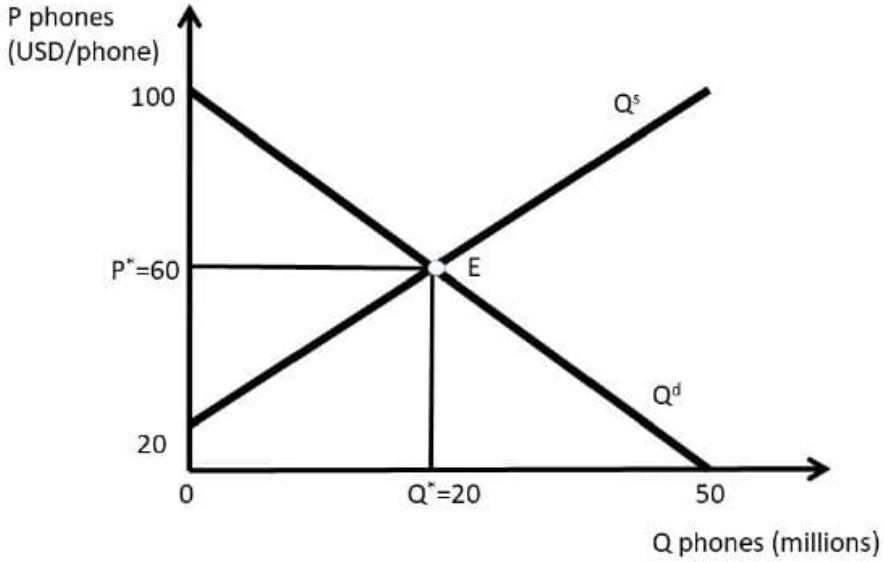


Figure 5.4.9: Phone Market Equilibirum

This is simply the power function rule from calculus [if $y = ax^b$, then $\frac{\partial y}{\partial x} = abx^{b-1}$]. Notice something important: the derivative of the inverse demand equation is the inverse of what is needed to calculate the price elasticity. This is due to the inverse demand function being, "price-dependent," with P on the left hand side. To find the derivative $\frac{\partial Q^d}{\partial P}$, invert the derivative by dividing one by the derivative.

$$\frac{\partial Q^d}{\partial P} = -\left(\frac{1}{2}\right) \tag{5.4.20}$$

$$E_d = \frac{\%\Delta Q^d}{\%\Delta P} = \left(\frac{\Delta Q^d}{\Delta P}\right)\left(\frac{P}{Q^d}\right) = \left(\frac{\partial Q^d}{\partial P}\right)\left(\frac{P}{Q^d}\right) = -\left(\frac{1}{2}\right)\left(\frac{60}{20}\right) = -1.5 \tag{5.4.21}$$

The absolute value of the own price elasticity of demand at the equilibrium point is:

$| E_d | = 1.5$. The demand for phones is elastic: if the price were increased one percent, the decrease in phone purchases would be 1.5 percent.

The own price elasticity of supply can be found using the same procedure:

$$E_s = \frac{\%\Delta Q^s}{\%\Delta P} = \left(\frac{\Delta Q^s}{\Delta P}\right)\left(\frac{P}{Q^s}\right) = \left(\frac{\partial Q^s}{\partial P}\right)\left(\frac{P}{Q^s}\right) \tag{5.4.22}$$

First, take the derivative of the inverse supply function (Equation 5.4.15).

$$\frac{\partial P}{\partial Q^s} = +2 \tag{5.4.23}$$

Invert this derivative to find the derivative needed to calculate the price elasticity of supply:

$$\frac{\partial Q^s}{\partial P} = +\left(\frac{1}{2}\right). \tag{5.4.24}$$

Then plug in the ingredients of the own price elasticity of supply:

$$E_s = \frac{\%\Delta Q^s}{\%\Delta P} = \left(\frac{\Delta Q^s}{\Delta P}\right)\left(\frac{P}{Q^s}\right) = \left(\frac{\partial Q^s}{\partial P}\right)\left(\frac{P}{Q^s}\right) = \left(\frac{1}{2}\right)\left(\frac{60}{20}\right) = 1.5 \tag{5.4.25}$$

The price elasticity of supply is also elastic: a one percent increase in price results in a 1.5 percent increase in the quantity supplied of phones.

Two points are worth mentioning here. First, the price elasticities of supply and demand are not always symmetrical, as they are in this case (-1.5 and +1.5). The elasticities depend on the shape of the inverse supply and demand functions. The symmetry of the functions used here can be seen in Figure 5.4.9. When the inverse supply and demand functions are not symmetrical, the absolute values of the elasticities will be of different magnitudes. The second important point concerns the use of inverse supply and demand functions. The inverse functions are used to align with the "backwards" nature of the supply and demand graphs: price is the independent variable, but appears on the vertical axis. To find the derivative needed to calculate the price elasticities, the procedure above first took the derivative of the inverse function, then inverted it to achieve $\frac{\partial Q}{\partial P}$. This derivative could also be found be first, inverting the inverse function to get the quantity isolated on the left hand side, then taking the derivative. This alternative procedure will result in the same elasticity calculation as the one used above. To test your knowledge, try this procedure to double check your answers!

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5.5: Concluding Comments

Market demand arises from the decisions of consumers. The aim of this chapter has been to provide background on three consumer choice models relevant to food demand. Each is based on the simple idea that consumers choose the best bundle that they can afford. The models differ in terms of how consumer utility is specified and how affordable sets are characterized.

In the neoclassical model of consumer choice, the consumer derives satisfaction directly from goods and services acquired in the marketplace. Affordability is defined as the set of product bundles the consumer can purchase with his or her money income. It was shown that given several reasonable assumptions, the neoclassical model of consumer choice can be used to derive individual demand schedules that have properties similar to market demand schedules introduced in Chapter 1. However, the model does not shed a great deal of light on why a consumer might prefer a particular market good or service or why he or she might prefer one product bundle to another.

Lancaster's model differs in that it focuses not on the products themselves but on the characteristics they contain. In Lancaster's model, you learned that the consumer derives satisfaction for characteristics, for example, sensory attributes or nutrients. Market provided goods are important to the model in that they constitute the delivery mechanism for the attributes desired by the consumer. Thus, Lancaster's model can provide additional insight into attributes of products that influence the consumer's desire for them. Lancaster's model provides theoretical underpinnings for hedonic pricing models. The logic of Lancaster's model is particularly suited to products that are in a state of latent demand as described in chapter 1. The Lancaster framework permits a new product innovation to be compared to existing products in the characteristic space and can provide insight into whether the new product would be competitive at a price that justifies its production cost. Many product design activities in the food marketing system can be viewed within the context of Lancaster's model examples include fortification of food offering and the design of product offerings with reduced fat, sodium and/or sugar content.

Finally, Becker's model differs in that market-sourced products are used as inputs for household production. Time is essential to understanding affordable set in Becker's model, which explicitly accounts for the opportunity costs of household-produced goods. The consumer's time allocation directly effects his/or her ability to secure products in the marketplace. Becker's model provides a useful template to understand growth in convenience foods over recent decades. Time spent in household production has a clear opportunity cost in the form of time not spent in the labor force and the value of foregone utility from leisure. As opportunities for women to work outside of the home have increased markedly in the post World-War-II era, the food system has responded by increasing product offerings that reduce preparation time.

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5.6: References

Becker, G. S. 1965. “A Theory of the Allocation of Time.” *Economic Journal* 75:493-517.

Lancaster, K. J. 1966. “A New Approach to Consumer Theory.” *Journal of Political Economy* 74:132-157.

Senauer, B., E. Asp, and J. Kinsey. 1991. *Food Trends and the Changing Consumer*. St. Paul, MN: Eagan Press.

Varian, H. 1992. *Microeconomic Analysis* 3rd Ed. New York, NY: W.W. Norton & Co.

Varian, H. 1993. *Intermediate Microeconomics: A Modern Approach.* 3rd Ed. New York, NY: W.W. Norton & Co.

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5.7: Problem Sets

Problem Set 1: Multiple Choice

Exercise 5.7.1

1. **This preference axiom says more is always preferred to less?**

a) Preferences are complete

b) Preferences are transitive

c) Preferences are convex

d) Preferences are monotonic

Answer available at the end of this section.

Exercise 5.7.2

2. **This preference axiom says that consumers are capable of ranking bundles.**

a) Preferences are complete

b) Preferences are transitive

c) Preferences are convex

d) Preferences are monotonic

Answer available at the end of this section.

Exercise 5.7.3

3. **Which preference axiom best characterizes the statement that "means are preferred to extremes"?**

a) Preferences are complete

b) Preferences are transitive

c) Preferences are convex

d) Preferences are monotonic

Answer available at the end of this section.

Exercise 5.7.4

4. **In Lancaster's model of the consumer, utility is a function of**

a) Leisure time

b) Household produced goods and services

c) Product characteristics

d) Purchased goods

Answer available at the end of this section.

Exercise 5.7.5

5. **In the Neoclassical model of the consumer, utility is a function of**

a) Leisure time

b) Household produced goods and services

c) Product characteristics

d) Purchased goods

Answer available at the end of this section.

Exercise 5.7.6

6. **Which best describes a hedonic pricing model?**

a) The full time income constraint from Becker's model

b) Product price is a function of product characteristics

c) Product price is a function of quantity placed on the market

d) All of the above

Answer available at the end of this section.

Exercise 5.7.7

7. **In consumer theory, the direct utility functions we examined in class**

a) Are ordinal functions

b) Are cardinal functions

c) Are pointless because utility cannot be measured

d) Are applicable in Becker's model but are not applicable in Lancaster's model

Answer available at the end of this section.

Exercise 5.7.8

8. **Which best summarizes the basic idea of consumer choice theory?**

a) Consumers optimize by choosing the healthiest but lowest cost bundle of food items

b) Consumers have preferences that are complete, reflexive, transitive, monotonic, and convex

c) Consumers select the bundle of goods of services they like best from all bundles in their budget set

d) Consumers minimize spending subject to meeting their minimum daily caloric needs

Answer available at the end of this section.

Exercise 5.7.9

9. **Hedonic pricing models**

a) Could be used to value characteristics that are not traded on the market

b) Explain price of a purchased good in terms of characteristics that consumers perceive to be important

c) Have theoretical roots in Lancaster's characteristics model

d) All of the above

e) Choices a and c only

Answer available at the end of this section.

Exercise 5.7.10

10. **Consumer sovereignty**

a) Means that consumers are vulnerable and so sovereign states need to be especially vigilant when implementing and enforcing consumer protection laws

b) Means that economic activity is ultimately directed by consumers through their purchase decisions

c) Means that economic activity is directed by central planners who are elected by sovereign consumers

d) Was first introduced by the Magna Carta, which placed limits on the power of the reigning sovereign

Answer available at the end of this section.

Exercise 5.7.11

11. **An ordinal utility function differs from a cardinal utility function in that**

a) Cardinal utility always satisfies the cardinal axioms of preferences (complete, reflexive, etc.) while ordinal utility might not.

b) Ordinal utility is usually used for ordinary products, while cardinal utility is used for the luxury goods

c) With an ordinal utility function we are interested primarily in how the function ranks bundles

d) Ordinal utility is a function of prices. Cardinal utility is a function of quantities

Answer available at the end of this section.

Exercise 5.7.12

12. **The full time-income constraint is featured in**

a) Becker's household production model

b) Lancaster's characteristics model

c) The neoclassical model

d) All of the above

Answer available at the end of this section.

Exercise 5.7.13

13. **This model is based on the simple idea that consumers choose the best bundle of goods and services that they can possibly afford**

a) Becker's household production model

b) Lancaster's characteristics model

c) The neoclassical model

d) All of the above

Answer available at the end of this section.

Exercise 5.7.14

14. **If preferences are transitive**

a) More is always preferred to less

b) The consumer likes variety (means are preferred to extremes)

c) The consumer is able to rank bundles

d) They have a logical ordering in that if X is preferred to Y, and Y is preferred to Z, then X is preferred to Z

Answer available at the end of this section.

Exercise 5.7.15

15. **If preferences are complete**

a) More is always preferred to less

b) The consumer likes variety (means are preferred to extremes)

c) The consumer is able to rank bundles

d) They have a logical ordering in that if X is preferred to Y, and Y is preferred to Z, then X is preferred to Z

Answer available at the end of this section.

Exercise 5.7.16

16. **Which best describes an expenditure intensive good as described in class**

a) An organic tenderloin roast and fresh local organic vegetables from the farmers' market

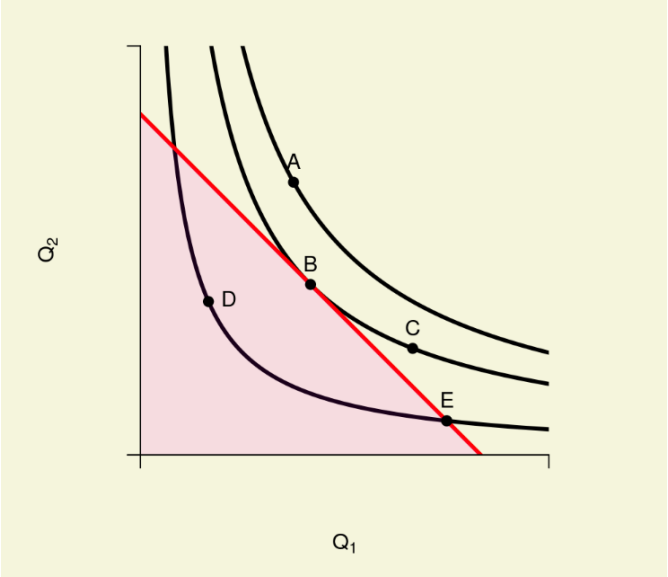
b) A fast food restaurant meal

c) A canoeing trip on Buffalo River

d) All-purpose flour

Answer available at the end of this section.

Use the diagram below to answer the remaining problems in this problem set.



Exercise 5.7.17

17. **The consumer likes C better than B**

a) True

b) False

Answer available at the end of this section.

Exercise 5.7.18

18. **C costs more than B**

a) True

b) False

Answer available at the end of this section.

Exercise 5.7.19

19. **E costs just as much as B**

a) True

b) False

Answer available at the end of this section.

Exercise 5.7.20

20. **D costs less than E**

a) True

b) False

Answer available at the end of this section.

Exercise 5.7.21

21. **A is the optimal choice**

a) True

b) False

Answer available at the end of this section.

Exercise 5.7.22

22. **The consumer likes B and E the same**

a) True

b) False

Answer available at the end of this section.

Exercise 5.7.23

23. **The consumer likes D and E the same**

a) True

b) False

Answer available at the end of this section.

Exercise 5.7.24

24. **Of labeled points, A is the most preferred**

a) True

b) False

Answer available at the end of this section.

Exercise 5.7.25

25. **Consider the utility functions in the table below and the preference map in the diagram above. Which, if any, of these functions provides a correct ordering of preferences?**

a) Function 1 only

b) Function 2 only

c) Functions 1 and 3

d) Functions 1,2,and 3

e) Functions 1, 3, and 4

Answer available at the end of this section.

Bundle	Function 1	Function 2	Function 3	Function 4
A	10	2	1000	0
B	5	5	500	-5
C	5	5	500	-5
D	2	10	200	-8
E	2	10	200	-8

Answers

Exercise 5.7.1
d

Exercise 5.7.2
a

Exercise 5.7.3
c

Exercise 5.7.4
c

Exercise 5.7.5
d

Exercise 5.7.6
b

Exercise 5.7.7
a

Exercise 5.7.8

c

Exercise 5.7.9

c

Exercise 5.7.10

b

Exercise 5.7.11

c

Exercise 5.7.12

a

Exercise 5.7.13

d

Exercise 5.7.14

d

Exercise 5.7.15

c

Exercise 5.7.16

b

Exercise 5.7.17

b

Exercise 5.7.18

a

Exercise 5.7.19

a

Exercise 5.7.20

a

Exercise 5.7.21

b

Exercise 5.7.22

b

Exercise 5.7.23

a

Exercise 5.7.24

a

Exercise 5.7.25

e

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6: PRICES DYNAMICS OVER TIME

Learning Objectives

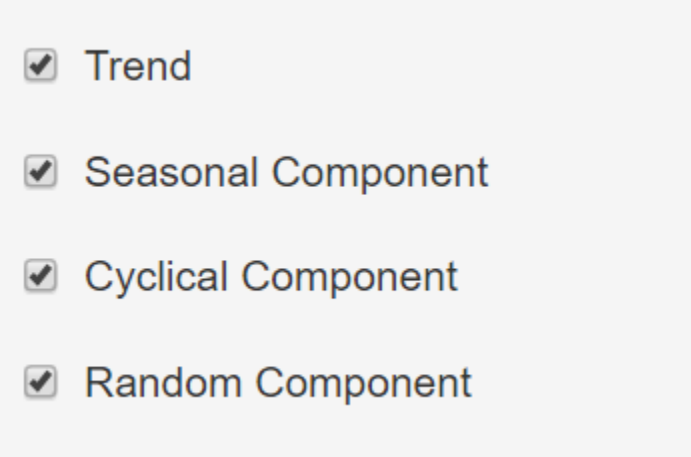
The overall aim of this chapter to provide you with some basic tools to work with and make sense of information contained in a price series. The specific objectives of this chapter are as follows:

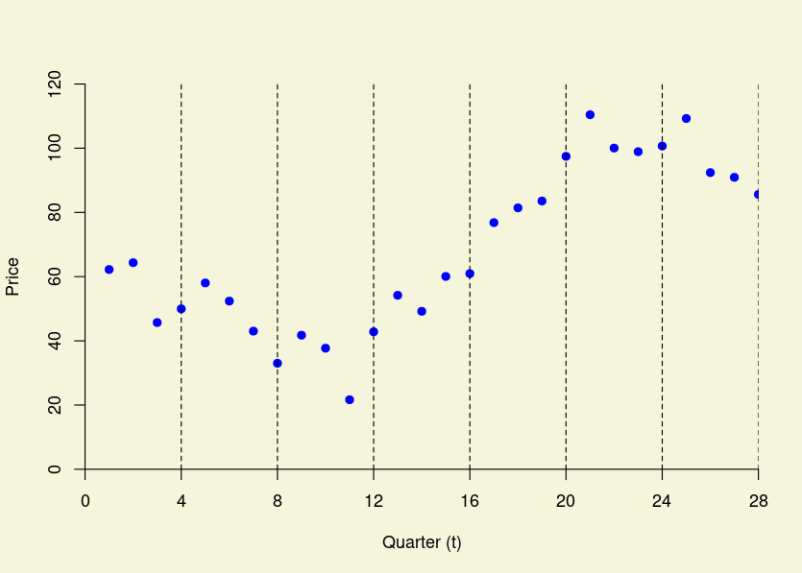
- **Explain** the four components of a price series.
- **Use** index numbers to account for inflation and express monetary values in constant dollars.
- **Compute** an N-period moving average to remove the seasonal component from a price series.
- **Distinguish** between demand and supply induced seasonality and be able to provide examples of each.
- **Describe** conditions that are likely to give rise to price cycles.

Markets can be defined in terms of three dimensions (1) a product or service, (2) a location, and (3) a point in time. This chapter emphasizes prices over time. What constitutes a point in time can vary depending on the question being asked and the product and geographic context of the market. In markets for commodity futures and options, high-frequency intraday prices are available, but it has also been common to analyze daily reference points such as the open, close or settlement price. Cash prices for some agricultural commodities are reported daily or weekly. Monthly or quarterly periodicities are also common. In this chapter, you will learn to think about price series in terms of several components. A time series can be decomposed into four components as illustrated in quarterly price series presented in Demonstration 1. Specifically, these components are:

- ***The trend.*** The trend is the general long-term direction of movement in the series. Demonstration 1 shows a positive trend, with prices increasing with time. To better visualize the trend in Demonstration 1, remove every other component but the trend from the demonstration.
- ***The seasonal component.*** A seasonal pattern is observed with regularity over a year. Use Demonstration 1 to remove everything but the seasonal component. Look at the series carefully and you will see that the price is highest in the first quarter of the year and is lowest in the third quarter. This pattern repeats itself each year.
- ***The cyclical component.*** A cyclical pattern repeats with some regularity over several years. Cyclical patterns differ from seasonal patterns in that cyclical patterns occur over multiple years, whereas seasonal patterns occur within one year. In Demonstration 1, remove all components but the cyclical component. The period shown illustrates one full cycle from a peak in quarter 1 to another peak in quarter 22. Thus, the cycle shown lasts about 5.5 years.
- ***The random component.*** Movements in the series that cannot be explained by the trend, seasonal, or cyclical components are considered to be random.

Demonstration 1. The Components of a Time Series





6.1: The Trend
6.2: Seasonal Component
6.3: Cyclical Component
6.4: Random Component
6.5: Concluding Comments
6.6: References
6.7: Problem Sets

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6.1: The Trend

The trend is the general long-term direction of movement in the series and is thought to arise when growth in long-run demand differs from growth in long-run supply. A positive trend, such as that shown in Demonstration 1, would result when increases in long-run demand outpace those in long-run supply. Similarly, a negative trend would occur when increases in long-run supply outpace increases in long-run demand.

One way to analyze a trend is through regression analysis. The analyst would estimate a model such as

$$P_t = \alpha + \beta t + \varepsilon_t,$$

where P_t is the price at time t, α is the average price over the period analyzed, β is the trend coefficient, and ε is an error term. The regression model could be augmented to include shift variables to remove seasonal components as well as quadratic terms to model cyclical patterns. Provided that the regression model captures the trend, seasonality, and cyclical components, $\epsilon t \epsilon t$ would reflect the random component of the time series. Another way to visualize a trend is to filter out seasonality and randomness through a moving average as described later in the chapter.

Because trends characterize the longer-term direction in prices, it is often necessary to account for inflation. Inflation refers to general increases in price levels over time. Deflation, by contrast, refers to general decreases in price levels over time. Because of inflation and deflation, the purchasing power of the dollar differs from year to year. In the post World-War II era, the US economy and most other economies have been characterized by inflation. Thus, you may incorrectly conclude that there is a positive trend in prices and that demand has outpaced supply, when in fact the price series simply reflects changes in the purchasing power of the dollar.

Real (Constant) vs. Nominal (Current) Prices

If you had a time machine that took you back to 1970, you would find that the supermarket price of a no-frills loaf of bread was about 24 cents. In 2016, a similar loaf of bread would have costed you about $1.40. These prices are ***nominal prices***. Nominal prices are what consumers actually paid for a product at the time of purchase. In 1970, the nominal price was 24 cents, and in 2016 the nominal price was $1.40. However, between 1970 and 2016, the purchasing power of the dollar changed considerably. The 24 cent price reflects the purchasing power of the dollar in 1970 and the $1.40 price reflects the purchasing power of the dollar in 2016. Of course, wages and consumer incomes have increased in nominal terms since 1970 as well.

The adjective “nominal” applies to any monetary value that has not been adjusted for inflation, e.g., nominal incomes, nominal tuition costs, nominal health care costs. Sometimes you will see monetary units expressed as “current dollars”. The adjective “current” is a synonym for “nominal.” Monetary units designated as current have similarly not been adjusted for inflation. If you see a table that has a note indicating that prices are in ***current dollars*** then you know that you are looking at nominal prices. With this in mind, the following two statements mean the same thing:

1. In nominal terms, the price of a loaf of bread was $0.24 in 1970 and $1.40 in 2016.
2. In current dollars, the price of a loaf of bread was $0.24 in 1970 and $1.40 in 2016.

Real prices (or ***constant prices***), by contrast, always refer to prices in terms of the purchasing power of the dollar in some reference year. Real prices (or constant prices) are adjusted for inflation. With real prices, the purchasing power of the dollar is held constant at some reference or base period. In a table or figure presenting real prices, the title, caption or a footnote will typically indicate the base period. For example, if prices are in constant 1990 dollars, this tells you that

1. The prices are adjusted for inflation, and
2. Prices reflect the purchasing power of the dollar in 1990.

As you will see below, it turns out that in constant 2016 dollars the price of bread was $1.48 in 1970 and $1.40 in 2016. Because these constant prices use 2016 as the reference period. The real price and nominal price will be the same for 2016.

In any kind of analysis with time series data, you would generally want to use real, not nominal, prices, especially if you are examining prices over an extended period of time. However, many sources where you might obtain data for your analysis will present nominal monetary values. For example, total sales figures from a company’s income statement will reflect nominal prices

for the year the income statement was generated. If you are looking at a company's sales over a period of several years, we might erroneously conclude that sales had grown when in actuality inflation, not true sales growth, resulted in higher values of total sales.

Converting Nominal (Current) Values into Real (Constant) Values

To convert any nominal price to a real price you need a broad price index that measures inflation. The most common index used in the United States is the Consumer Price Index for all Urban Consumers (CPI-U). The Consumer Price Index is provided by the US Department of Labor and is released each month. Annual values of the Consumer Price Index for some selected years are reported in Table 6.1.1. You can obtain values of the CPI-U directly from the US Department of Labor's Bureau of Labor Statistics website (US-BLS 2017).

Table 6.1.1. Consumer Price Index for All Urban Consumers (1982-84 = 100), Selected Years

Year	CPI-U	Year	CPI-U
1960	29.6	1995	152.4
1965	31.5	2000	172.2
1970	38.8	2005	195.3
1975	53.8	2010	218.1
1980	82.4	2011	224.9
1982	96.5	2012	229.6
1983	99.6	2013	233.0
1984	103.9	2014	236.7
1985	107.6	2015	237.0
1990	130.7	2016	240.0

A price index, such as the CPI-U presented in Table 1, reflects price levels as a percentage of prices in some base period. 1982-84 is the base period currently being used by the US Bureau of Labor Statistics, the entity responsible for computing the CPI (US-BLS 2017). Take an average of the index values reported in Table 1 for 1982, 1983, and 1984 and you will see that this average is 100.

$$\frac{96.5 + 99.6 + 103.9}{3} = 100$$

The BLS has been using the 1982-84 base period since January 1988.

The numbers in Table 1 present price levels as a percentage of the 1982-84 base period. To illustrate, consider the value of the index in 2000. In 2000, the CPI is 172.2. This means that general price levels in 2000 were (172.2 - 100) = 72.2 percent higher than they were during the 1982-84 base period. Similarly, the value of the index in 2016 is 240.0. Price levels in 2016 were (240-100) = 140 percent higher than in the base period. In 1980, the value of the index is 82.4. This means that price levels were (82.4-100) = -17.6 percent higher (or 17.6 percent lower) than they were during the 1982-84 base period.

The CPI-U reflects prices that consumers pay over a broad category of expense items including, food, housing, transportation, apparel, health care, education, and so forth (US-BLS 2017). As such, it is a measure of the purchasing power of the dollar relative to the base year and can be used to convert nominal prices into real prices.

Notice from Table 1 that the CPI-U increases as time passes. This indicates that the economy has been characterized by inflation. If the CPI fell from one year to the next, it would indicate deflation. Deflation occurred in the US during the great depression of the 1930s. The CPI-U with a base year of 1982-84 fell from 17.2 in 1929 to 12.9 in 1933. During the post-war period, year-to-year changes in the CPI have been positive with few exceptions. In the recent great recession, the annual-average CPI did fall slightly from 215.3 in 2008 to 214.5 in 2009.

Given a broad price index like the CPI-U, nominal prices can be converted into real prices via the following formula:

$$Real\ \ Price = \frac{Nominal\ Price}{Index} \times 100$$

When you do this conversion, your real prices will reflect the purchasing power of the dollar in the base period of your index. Consequently, if we used the CPI in Table 6.1.1 to adjust nominal prices for inflation, we would get a real price series that reflects the purchasing power of the dollar during the 1982-84 period. Using Table 6.1.1, we could get real prices for bread in constant 1982-84 dollars as shown in Table 6.1.2.

Table 6.1.2. Converting Bread Prices from Nominal to Real Terms

Year	Nominal Price	Real Price (1982-84 dollars)
1970	$0.24	$\frac{\$0.24}{38.8} \times 100 = \$0.62$
2016	$1.40	$\frac{\$1.40}{240.0} \times 100 = \$0.58$

Thus you can conclude that in real terms, the price of a no-frills loaf of bread decreased by 4 cents. The problem is that these 4 cents reflect the purchasing power of 1982-84 dollars. 1982-84 was a long time ago, before most of you were even born. Even old timers might have problems remembering what prices were way back in 1982-84.

Changing the Base Period

Fortunately, the base period of any price index can be changed. All you need to do is

1. choose a new base period,
2. divide the index numbers in all periods by the value of the original index for the new base period, and
3. multiply the resulting new index by 100.

For example, suppose you wanted 2016 to be the base period. Divide every index number in the series by the 2016 value of 240.0 and multiply the resulting new numbers by 100:

$$I^t_{2016=100} = \frac{I^t_{1982-84=100}}{I^{2016}_{1982-84=100}} \times 100,$$

where I refers to the index, and t reflects the year in question. This conversion is presented in Table 6.1.3. Note that the index value in column 3 of the table for 2016 is now 100. Because there has been positive inflation during recent years, index values in years prior to 2016 in column 3 all have values less than 100. Take a moment to replicate a few of the transformed index values in the third column of the table.

Table 6.1.3. Consumer Price Index for All Urban Consumers

Year	1982-84=100	2016=100
1970	38.8	16.2
1980	82.4	34.3
1990	130.7	54.5
2000	172.2	71.7
2010	218.1	90.9
2016	240.0	100.0

If you use this transformed index (2016=100) to adjust for inflation, you will obtain a real price series that reflects the purchasing power of the dollar in 2016. With this in mind, the real price of bread can be expressed in constant 2016 dollars as shown in Table 6.1.4.

Table 6.1.4. Real and Nominal Prices for Bread

Year	Nominal Price	Real Price (2016 = 100)
1970	0.24	$\frac{0.24}{16.2} \times 100 = 1.48$
2016	1.40	$\frac{1.40}{100.0} \times 100 = 1.40$

Be sure to notice that the real price equals the nominal price in the base year. This is because real prices reflect the purchasing power in terms of nominal base-year dollars.

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6.2: Seasonal Component

A seasonal pattern is observed with regularity within a given period of time, usually within a year. Typically, the interest is in seasonal patterns over a calendar or marketing year, but there may be contexts in which we could see regular patterns over shorter periods. For example, shopping traffic in a supermarket is seasonal through a week (with higher traffic on weekends) or even on a weekday (with more traffic around the end of the workday).

Seasonal patterns can be demand-induced or supply-induced. For example, demand for products like Christmas trees, carving pumpkins, and whole turkeys are highly seasonal. In these examples, demand is driven by consumption around holidays. In volume, although not so much in price, there are clear demand-induced seasonal patterns in wine consumption (Anez 2005). White and rose wines are traditionally served chilled. These have higher volume sales in the summer months. Red wines, traditionally served at room temperature, have higher volume sales in the winter months. There are volume spikes for all wines regardless of color around holidays.

Supply-induced seasonal patterns are observed in the market for perishable commodities like fruits and vegetables. For example, Sobekova, Thomsen and Ahrendsen (2013) show seasonal price patterns for strawberries, blueberries, blackberries and raspberries. For each of these crops, there is a clear relationship between available supply at different points in the year and price. This is because berries are sourced from different regions of the country or world during different parts of the year. The costs of producing and shipping berries to market differ depending on the supply region. Essentially, the supply curve for berries differs depending on the season of the year and this leads to seasonality in the prices of these berries.

Storage costs can result in supply-induced seasonal price patterns for storable commodities like grains and oilseeds. These crops are harvested once a year, but demand is spread over the year. It is often the case that prices are lowest around the harvest season but then increase in the following months. The increase in price is necessary to provide incentives to store commodities and make them available for use in non-harvest months. Figure 1 shows average cash prices for corn by month over the 2001 to 2016 period. The marketing year for corn runs from September 1 through August 31. Notice that prices are lowest during the harvest months (September through November) and increase consistently until July, about the time when there are good expectations of what the upcoming corn crop will be and when elevators are under pressure to make room for wheat and other small grains harvested in the summer.

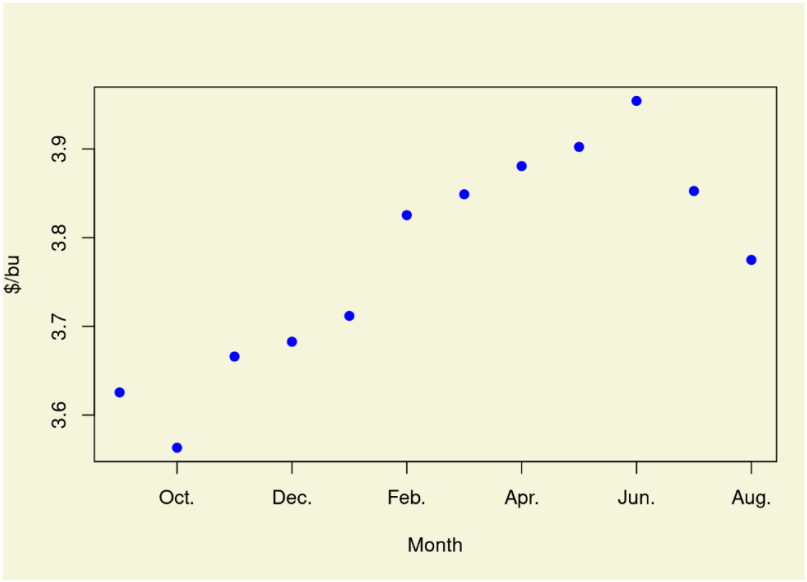


Figure 6.2.1: **Average cash price for corn by month of the marketing year (2001-2016). Source: Based on cash prices reported by Top Flight Grain Cooperative (Illinois) via https://www.quandl.com/data/TFGRAIN/CORN-Cash-Price-of-Corn.**

An n-period ***moving average*** is an average of the n most recent time series observations. If one chooses n to correspond to the periodicity of the data, a moving average can be used to remove the seasonal component of a time series, which may help you better see the trend or cyclical components. The data presented in Table 6.2.1 are quarterly (four periods per year). Verify that the four-period moving average is simply the average of the four most recent observations. Note also that these price data show

a very strong seasonal pattern. The moving average, however, removes that seasonality. This can be seen in Figure 6.2.2, which charts the data in Table 6.2.1 along with the four-period moving average.

Table 6.2.1. Computing a Four-period Moving Average

t	Quarter	Price	Four-pd. Moving Avg.
1	1	3	-
2	2	8	-
3	3	4	-
4	4	8	5.75
5	1	11	7.75
6	2	16	9.75
7	3	12	11.75
8	4	16	13.75
9	1	19	15.75
10	2	24	17.75
11	3	20	19.75
12	4	24	21.75
13	1	27	23.75
14	2	32	25.75
15	3	28	27.75
16	4	32	29.75

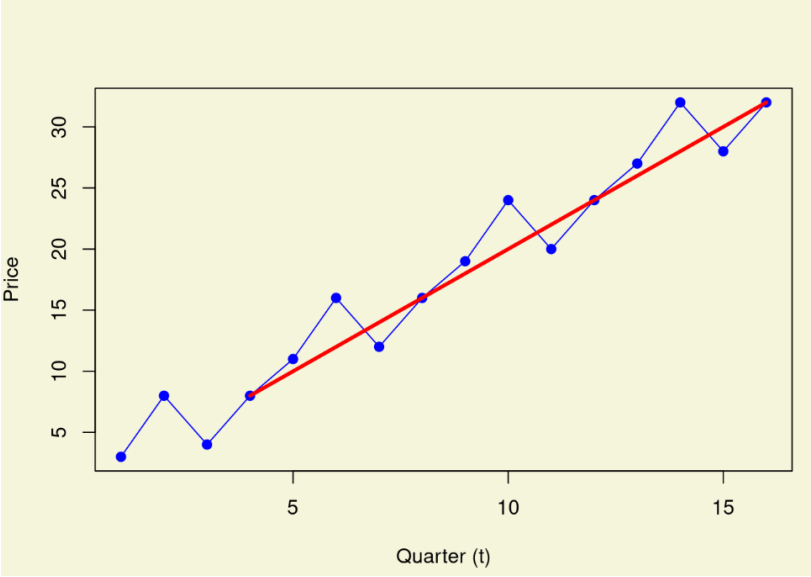


Figure 6.2.2: Table 6.2.1 Data with a Four-period Moving Average (in Red)

In the example above, a four-period moving average was used because we had quarterly data. Every point in our moving average included one each of quarter 1 through 4. If, instead, we were interested in removing seasonality from monthly data or weekly data, we would use 12-period or 52-period moving average instead. The 12-period moving average would be used for monthly data because there are 12 months per year. The 52-period moving average would be used for weekly data since there are 52 weeks per year.

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6.3: Cyclical Component

A cyclical pattern repeats with some regularity over several years. Cyclical patterns differ from seasonal patterns in that cyclical patterns occur over multiple years, whereas seasonal patterns occur within one year.

One example of a cyclical pattern, the business cycle, is from macroeconomics. Over time, economic expansions are followed by economic recessions followed again by economic expansions. There is not perfect regularity in the business cycle, as expansions and recessions differ in length. Nevertheless, this process has repeated itself over and over through time.

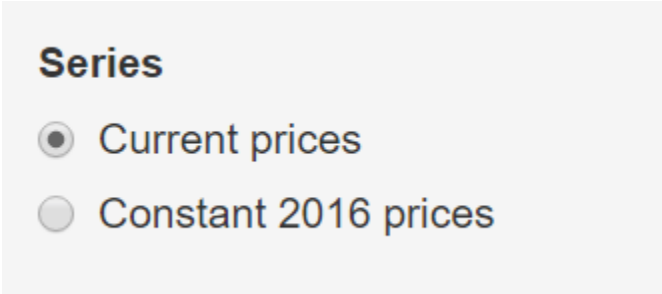
Cycles are also observed in some agricultural commodity prices and are most pronounced when there is a time lapse between a change in price and the producer's response to this change. The time lapse is due to two things:

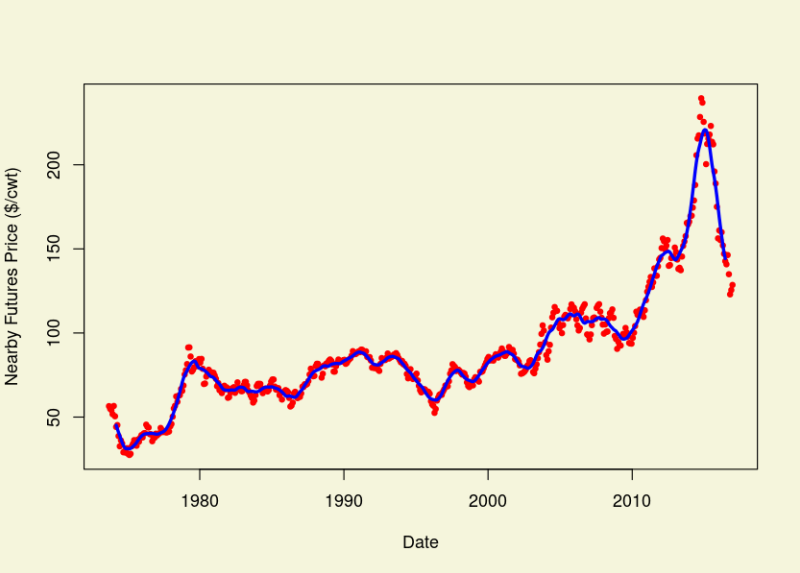
1. ***A biological lag***. The biological lag refers to the length of time between the decision to expand production and the resulting change in supply.
2. ***A psychological lag***. The psychological lag is the length of time when prices must be high or low in order to convince producers that production plans should be changed.

Price cycles emerge when future production decisions are based on current prices and when producers have little control over prices (i.e., when producers are price takers). Thus, cycles are more likely to emerge in industries where there are a large number of relatively small operations. Price cycles are also more likely when there is a a large degree of control over output. Otherwise, random shocks tend to disrupt the cyclical pattern and cause it to dissipate. For this reason, cycles are often more common for livestock than for crops.

One commonly mentioned price cycle is the cattle cycle. The cattle cycle lasts about 8 to 12 years from peak to peak or trough to trough. There is some evidence of cycles, albeit shorter cycles, in hogs and broilers. Demonstration $6.3.1$ shows monthly feeder cattle prices from the nearby feeder cattle futures contract from the mid-1970s through 2016. The raw prices are plotted as red points and a centered 12-period moving average is superimposed in blue. Do you see any evidence of a cattle cycle in these data? The demonstration allows you to examine the data in both nominal and real terms. Evidence of the cattle cycle is easier to see if you look at the data in real terms.

Demonstration $6.3.1$. Feeder Cattle Prices with 12-Month Centered Moving Average (Sept. 1973 through Dec. 2016)





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6.4: Random Component

Movements in the series that cannot be explained by the trend, seasonal, or cyclical components are considered to be random. Many exogenous factors can cause demand or supply to shift and the equilibrium price to change. In agriculture, these include weather, plant or animal diseases, political upheavals that affect trade, and a number of other shocks to demand or supply. A moving average as described above can help to remove random elements of the time series as well as seasonality. Large random shocks could also disrupt a cyclical pattern as described above. In empirical work randomness describes movements in a price series that cannot be explained with the model.

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6.5: Concluding Comments

The overall aim of this chapter was to provide you with some basic tools to work with and make sense of information contained in a time series of prices. At the University of Arkansas, there is a full-semester course dedicated specifically to agricultural prices and forecasting. This is true of most agricultural business and or agricultural economics programs. Consequently, coverage of price series in a general survey course will necessarily be brief. Nevertheless, given the information presented in this chapter, you should be able to identify the different components of a price time series, perform basic adjustment of a series for inflation, and explain some of the conditions that give rise to seasonal and cyclical patterns in agricultural commodity prices. Spend some time with the problem sets below to reinforce the material presented in this chapter.

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6.6: References

The overall aim of this chapter was to provide you with some basic tools to work with and make sense of information contained in a time series of prices. At the University of Arkansas, there is a full-semester course dedicated specifically to agricultural prices and forecasting. This is true of most agricultural business and or agricultural economics programs. Consequently, coverage of price series in a general survey course will necessarily be brief. Nevertheless, given the information presented in this chapter, you should be able to identify the different components of a price time series, perform basic adjustment of a series for inflation, and explain some of the conditions that give rise to seasonal and cyclical patterns in agricultural commodity prices. Spend some time with the problem sets below to reinforce the material presented in this chapter.

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6.7: Problem Sets

Problem Set 1: Inflation Adjustment

Year	CPI-U (1982-84=100)
1970	38.8
1980	82.4
1990	130.7
2000	172.2
2010	218.1
2016	240.0

Exercise 6.1

Given the following:

The nominal price in 2000 was $120.

The nominal price in 2016 was $520.

Express these prices in constant 1990 dollars.

Answer available at the end of this section.

Exercise 6.2

Given the following:

The nominal price in 2000 was $220.

The nominal price in 2016 was $670.

Express these prices in constant 1970 dollars.

Answer available at the end of this section.

Exercise 6.3

Given the following:

The nominal price in 2000 was $310.

The nominal price in 2016 was $320.

Express these prices in constant 2016 dollars.

Answer available at the end of this section.

Exercise 6.4

Given the following:

The nominal price in 2000 was $415.

The nominal price in 2016 was $670.

Express these prices in constant 1982-84 dollars.

Answer available at the end of this section.

Exercise 6.5

Given the following:

The nominal price in 2000 was $520.

The nominal price in 2016 was $560.

Express these prices in constant 1980 dollars.

Answer available at the end of this section.

Exercise 6.6

Given the following:

The nominal price in 2000 was $370.

The nominal price in 2016 was $400.

Express these prices in constant 2000 dollars.

Answer available at the end of this section.

Exercise 6.7

Given the following:

The nominal price in 2000 was $320.

The nominal price in 2016 was $360.

Express these prices in constant 2010 dollars.

Answer available at the end of this section.

Exercise 6.8

Given the following:

The nominal price in 2000 was $870.

The nominal price in 2016 was $910.

Express these prices in constant 1990 dollars.

Answer available at the end of this section.

Exercise 6.9

The nominal price in 2000 was $425.

The nominal price in 2016 was $415.

Express these prices in constant 2016 dollars.

Answer available at the end of this section.

Exercise 6.10

Given the following:

The nominal price in 2000 was $425.

The nominal price in 2016 was $415.

Express these prices in constant 1982-84 dollars.

Answer available at the end of this section.

Problem Set 2: Multiple Choice

Exercise 6.11

1. **Which scenario is most likely to give rise to seasonal price patterns in a prices series?**

a) Storage costs for a storable agricultural commodity

b) Production lags (e.g., biological lags)

c) Random factors that shock supply or demand

d) A consistent and sustained general growth in market demand over a long period of time

Answer available at the end of this section.

Exercise 6.12

2. **Which scenario is most likely to give rise to cyclical price patterns in a price series?**

a) Storage costs for a storable agricultural commodity

b) Production lags (e.g., biological lags)

c) Random factors that shock supply or demand

d) A consistent and sustained general growth in market demand over a long period of time

Answer available at the end of this section.

Exercise 6.13

3. **Which scenario is most likely to give rise to a trend in a price series?**

a) Storage costs for a storable agricultural commodity

b) Production lags (e.g., biological lags)

c) Random factors that shock supply or demand

d) A consistent and sustained general growth in market demand over a long period of time

Answer available at the end of this section.

Exercise 6.14

4. **Production lags, such as the biological lag or the psychological lag are likely to give rise to**

a) Spatial patterns in a time series of prices

b) Cyclical patterns in a time series of prices

c) Seasonal patterns in a time series of prices

d) All of the above

Answer available at the end of this section.

Exercise 6.15

5. **Which best describes inflation?**

a) Inflated statements such as “our product is the most delicious”

b) An effort to set the selling price above the break-even point

c) A general increase in calorie consumption as foods have become cheaper over time

d) A general increase in price levels across the economy

Answer available at the end of this section.

Exercise 6.16

6. **What best describes a four-period moving average?**

a) An average of the four periods with the largest values

b) An average of the four periods with the smallest values

c) An average of the four most recent periods

d) All of the above

Answer available at the end of this section.

Exercise 6.17

7. **Which is not one of the four components of a time series?**

a) The trend component

b) The random component

c) The spatial component

d) The seasonal component

Answer available at the end of this section.

Exercise 6.18

8. **If a price index number is 103, we can say:**

a) That prices are 103 percent higher than they were in the base year.

b) That price levels are 3 percent higher than they were in the base year.

c) Nothing, unless we first convert to nominal dollars.

d) That relative to the base year, prices have fallen slightly.

Answer available at the end of this section.

Exercise 6.19

9. **If you were to adjust a monetary time series for inflation using the Consumer Price Index with 1982-84 = 100 you would get**

a) nominal prices.

b) real prices in 1982-84 dollars.

c) prices that are always equal to 100.

d) current prices.

Answer available at the end of this section.

Exercise 6.20

10. **If you have weekly data and wanted to remove seasonality, you could**

a) Use a 52-period moving average

b) Use a 7-period moving average

c) Use a 5-period moving average (assuming weekends are not included)

d) Estimate the biological lag model

e) Choices (b) and (c) only

Answer available at the end of this section.

Exercise 6.21

11. **Fluctuations in prices over time that cannot be explained by a trend, a cycle, or a seasonal pattern are called**

a) the market component of the time series.

b) the demand-induced component of the time series.

c) the equilibrium component of the time series.

d) the random component of the time series.

Answer available at the end of this section.

Exercise 6.22

12. **If a price index has a value of 0.96 then we know that**

a) We are probably looking at the base period since this number is close to 100.

b) Relative to the base period prices are 4 percent lower.

c) Relative to the base period prices are 96 percent higher.

d) We are dealing with a producer price index and not a consumer price index.

Answer available at the end of this section.

Exercise 6.23

13. **If you are presented with 'nominal' prices then you know that:**

a) Prices are in US dollars as opposed to some other currency

b) These prices have not been adjusted for inflation

c) These prices have been adjusted for inflation

d) These prices reflect the trade-off between two physical commodities, for example the price of one nominal product such as corn as a ratio to the price of another nominal product such as soybeans.

Answer available at the end of this section.

Exercise 6.24

14. **If you see a table indicated that prices are in constant 2010 dollars then you know that**

a) You are looking at current prices.

b) Prices have been adjusted for inflation.

c) Prices have not been adjusted for inflation.

d) Both (a) and (c).

Answer available at the end of this section.

Exercise 6.25

15. **A price cycle is most likely to be observed**

1. In areas of the United States, such as Colorado, where cycling is an especially popular pastime.
2. When there has been a general increase in long run demand over the period being analyzed.
3. When there has been a general decrease in long run supply over the period being analyzed.
4. When there is a significant biological lag (e.g., tree fruits, livestock).

Answer available at the end of this section.

Exercise 6.26

16. **If we have monthly time series data that is highly seasonal, the best way to remove the seasonal component would be to**

1. Employ the time series seasonal decompression model that has been the main topic of the course since we returned from Spring Break.
2. Apply a 12-period moving average to the data.
3. Throw out observations from August and December. In most cultures, these months usually contain aberrations that are due to summer vacations and major winter holidays.
4. Do none of the above. We must first determine whether the seasonal component is supply induced or demand induced.

Answer available at the end of this section.

Exercise 6.27

17. **In the base year, the value of a price index is**

1. 100
2. 0
3. Indeterminate unless you are using inflation adjusted numbers
4. The highest point in the index series

Answer available at the end of this section.

Answers

Exercise 6.1

The real price in 2000 was $91.08.

The real price in 2016 was $283.18.

Exercise 6.2

The real price in 2000 was $49.57.
The real price in 2016 was $108.32.

Exercise 6.3

The real price in 2000 was $432.06.
The real price in 2016 was $320.

Exercise 6.4

The real price in 2000 was $241.
The real price in 2016 was $279.17.

Exercise 6.5

The real price in 2000 was $248.83.
The real price in 2016 was $192.27.

Exercise 6.6

The real price in 2000 was $370.
The real price in 2016 was $287.01.

Exercise 6.7

The real price in 2000 was $405.32.
The real price in 2016 was $327.15.

Exercise 6.8

The real price in 2000 was $660.34.
The real price in 2016 was $495.56.

Exercise 6.9

The real price in 2000 was $592.33.
The real price in 2016 was $415.

Exercise 6.10

The real price in 2000 was $246.81.
The real price in 2016 was $172.92.

Exercise 6.11

a

Exercise 6.12

b

Exercise 6.13

d

Exercise 6.14

b

Exercise 6.15

d

Exercise 6.16

c

Exercise 6.17

c

Exercise 6.18

b

Exercise 6.19

b

Exercise 6.20

a

Exercise 6.21

d

Exercise 6.22

b

Exercise 6.23

b

Exercise 6.24

b

Exercise 6.25

d

Exercise 6.26

b

Exercise 6.27

a

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7: MARKET STRUCTURES IN AGRICULTURE

Learning Objectives

This chapter is about competition and market outcomes under these different market structures. The specific learning objectives for the chapter are as follows:

- **Describe** and **explain** characteristics of different market structures on the selling side of the market.
- **Use** the MR = MC profit maximizing condition to find profit maximizing solutions under different market structures.
- **Explain** the strategic interactions in duopoly models, distinguish between Cournot and Bertrand models of duopoly, and explain how each is an example of the prisoners' dilemma
- **Explain** the folk theorem and the ability of firms to avoid prisoners' dilemma outcomes in price competition over time.
- **Understand** the economic welfare implications of imperfectly competitive market structures relative to the perfectly competitive benchmark.

Markets vary in ways that affect competition and pricing. In some markets, competition is fierce. In others, it is light. Some firms have broad discretion in setting prices, while others face take-it-or-leave-it market prices. Pricing and competition depend on the structural characteristics of the market. Economists classify markets as monopolies, oligopolies, monopolistically competitive, or perfectly competitive depending on the characteristics of selling firms in the market. A brief overview of each market structure is as follows:

A ***monopoly*** is a market with only one seller. The seller (called a monopolist) will often have quite a bit of control over the price that it charges. Earlier in the course, you examined a firm that was a price taker. A monopolist is not a price taker. As the only seller, the monopolist has an incentive to keep its price above its marginal cost. In so doing, it takes surplus from consumers and turns that surplus into profits for itself. Naturally, sellers like to have monopoly power. The problem for the monopolist is to get as much of the consumer surplus as it can. This problem is complicated in that the monopolist faces the market demand curve. Because of the law of demand, the monopolist must lower its price if it wants to sell more, which entails sacrificing its profit margin. On the other hand, if the monopolist attempts to raise price, and thereby increase its profit margin, it sacrifices volume. There is a balancing act here that you have seen before with demand elasticities in Chapter 3. In this chapter, you will see that the demand elasticity facing the monopolist is relevant and can help you solve the monopolist's problem.

An ***oligopoly*** is a market where there are a few sellers. There must be at least two sellers (a duopoly), and there is no magic number on what constitutes the upper limit of a "few" sellers. Like monopolists, oligopolists do have some discretion in setting their prices. However, the problem is further complicated by the fact that the oligopolist must pay attention to the actions of its competitors. Interactions among competitors are of primary interest in oligopoly models.

Monopolistic competition refers to situations where there are generally many sellers (again, there is no magic number that divides "few sellers" from "many sellers"). A key feature of monopolistic competition is that products are differentiated in the minds of consumers and/or transactions costs give rise to varied perceptions among consumers as to the advantages or disadvantages of patronizing one firm over another. Because products are differentiated, sellers are not price takers. Like the monopolist, firms in monopolistic competition face a downward sloping demand curve. In fact, you will see that the individual firm's problem in monopolistic competition has the same set-up as the monopolist's problem.

Perfect competition refers to situations where there are many sellers. Products are homogeneous or differ only in ways that readily apparent to all buyers. The actions of any single seller has no effect on the market price. Firms under perfect competition are price takers. The price taking assumption was introduced earlier in Chapter 2. This assumption is the one key feature of perfect competition. While the market demand curve slopes downward, the firm does not face the market demand curve; it only sees the prevailing market price. It can sell all that it wants (or all that it can produce) at the going market price. If the firm attempts to raise its price, there are no buyers. For this reason, it can be said that the firm faces an elasticity of demand that is negative infinity.

7.1: Considerations in Classifying a Market

7.2: Market Structures

7.3: Marginal Revenue for Imperfectly Competitive Markets
7.4: Monopolistic Competition
7.5: Profit Maximization for a Monopolist or Monopolistically Competitive Firm
7.6: Oligopoly Models
7.7: Profit Maximization in an Oligopoly
7.8: Oligopoly, Collusion, and Game Theory
7.9: Concluding Comments- Effects of Imperfect Competition on Economic Welfare
7.10: References
7.11: Problem Sets

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7.1: Considerations in Classifying a Market

How do you know whether a market is a monopoly, an oligopoly, monopolistically competitive, or perfectly competitive? To answer this question, it is useful to clarify the boundaries of the market you are considering. There are three dimensions of a market. These are the product, the time, and the place. You should think about market boundaries in terms of each of these three dimensions. In the product dimension, clarify how narrowly you are defining the product. For instance, are you interested in the market for herbicides broadly, or are you interested in the market for herbicides designed to control a specific weed or class of weeds? Once you have specified the product boundaries, you can then identify competitors that are operating in the market. The next dimension is time. Agricultural products are sometimes sourced from different locations at different times of the year. Because of this, the set of sellers who comprise the market could be different at different points in time. Finally, the place dimension is important because agricultural products are bulky and transportation costs are often an important consideration. Thus, sellers in one geographic area may be different than sellers in another. Moreover, there may be more sellers in one geographic area than another depending on demand conditions in the respective geographic areas. Having defined the boundaries of a market along these three dimensions (product, time, and place), you can use several characteristics of the market to classify its structure.

The first, and probably most obvious, characteristic is ***the number of firms that comprise the market***. The number of firms is central to the definitions of market structures above. In a monopoly, the market is comprised of one firm. In an oligopoly there are a few firms. If there are many firms, the market is either monopolistically or perfectly competitive, depending on the nature of the product.

Another issue of specific importance is ***whether the product of one seller is different from the product of another in the minds of consumers***. If so, the products are differentiated. If not, the products are homogeneous. If products are differentiated, it is useful to distinguish between two different types of product differentiation:

1. A product is vertically differentiated if there are clear quality differences that can be measured objectively. All buyers can agree upon the presence or absence of the quality attribute, regardless of whether the buyer actually places a value on the attribute in question. For example, in lumber, there are vertical differences between oak and pine. Buyers are knowledgeable about these differences and situations wherein one type of lumber is better suited than the other. Usually there are vertical differences among agricultural products. In many cases, grades and standards are used to convey information about these vertical quality differences.
2. Products are horizontally differentiated if there are less tangible quality differences among products that are nonetheless important to the consumer or some segments of consumers. Horizontal differences usually come down to a matter of taste. Most horizontal differences are conveyed through brand image. For example, if you were to compare the ingredient lists on two different brands of cola, you would see that they were nearly identical. It is hard to make the case that one brand is truly better than another for its intended purpose. However, some consumers are probably quite loyal to one of the brands and may even dislike the other.

If horizontal product differences exist, then brands can play a role in conveying these differences, and an industry comprised of many competitors will be monopolistically competitive, as opposed to being perfectly competitive. Vertical product difference can exist in either perfect or monopolistic competition. In a perfectly competitive market, the market price is augmented by a series of market-determined discounts or premiums to account for the vertical quality differences.

Finally, ***the ease with which new firms can enter the market*** is important to market structure and market outcomes. Entrants are latent or potential competitors. As you learned in Chapter 2, if an outside firm finds a market to be attractive, it will come into the market, cause supply to shift outwards and depress prices. Outcomes of some of the market structures depend on entry being difficult in one way or another. Entry can be difficult for several reasons:

1. *Economies of scale are large compared to the size of the market.* In some cases, production technology is such that a firm must produce a very large number of units in order to cover fixed costs. If demand is limited, there may only be room for one or two firms to operate at an efficient scale within a given market. This could foreclose entry because outside firms will not be able to achieve an efficient scale if the market is entered.
2. *Access to raw materials, technology, or distribution channels.* The inability to access key sources of raw materials, technology, or distribution channels can prevent entry, even if the production process is well understood and economies of scale are inconsequential. In some cases, access is limited by patents or other legal restrictions. This is common with some plant materials, seed varieties, and crop protectants.

3. *Network externalities.* A network externality exists if there are benefits when multiple consumers use the same platform. A livestock auction provides a good example. Buyers benefit when there are more sellers participating in the auction. Similarly, sellers benefit when there are more buyers participating in the auction. Software, such as a word processing package, provides another example of a network externality. You have an incentive to use the package that is most commonly used by other users. This way, if a colleague sends you a document, you will likely be able to open and edit it without problems. Once established, the existence of network externalities in a market can make entry difficult.

Usually, entry is impossible in a market that is a monopoly. The inability to enter the market is presumably why the market can remain a monopoly. There is one exception, however. This is the case of ***a contestable monopoly*** (Baumol, Panzar, and Willig 1982). A contestable monopoly exists in cases where the market can be served by one seller, but if this seller attempts to exploit its monopoly position by charging a high price, the market will be attacked by entrants who will cause the price to fall. If entrants can get in and out of the market easily, the monopolist will be attacked by entry whenever the monopolist attempts to raise its price. A contestable monopoly can exist if the fixed costs of entry can be recovered upon exit. An argument could be made that some food brands have characteristics of contestable monopolies.

Table 7.1.1. *Summary of Industry Characteristics and Market Structures*

Structure	Number of Firms	Horizontal Differences	Vertical Differences	Entry
Monopoly	One	Not Applicable	Possible, by product line	Difficult*
Oligopoly	Few	Possible	Possible	Difficult
Monopolistic Comp.	Many	Yes	Possible	Easy
Perfect Comp.	Many	No	Possible	Easy

* The exception is a contestable monopoly

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7.2: Market Structures

Market Structure Spectrum and Characteristics

Table 5.1 shows the four major categories of market structures and their characteristics.

Table 5.1 Market Structure Characteristics

Perfect Competition	Monopolistic Competition	Oligopoly	Monopoly
Homogeneous good	Differentiated good	Differentiated good	One good
Numerous firms	Many firms	Few firms	One firm
Free entry and exit	Free entry and exit	Barriers to entry	No entry

Perfect competition is on one end of the market structure spectrum, with numerous firms. The word, “numerous” has special meaning in this context. In a perfectly competitive industry, each firm is so small relative to the market that it cannot affect the price of the good. Each perfectly competitive firm is a price taker. Therefore, numerous firms means that each firm is so small that it is a price taker.

Monopoly is the other extreme of the market structure spectrum, with a single firm. Monopolies have monopoly power, or the ability to change the price of the good. Monopoly power is also called market power, and is measured by the Lerner Index.

This chapter defines and describes two intermediary market structures: monopolistic competition and oligopoly.

Monopolistic Competition = A market structure characterized by a differentiated product and freedom of entry and exit.

Monopolistically Competitive firms have one characteristic that is like a monopoly (a differentiated product provides market power), and one characteristic that is like a competitive firm (freedom of entry and exit). This form of market structure is common in market-based economies, and a trip to the grocery store reveals large numbers of differentiated products: toothpaste, laundry soap, breakfast cereal, and so on.

Next, we define the market structure **oligopoly**.

Oligopoly = A market structure characterized by barriers to entry and a few firms.

Oligopoly is a fascinating market structure due to interaction and interdependency between oligopolistic firms. What one firm does affects the other firms in the oligopoly.

Since monopolistic competition and oligopoly are intermediary market structures, the next section will review the properties and characteristics of perfect competition and monopoly. These characteristics will provide the defining characteristics of monopolistic competition and oligopoly.

Review of Perfect Competition

The perfectly competitive industry has four characteristics:

1. Homogenous product,
2. Large number of buyers and sellers (numerous firms),
3. Freedom of entry and exit, and

4. Perfect information.

The possibility of entry and exit of firms occurs in the long run, since the number of firms is fixed in the short run.

An equilibrium is defined as a point where there is no tendency to change. The concept of equilibrium can be extended to include the short run and long run.

Short Run Equilibrium = A point from which there is no tendency to change (a steady state), and a fixed number of firms.

Long Run Equilibrium = A point from which there is no tendency to change (a steady state), and entry and exit of firms.

In the short run, the number of firms is fixed, whereas in the long run, entry and exit of firms is possible, based on profit conditions. We will compare the short and long run for a competitive firm in Figure 7.2.1. The two panels in Figure 7.2.1 are for the firm (left) and industry (right), with vastly different units. This is emphasized by using "q" for the firm's output level, and "Q" for the industry output level. The graph shows both short run and long run equilibria for a perfectly competitive firm and industry. In short run equilibrium, the firms faces a high price (P_{SR}), produces quantity Q_{SR} at $P_{SR} = MC$, and earns positive profits π_{SR}.

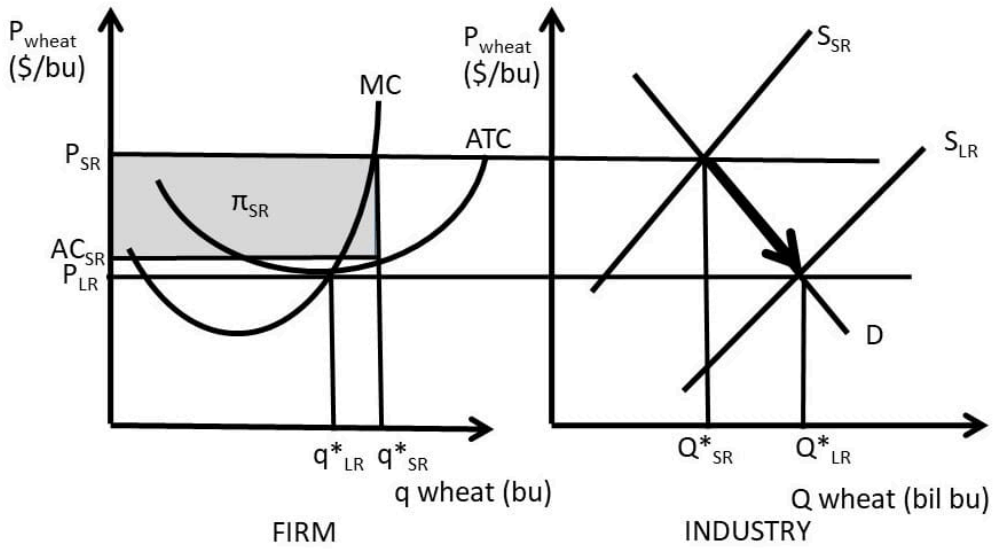


Figure 7.2.1: Short Run and Long Run Equilibria for a Perfectly Competitive Firm

Positive profits in the short run $(\pi_{SR} > 0)$ lead to entry of other firms, as there are no barriers to entry in a competitive industry. The entry of new firms shifts the supply curve in the industry graph from supply S_{SR} to supply S_{LR}. Entry will occur until profits are driven to zero, and long run equilibrium is reached at Q^*_{LR}. In the long run, economic profits are equal to zero, so there is no incentive for entry or exit. Each firm is earning exactly what it is worth, the opportunity costs of all resources. In long run equilibrium, profits are zero $(\pi_{LR} = 0)$, and price equals the minimum average cost point $(P = \min AC = MC)$. Marginal costs equal average costs at the minimum average cost point. At the long run price, supply equals demand at price P_{LR}.

Review of Monopoly

The characteristics of monopoly include: (1) one firm, (2) one product, and (3) no entry (Table 5.1). The monopoly solution is shown in Figure 7.2.2.

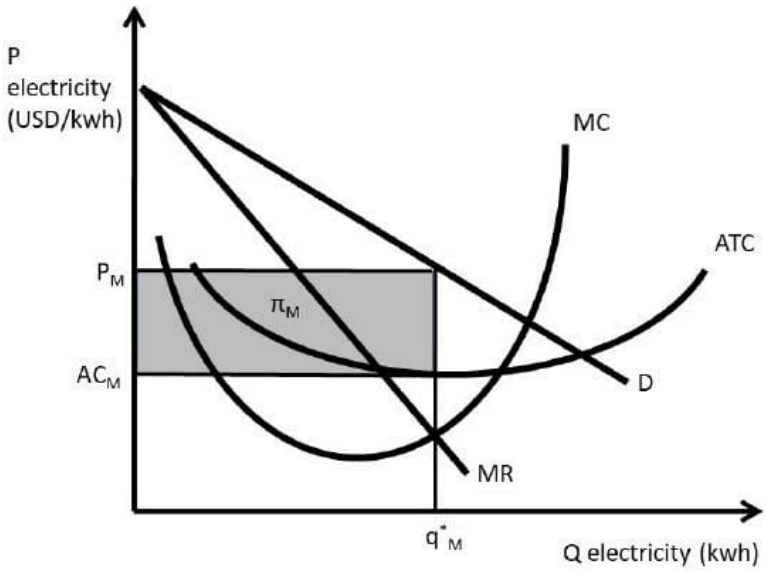


Figure 7.2.2: Monopoly Profit Maximization

Note that long-run profits can exist for a monopoly, since barriers to entry halt any potential entrants from joining the industry. In the next section, we will explore market structures that lie between the two extremes of perfect competition and monopoly.

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7.3: Marginal Revenue for Imperfectly Competitive Markets

The basics of profit maximization were described in Chapter 2 for a price-taking firm. A price-taking firm falls under the perfectly competitive market structure. Let us now extend the concept to other market structures, situations where firms are not price takers. Recall that marginal revenue (MR) was defined as the increase in revenue that results from producing an additional unit of output. Recall also that marginal cost (MC) was defined as the increase in total cost that results from producing an additional unit of output. Profit is maximized where MR = MC. One way to prove this is to use the logic of contradiction.

To prove that the only situation where profit could be maximized is if MR = MC, let us suppose otherwise. Suppose MR > MC, could profit be maximized? The answer is no. If the firm produced on more unit, its revenue would increase by MR but its cost would increase by MC. Since MR > MC, its profit would go up as it produced more. Thus, profit could not be at a maximum if MR > MC. Now suppose that MR < MC, could profit be maximized? Again the answer is no. If the firm produced one less unit, its revenue would go down by MR and its cost would go down by MC. Since MR < MC, its profit would go up as it produced less. Thus profits could not be maximized if MR < MC.

In Chapter 2, you learned that MR = P for a firm that is in a perfectly competitive market (a firm that is a price taker). In imperfectly competitive markets like monopoly, oligopoly, or monopolistic competition, this is not the case. In fact, MR < P in imperfectly competitive markets. This is because the price that the firm receives is impacted by quantity that the firm places on the market. A general formula for marginal revenue that applies to all market structures is

$$MR = P + \frac{\Delta P}{\Delta Q}Q. \tag{7.3.1}$$

The law of demand indicates that $\frac{\Delta P}{\Delta Q} < 0$. If more is placed on the market, price will need to fall in order to induce additional consumers into the market and/or convince existing consumers to purchase larger amounts. Thus, marginal revenue depends on the quantity placed on the market so long as $\frac{\Delta P}{\Delta Q}$ does not equal zero.

Marginal Revenue if Inverse Demand is Linear

Look carefully at the MR formula above. The second term, $\frac{\Delta P}{\Delta Q}Q$, is the slope of the inverse demand curve facing the firm multiplied by quantity. The first term, P, is the inverse demand curve itself. Thus if you have a linear inverse demand curve of the form

$P = a + bQ$, you can use the fact that $b = \frac{\Delta P}{\Delta Q}$ and the general formula above to find a simple expression for marginal revenue:

$$MR = P + bQ = a + bQ + bQ \Rightarrow MR = a + 2bQ. \tag{7.3.2}$$

Thus, if the inverse demand curve is linear, then the marginal revenue curve will have the same intercept as the inverse demand curve and twice the slope. In the formula above, it is important to emphasize that the inverse demand curve in question is that which faces the firm. Unless the firm is a monopolist, the inverse demand curve facing the firm will be different than the inverse demand curve facing the market.

Marginal Revenue in Terms of the Elasticity of Demand Facing the Firm

Using the definition of the point elasticity and a little bit of algebra, you can use the general formula for marginal revenue above to show that

$$MR = P(1 + \frac{1}{\varepsilon}), \tag{7.3.3}$$

where ε is the price elasticity of demand facing the firm. It is important to emphasize that in this case, ε is the elasticity facing the firm, which is not the same as the market elasticity. Only if the firm is a monopolist will the elasticity of market demand be

the same as the elasticity of demand facing the firm.

There are two interesting implications of the elasticity version of the MR formula. First, if you know demand elasticity and assume profit maximizing behavior, you can arrive at an estimate of marginal cost because $MR = MC$ when profits are maximized. Second, given a non-negative marginal cost, a firm that faces a downward sloping demand curve will always price in a region where demand is elastic. This argument has been made before in Chapter 3. Here you see it again in terms of the firm's profit maximizing condition.

Elasticity of Demand Facing Firms in Perfect Competition

The difference between the elasticity of demand facing a firm and that facing the market is most pronounced in perfect competition. In perfect competition, there are many firms. Each firm is small relative to the size of the market. As a result, the firm can put more quantity on the market and not have a material effect on the market price. In this case, $\frac{\Delta P}{\Delta Q} = 0$ and the elasticity of demand facing the firm is $-\infty$. The market demand may be elastic or inelastic. However, the elasticity facing the firm is negative infinity (perfectly elastic). In other words, if the competitive firm attempts to raise its price, it loses all of its sales. Thus,

$$MR = P(1 + \frac{1}{-\infty}) = P. \tag{7.3.4}$$

This is the profit maximizing condition for price-taking firm that was presented earlier in Chapter 2.

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7.4: Monopolistic Competition

Monopolistic competition is a market structure defined by free entry and exit, like competition, and differentiated products, like monopoly. Differentiated products provide each firm with some market power. Advertising and marketing of each individual product provide uniqueness that causes the demand curve of each good to be downward sloping. Free entry indicates that each firm competes with other firms and profits are equal to zero on long run equilibrium. If a monopolistically competitive firm is earning positive economic profits, entry will occur until economic profits are equal to zero.

Monopolistic Competition in the Short and Long Runs

The demand curve of a monopolistically competitive firm is downward sloping, indicating that the firm has a degree of market power. Market power derives from product differentiation, since each firm produces a different product. Each good has many close substitutes, so market power is limited: if the price is increased too much, consumers will shift to competitors' products.

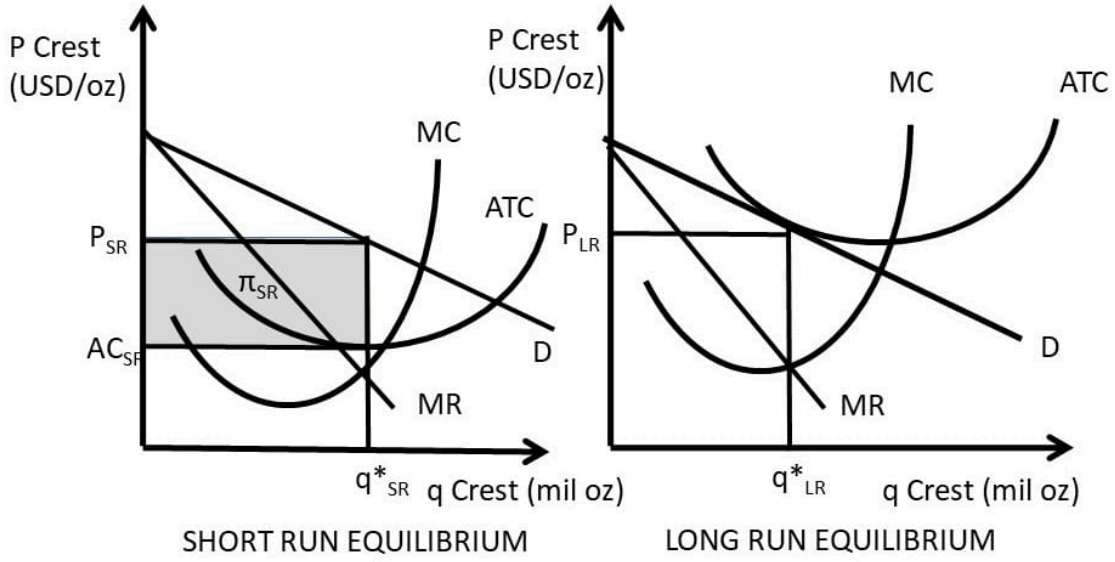


Figure 7.4.1: Monopolistic Competition in the Short Run and Long Run

Short and long run equilibria for the monopolistically competitive firm are shown in Figure 7.4.1. The demand curve facing the firm is downward sloping, but relatively elastic due to the availability of close substitutes. The short run equilibrium appears in the left hand panel, and is nearly identical to the monopoly graph. The only difference is that for a monopolistically competitive firm, the demand is relatively elastic, or flat. Otherwise, the short run profit-maximizing solution is the same as a monopoly. The firm sets marginal revenue equal to marginal cost, produces output level q^*_{SR} and charges price P_{SR}. The profit level is shown by the shaded rectangle π.

The long run equilibrium is shown in the right hand panel. Entry of other firms occurs until profits are equal to zero; total revenues are equal to total costs. Thus, the demand curve is tangent to the average cost curve at the optimal long run quantity, q^*_{LR}. The long run profit-maximizing quantity is found where marginal revenue equals marginal cost, which also occurs at q^*_{LR}.

Economic Efficiency and Monopolistic Competition

There are two sources of inefficiency in monopolistic competition. First, **dead weight loss** (DWL) due to monopoly power: price is higher than marginal cost $(P > MC)$. Second, **excess capacity**: the equilibrium quantity is smaller than the lowest cost quantity at the minimum point on the average cost curve $(q^*_{LR} < q_{minAC})$. These two sources of inefficiency can be seen in Figure 7.4.2.

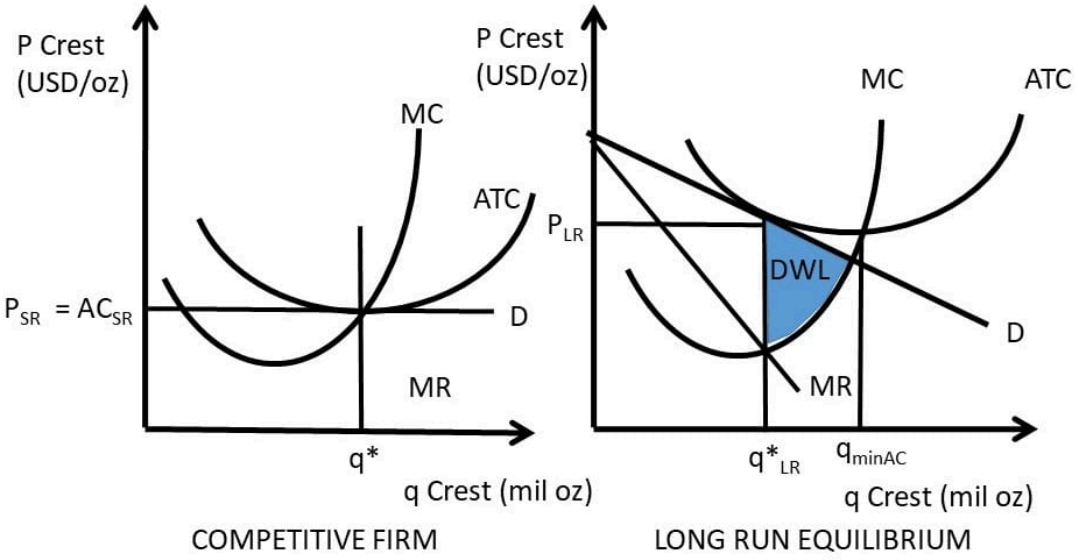


Figure 7.4.2: Comparison of Efficiency for Competition and Monopolistic Competition

First, there is dead weight loss (DWL) due to market power: the price is higher than marginal cost in long run equilibrium. In the right hand panel of Figure 7.4.2, the price at the long run equilibrium quantity is P_{LR}, and marginal cost is lower: $P_{LR} > MC$. This causes dead weight loss to society, since the competitive equilibrium would be at a larger quantity where $P = MC$. Total dead weight loss is the shaded area beneath the demand curve and above the MC curve in figure 7.4.2.

The second source of inefficiency associated with monopolistic competition is excess capacity. This can also be seen in the right hand panel of Figure 7.4.2, where the long run equilibrium quantity is lower than the quantity where average costs are lowest (q_{minAC}). Therefore, the firm could produce at a lower cost by increasing output to the level where average costs are minimized.

Given these two inefficiencies associated with monopolistic competition, some individuals and groups have called for government intervention. Regulation could be used to reduce or eliminate the inefficiencies by removing product differentiation. This would result in a single product instead of a large number of close substitutes.

Regulation is probably not a good solution to the inefficiencies of monopolistic competition, for two reasons. First, the market power of a typical firm in most monopolistically competitive industries is small. Each monopolistically competitive industry has many firms that produce sufficiently substitutable products to provide enough competition to result in relatively low levels of market power. If the firms have small levels of market power, then the deadweight loss and excess capacity inefficiencies are likely to be small.

Second, the benefit provided by monopolistic competition is product diversity. The gain from product diversity can be large, as consumers are willing to pay for different characteristics and qualities. Therefore, the gain from product diversity is likely to outweigh the costs of inefficiency. Evidence for this claim can be seen in market-based economies, where there is a huge amount of product diversity.

The next chapter will introduce and discuss oligopoly: strategic interactions between firms!

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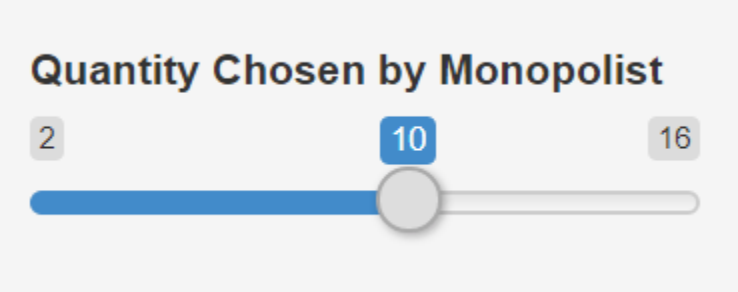
7.5: Profit Maximization for a Monopolist or Monopolistically Competitive Firm

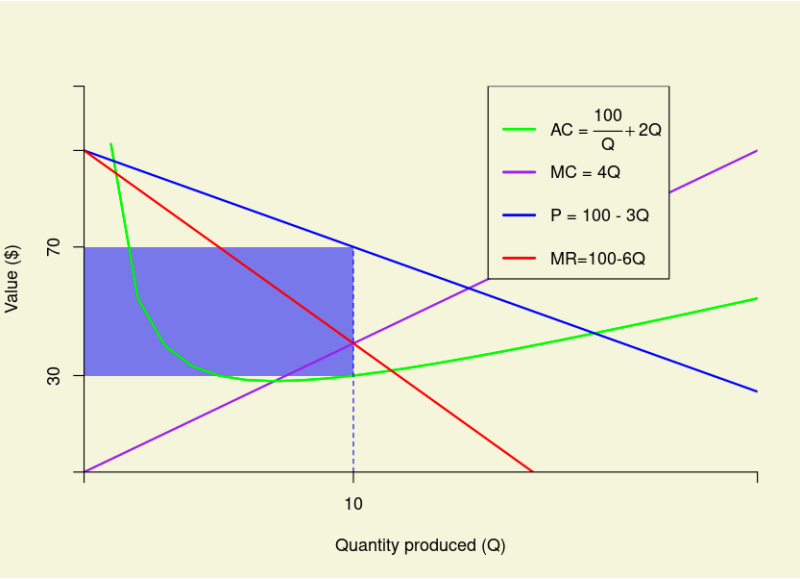
The profit maximizing condition can be used to solve the monopolist's problem. Suppose, as in Demonstration $7.5.1$ below, that the inverse demand curve facing the monopolist is $P = 100 - 3Q$. Since this inverse demand curve is linear, the marginal revenue curve has the same intercept and a slope that is twice as steep. Thus, $MR = 100 - 6Q$. Suppose further that marginal cost is equal to $4Q. Set $MR = MC$ or $100 - 6Q = 4Q$and solve for Q. You get Q = 10 units. This is the profit maximizing quantity.

Next, use the inverse demand curve to find the profit maximizing price. Although the monopolist equates marginal revenue with marginal cost, it uses the inverse demand curve (not the marginal revenue curve) to set the price. Substituting the profit maximizing quantity into the inverse demand curve, you get a price of $100 - 3(10) = \$70$.

Notice in the demonstration that the area of the blue rectangle represents profits. Use Demonstration 1 to verify that profits go down if the monopolist does no set the quantity so that $MR = MC$.

Demonstration $7.5.1$. Profit Maximization Problem for a Monopolist





Marginal Cost (MC) = $40.00

Average Total Cost (AC) = $30.00

Profit = (P - AC)Q =$400.00

The steps involved in finding the solution to the firm's problem under monopolistic competition are exactly the same as the monopolist's problem above. The primary difference between monopoly and monopolistic competition is that entry is possible in

monopolistic competition. If profits are positive, new firms will enter the market and/or existing firms will mimic the successful practices of competitors. When economic profits are zero, there is no additional entry, and the market is at an equilibrium. In a no-entry equilibrium under monopolistic competition, the rectangular area that represents profits will be just equal to the sunk costs that would need to be incurred if the market were to be entered by a new firm. New firms would see entry into the market as unattractive since the profits to be gained would be consumed by the sunk costs of entry.

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7.6: Oligopoly Models

An oligopoly is defined as a market structure with few firms and barriers to entry.

Oligopoly = A market structure with few firms and barriers to entry.

There is often a high level of competition between firms, as each firm makes decisions on prices, quantities, and advertising to maximize profits. Since there are a small number of firms in an oligopoly, each firm's profit level depends not only on the firm's own decisions, but also on the decisions of the other firms in the oligopolistic industry.

Strategic Interactions

Each firm must consider both: (1) other firms' reactions to a firm's own decisions, and (2) the own firm's reactions to the other firms' decisions. Thus, there is a continuous interplay between decisions and reactions to those decisions by all firms in the industry. Each oligopolist must take into account these strategic interactions when making decisions. Since all firms in an oligopoly have outcomes that depend on the other firms, these strategic interactions are the foundation of the study and understanding of oligopoly.

For example, each automobile firm's market share depends on the prices and quantities of all of the other firms in the industry. If Ford lowers prices relative to other car manufacturers, it will increase its market share at the expense of the other automobile companies.

When making decisions that consider the possible reactions of other firms, firm managers usually assume that the managers of competing firms are rational and intelligent. These strategic interactions form the study of game theory, the topic of Chapter 6 below. John Nash (1928-2015), an American mathematician, was a pioneer in game theory. Economists and mathematicians use the concept of a Nash Equilibrium (NE) to describe a common outcome in game theory that is frequently used in the study of oligopoly.

Nash Equilibrium = An outcome where there is no tendency to change based on each individual choosing a strategy given the strategy of rivals.

In the study of oligopoly, the Nash Equilibrium assumes that each firm makes rational profit-maximizing decisions while holding the behavior of rival firms constant. This assumption is made to simplify oligopoly models, given the potential for enormous complexity of strategic interactions between firms. As an aside, this assumption is one of the interesting themes of the motion picture, "A Beautiful Mind," starring Russell Crowe as John Nash. The concept of Nash Equilibrium is also the foundation of the models of oligopoly presented in the next three sections: the Cournot, Bertrand, and Stackelberg models of oligopoly.

Cournot Model

Augustin Cournot (1801-1877), a French mathematician, developed the first model of oligopoly explored here. The Cournot model is a model of oligopoly in which firms produce a homogeneous good, assuming that the competitor's output is fixed when deciding how much to produce.

A numerical example of the Cournot model follows, where it is assumed that there are two identical firms (a duopoly), with output given by $Q_i (i = 1, 2)$. Therefore, total industry output is equal to: $Q = Q_1 + Q_2$. Market demand is a function of price and given by $Q^d = Q^d(P)$, thus the inverse demand function is $P = P(Q^d)$. Note that the price depends on the market output Q, which is the sum of both individual firm's outputs. In this way, each firm's output has an influence on the price and profits of both firms. This is the basis for strategic interaction in the Cournot model: if one firm increases output, it lowers the price facing both firms. The inverse demand function and cost function are given in Equation 7.6.1.

$$P = 40 – QC(Q_i) = 7Q_i \tag{7.6.1}$$

with $i = 1, 2$.

Each firm chooses the optimal, profit-maximizing output level given the other firm's output. This will result in a Nash Equilibrium,

since each firm is holding the behavior of the rival constant. Firm One maximizes profits as follows.

$$\begin{aligned}
\max \pi_1 &= TR_1 – TC_1 \\
\max \pi_1 &= P(Q)Q_1 – C(Q_1) \text{ [price depends on total output } Q = Q_1 + Q_2] \\
\max \pi_1 &= [40 – Q]Q_1 – 7Q_1 \\
\max \pi_1 &= [40 – Q_1 – Q_2]Q_1 – 7Q_1 \\
\max \pi_1 &= 40Q_1 – Q_1^2 – Q_2Q_1 – 7Q_1 \\
\frac{\partial \pi_1}{\partial Q_1} &= 40 – 2Q_1 – Q_2 – 7 = 0 \\
2Q_1 &= 33 – Q_2 \\
Q_1^* &= 16.5 – 0.5Q_2
\end{aligned}$$

This equation is called the “Reaction Function” of Firm One. This is as far as the mathematical solution can be simplified, and represents the Cournot solution for Firm One. It is a reaction function since it describes Firm One’s reaction given the output level of Firm Two. This equation represents the strategic interactions between the two firms, as changes in Firm Two’s output level will result in changes in Firm One’s response. Firm One’s optimal output level depends on Firm Two’s behavior and decision making. Oligopolists are interconnected in both behavior and outcomes.

The two firms are assumed to be identical in this duopoly. Therefore, Firm Two’s reaction function will be symmetrical to the Firm One’s reaction function (check this by setting up and solving the profit-maximization equation for Firm Two):

$$Q_2^* = 16.5 – 0.5Q_1$$

The two reaction functions can be used to solve for the Cournot-Nash Equilibrium. There are two equations and two unknowns (Q_1 and Q_2), so a numerical solution is found through substitution of one equation into the other.

$$\begin{aligned}
Q_1^* &= 16.5 – 0.5(16.5 – 0.5Q_1) \\
Q_1^* &= 16.5 – 8.25 + 0.25Q_1 \\
Q_1^* &= 8.25 + 0.25Q_1 \\
0.75Q_1^* &= 8.25 \\
Q_1^* &= 11
\end{aligned}$$

Due to symmetry from the assumption of identical firms:

$$\begin{aligned}
Q_i &= 11 \qquad\qquad i = 1, 2 \\
Q &= 22 \text{ units} \\
P &= 18 \text{ USD/unit}
\end{aligned}$$

Profits for each firm are:

$$\pi_i = P(Q)Q_i – C(Q_i) = 18(11) – 7(11) = (18 – 7)11 = 11(11) = 121 \text{ USD}$$

This is the Cournot-Nash solution for oligopoly, found by each firm assuming that the other firm holds its output level constant. The Cournot model can be easily extended to more than two firms, but the math does get increasingly complex as more firms are added. Economists utilize the Cournot model because is based on intuitive and realistic assumptions, and the Cournot solution is intermediary between the outcomes of the two extreme market structures of perfect competition and monopoly.

This can be seen by solving the numerical example for competition, Cournot, and monopoly models, and comparing the solutions for each market structure.

In a competitive industry, free entry results in price equal to marginal cost ($P = MC$). In the case of the numerical example, $P_C = 7$. When this competitive price is substituted into the inverse demand equation, $7 = 40 – Q$, or $Q_c = 33$. Profits are found by solving $(P – MC)Q$, or $\pi_c = (7 – 7)Q = 0$. The competitive solution is given in Equation 7.6.2.

$$P_c = 7 \text{ USD/unit } Q_c = 33 \text{ units } \pi_c = 0 \text{ USD} \tag{7.6.2}$$

The monopoly solution is found by maximizing profits as a single firm.

$$\max \pi_m = TR_m – TC_m$$
$$\max \pi_m = P(Q_m)Q_m – C(Q_m) \text{ [price depends on total output } Q_m]$$
$$\max \pi_m = [40 – Q_m]Q_m – 7Q_m$$
$$\max \pi_m = 40Q_m – Q_m^2 – 7Q_m$$

$$\frac{\partial \pi_m}{\partial Q_m} = 40 – 2Q_m – 7 = 0$$
$$2Q_m = 33$$
$$Q_m^* = 16.5$$
$$P_m = 40 – 16.5 = 23.5$$
$$\pi_m = (P_m – MC_m)Q_m = (23.5 – 7)16.5 = 16.5(16.5) = 272.25 \text{ USD}$$

The monopoly solution is given in Equation 7.6.3.

$$\begin{aligned} P_m &= 23.5 \text{ USD/unit} \\ Q_m &= 16.5 \text{ units} \\ \pi_m &= 272.5 \text{ USD} \end{aligned} \tag{7.6.3}$$

The competitive, Cournot, and monopoly solutions can be compared on the same graph for the numerical example (Figure 7.6.1).

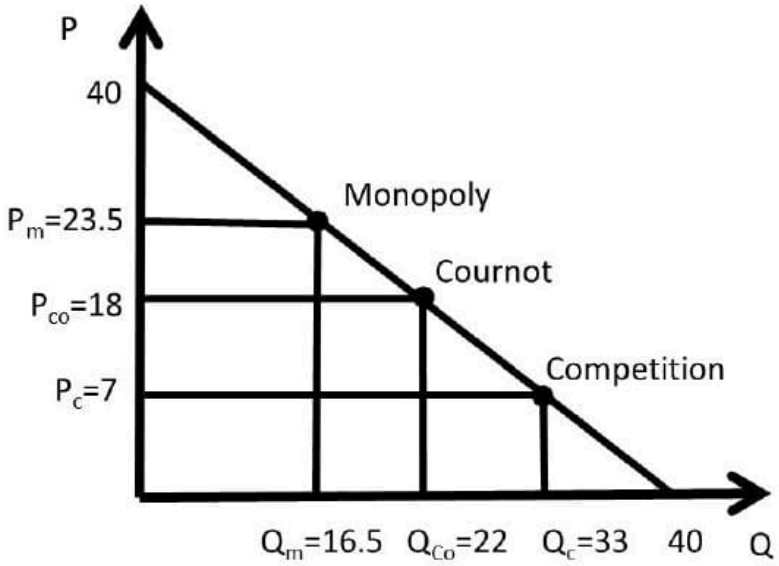


Figure 7.6.1: Comparisons of Perfect Competition, Cournot, and Monopoly Solutions

The Cournot price and quantity are between perfect competition and monopoly, which is an expected result, since the number of firms in an oligopoly lies between the two market structure extremes.

Bertrand Model

Joseph Louis François Bertrand (1822-1900) was also a French mathematician who developed a competing model to the Cournot model. Bertrand asked the question, “what would happen in an oligopoly model if each firm held the other firm’s price constant?” The Bertrand model is a model of oligopoly in which firms produce a homogeneous good, and each firm takes the **price** of competitors fixed when deciding what price to charge.

Assume two firms in an oligopoly (a duopoly), where the two firms choose the price of their good simultaneously at the beginning of each period. Consumers purchase from the firm with the lowest price, since the products are homogeneous (perfect substitutes). If the two firms charge the same price, one-half of the consumers buy from each firm. Let the demand equation be given by $Q^d = Q^d(P)$. The Bertrand model follows these three statements:

1. If $P_1 < P_2$, then Firm One sells Q^d and Firm Two sells 0,
2. If $P_1 > P_2$, then Firm One sells 0 and Firm Two sells Q^d, and
3. If $P_1 = P_2$, then Firm One sells $0.5Q^d$ and Firm Two sells $0.5Q^d$.

A numerical example demonstrates the outcome of the Bertrand model, which is a Nash Equilibrium. Assume two firms sell a homogeneous product, and compete by choosing prices simultaneously, while holding the other firm's price constant. Let the demand function be given by $Q^d = 50–P$ and the costs are summarized by $MC_1 = MC_2 = 5$.

(1) Firm One sets $P_1 = 20$, and Firm Two sets $P_2 = 15$. Firm Two has the lower price, so all customers purchase the good from Firm Two.

$$\begin{aligned} Q_1 &= 0 \\ Q_2 &= 35 \\ \pi_1 &= 0 \\ \pi_2 &= (15–5)35 = 350 \text{ USD}. \end{aligned}$$

After period one, Firm One has a strong incentive to lower the price (P_1) below P_2.The Bertrand assumption is that both firms will choose a price, holding the other firm's price constant. Thus, Firm One undercuts P_2 slightly, assuming that Firm Two will maintain its price at $P_2 = 15$. Firm Two will keep the same price, assuming that Firm One will maintain $P_1 = 20$.

(2) Firm One sets $P_1 = 14$, and Firm Two sets $P_2 = 15$. Firm One has the lower price, so all customers purchase the good from Firm One.

$$\begin{aligned} Q_1 &= 36 \\ Q_2 &= 0 \\ \pi_1 &= (14–5)36 = 324 \text{ USD}, \\ \pi_2 &= 0. \end{aligned}$$

After period two, Firm Two has a strong incentive to lower price below P_1. This process of undercutting the other firm's price will continue and a "price war" will result in the price being driven down to marginal cost. In equilibrium, both firms lower their price until price is equal to marginal cost: $P_1 = P_2 = MC_1 = MC_2$. The price cannot go lower than this, or the firms would go out of business due to negative economic profits. To restate the Bertrand model, each firm selects a price, given the other firm's price. The Bertrand results are given in Equation 7.6.4.

$$\begin{aligned} &P_1 = P_2 = MC_1 = MC_2 \\ &Q_1 = Q_2 = 0.5Q_d \\ &\pi_1 = \pi_2 = 0 \text{ in the } SR \text{ and } LR. \end{aligned} \tag{7.6.4}$$

The Bertrand model of oligopoly suggests that oligopolies are characterized by the competitive solution, due to competing over price. There are many oligopolies that behave this way, such as gasoline stations at a given location. Other oligopolies may behave more like Cournot oligopolists, with an outcome somewhere in between perfect competition and monopoly.

Stackelberg Model

Heinrich Freiherr von Stackelberg (1905-1946) was a German economist who contributed to game theory and the study of market structures with a model of firm leadership, or the Stackelberg model of oligopoly. This model assumes that there are two firms in the industry, but they are asymmetrical: there is a "leader" and a "follower." Stackelberg used this model of oligopoly to determine if there was an advantage to going first, or a "first-mover advantage."

A numerical example is used to explore the Stackelberg model. Assume two firms, where Firm One is the leader and produces Q_1 units of a homogeneous good. Firm Two is the follower, and produces Q_2 units of the good. The inverse demand function is given by $P = 100–Q$, where $Q = Q_1 + Q_2$. The costs of production are given by the cost function: $C(Q) = 10Q$.

This model is solved recursively, or backwards. Mathematically, the problem must be solved this way to find a solution. Intuitively, each firm will hold the other firm's output constant, similar to Cournot, but the leader must know the follower's best strategy to move first. Thus, Firm One solves Firm Two's profit maximization problem to know what output it will produce, or Firm Two's reaction function. Once the reaction function of the follower (Firm Two) is known, then the leader (Firm One) maximizes profits

by substitution of Firm Two's reaction function into Firm One's profit maximization equation. All of this is shown in the following example.

Firm One starts by solving for Firm Two's reaction function:

$$\begin{aligned}
\max \pi_2 &= TR_2\text{–}TC_2 \\
\max \pi_2 &= P(Q)Q_2\text{–}C(Q_2) && \text{[price depends on total output } Q = Q_1 + Q_2\text{]} \\
\max \pi_2 &= [100\text{–}Q]Q_2\text{–}10Q_2 \\
\max \pi_2 &= [100\text{–}Q_1\text{–}Q_2]Q_2\text{–}10Q_2 \\
\max \pi_2 &= 100Q_2\text{–}Q_1Q_2\text{–}Q_2^2\text{–}10Q_2 \\
\frac{\partial \pi_2}{\partial Q_2} &= 100\text{–}Q_1\text{–}2Q_2\text{–}10 = 0 \\
2Q_2 &= 90\text{–}Q_1 \\
Q_2^* &= 45\text{–}0.5Q_1
\end{aligned}$$

This is the reaction function of the follower, Firm Two. Next, Firm One, the leader, maximizes profits holding the follower's output constant using the reaction function.

$$\begin{aligned}
\max \pi_1 &= TR_1\text{–}TC_1 \\
\max \pi_1 &= P(Q)Q_1\text{–}C(Q_1) && \text{[price depends on total output } Q = Q1 + Q2\text{]} \\
\max \pi_1 &= [100\text{–}Q]Q_1\text{–}10Q_1 \\
\max \pi_1 &= [100\text{–}Q_1\text{–}Q_2]Q_1\text{–}10Q_1 \\
\max \pi_1 &= [100\text{–}Q1\text{–}(45\text{–}0.5Q_1)]Q_1\text{–}10Q_1 && \text{[substitution of One's reaction function]} \\
\max \pi_1 &= [100\text{–}Q_1\text{–}45 + 0.5Q_1]Q_1\text{–}10Q_1 \\
\max \pi_1 &= [55\text{–}0.5Q_1]Q_1\text{–}10Q_1 \\
\max \pi_1 &= 55Q_1\text{–}0.5Q_1^2\text{–}10Q_1 \\
\frac{\partial \pi_1}{\partial Q_1} &= 55\text{–}Q_1\text{–}10 = 0 \\
Q_1^* &= 45
\end{aligned}$$

This can be substituted back into Firm Two's reaction function to solve for Q_2^*.

$$\begin{aligned}
Q_2^* &= 45\text{–}0.5Q_1 = 45\text{–}0.5(45) = 45\text{–}22.5 = 22.5 \\
Q &= Q_1 + Q_2 = 45 + 22.5 = 67.5 \\
P &= 100\text{–}Q = 100\text{–}67.5 = 32.5 \\
\pi_1 &= (32.5\text{–}10)45 = 22.5(45) = 1012.5 \text{ USD} \\
\pi_2 &= (32.5\text{–}10)22.5 = 22.5(22.5) = 506.25 \text{ USD}
\end{aligned}$$

We have now covered three models of oligopoly: Cournot, Bertrand, and Stackelberg. These three models are alternative representations of oligopolistic behavior. The Bertand model is relatively easy to identify in the real world, since it results in a price war and competitive prices. It may be more difficult to identify which of the quantity models to use to analyze a real-world industry: Cournot or Stackelberg?

The model that is most appropriate depends on the industry under investigation.

1. The Cournot model may be most appropriate for an industry with similar firms, with no market advantages or leadership.
2. The Stackelberg model may be most appropriate for an industry dominated by relatively large firms.

Oligopoly has many different possible outcomes, and several economic models to better understand the diversity of industries. Notice that if the firms in an oligopoly colluded, or acted as a single firm, they could achieve the monopoly outcome. If firms banded together to make united decisions, the firms could set the price or quantity as a monopolist would. This is illegal in many nations, including the United States, since the outcome is anti-competitive, and consumers would have to pay monopoly prices under collusion.

If firms were able to collude, they could divide the market into shares and jointly produce the monopoly quantity by restricting output. This would result in the monopoly price, and the firms would earn monopoly profits. However, under such circumstances, there is always an incentive to "cheat" on the agreement by producing and selling more output. If the other firms in the industry restricted output, a firm could increase profits by increasing output, at the expense of the other firms in the collusive agreement. We will discuss this possibility in the next section.

To summarize our discussion of oligopoly thus far, we have two models that assume that a firm holds the other firm's output constant: Cournot and Stackelberg. These two models result in positive economic profits, at a level between perfect competition and monopoly. The third model, Bertrand, assumes that each firm holds the other firm's price constant. The Bertrand model results in zero economic profits, as the price is bid down to the competitive level, $P = MC$.

The most important characteristic of oligopoly is that firm decisions are based on strategic interactions. Each firm's behavior is strategic, and strategy depends on the other firms' strategies. Therefore, oligopolists are locked into a relationship with rivals that differs markedly from perfect competition and monopoly.

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7.7: Profit Maximization in an Oligopoly

To introduce oligopoly, consider an example where there are only two firms that supply the market, Firm A and Firm B. This is the simplest form of oligopoly (a duopoly). To simplify the example further, assume that both firms have identical variable cost functions $VC = 20Q_i$, where $i^{\text{int}}[A, B]$. This means that the marginal cost facing each firm is $MC = 20$. Finally, suppose that the inverse demand curve for this industry is $P = 200 - 2Q_A - 2Q_B$

Just to be clear, Q_A is the amount that Firm A produces and Q_B is the amount that Firm B produces.

Because the inverse demand curve is linear, it is easy to find marginal revenue. Note that Firm A can only choose Q_A. The amount of Q_B is outside of Firm A's control, so the Q_B component of the industry inverse demand curve becomes part of the intercept of the inverse demand curve that Firm A actually faces. With this in mind, the MR for Firm A is

$MR_A = 200 - 4Q_A - 2Q_B$.

Set $MR = MC$ for Firm A to find profit maximizing quantity for Firm A conditional on Firm B's output choice

$200 - 4Q_A - 2Q_B = 200 \Rightarrow Q_A = 45 - \frac{1}{2}Q_B$.

This is known as the **reaction function** for Firm A. It indicates Firm A's optimal quantity choice as a function of Firm B's quantity. In other words, it says how Firm A's quantity will react to a change in Firm B's quantity.

Next, repeat the above steps to find profit maximizing quantity for Firm B conditional on Firm A's output choice. MR for Firm B is

$MR_B = 200 - 2Q_A - 4Q_B$.

Set MR = MC for Firm B and solve for Q_B to get Firm B's reaction function.

$200 - 2Q_A - 4Q_B = 20 \Rightarrow Q_B = 45\frac{1}{2}Q_A$

Cournot Nash Equilibrium

A **Cournot Nash equilibrium** occurs where the reaction functions for these two firms intersect (see Figure 7.7.1). To find the equilibrium, we can substitute Firm B's reaction function into the reaction function for Firm A:

\(Q_{A} = 45 - \dfrac{1}{2}(45 - \dfrac{1}{2}Q_{A})

Now there is one equation and one unknown. Solving for Q_A provides $Q_A = 30$. Putting this back into Firm B's reaction function, we find that $Q_B = 30$ as well.

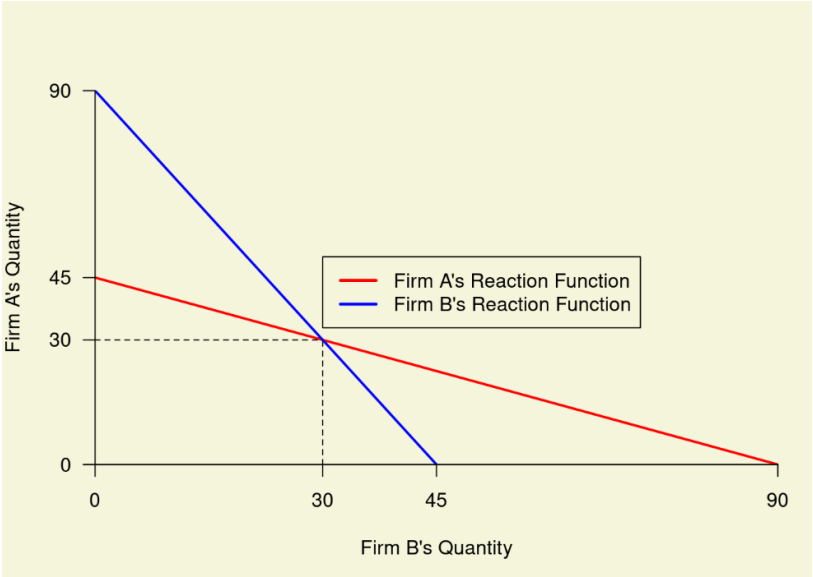


Figure 7.7.1: **Cournot Nash Equilibrium for Two Firms in Oligopoly**

Finally, we can find the price at the Cournot Nash Equilibrium by putting these quantities into the industry inverse demand curve to get

$$P = 200 - 2(30) - 2(30) = 80.$$

A Nash equilibrium refers to a situation wherein each agent chooses a strategy that maximizes his or her payoffs conditional on the strategies of all other agents. In the example above, the strategy variable is the quantity to be placed on the market. The Cournot equilibrium is a Nash equilibrium because 30 units is the optimal quantity to be placed on the market by Firm A, given that Firm B places 30 units on the market and *vice versa*. This type of equilibrium, is named after John Forbes Nash, Jr., a mathematician who was awarded the Nobel Prize in Economics for this idea. The model in this example is one of Cournot oligopoly, wherein competition is on quantity. This model is named after another mathematician, Antoine Augustin Cournot.

The Prisoners' Dilemma

The Cournot Nash equilibrium outcome is not optimal from the standpoint of the two oligopolists because there exists another feasible outcome that provides each firm with a higher level profits. To demonstrate, suppose that the two firms merged. Now there would be just one combined quantity to put on the market $Q_M = Q_A + Q_B$. The inverse demand equation for the combined firm would be

$$P = 200 - 2Q_M.$$

Assuming that the merger does not impact marginal cost, the marginal cost would still be $MC = 20$, but marginal revenue for the merged firm would now be $P - 200 - 4Q_M$. Setting marginal revenue equal to marginal cost and solving for Q_M results in the merged firm (now a monopolist) putting a quantity of 45 units on the market and charging a price of $P = 200 - 2(45) = \$110$. The point here is that technically it would be feasible for the oligopolists to each put half of this amount, 22.5 units, on the market. The industry price would be \$110, and they would each be more profitable.

- At the Cournot Nash equilibrium, each firm makes profits above fixed costs of $(80 - 20) \times 30 = \$1800$.
- By each putting half of the monopoly quantity on the market, each firm would make profits above fixed costs of $(110 - 20) \times 22.5 = \$2025$

The prisoners' dilemma is a metaphor commonly used in the social sciences, including economics, to help understand problems such as that facing the oligopolists in Cournot competition. In the prisoners' dilemma, two criminals are apprehended and placed in separate cells. The prosecutor has enough evidence to put each away for two years. However, these criminals are guilty of an offence that carries an eight year sentence if evidence is sufficient to convict. The prosecutor needs one or both of the prisoners to turn state's evidence. The payoffs facing these prisoners is summarized in the following table

Table 7.7.1. Payoffs in the Prisoners' Dilemma

Prisoner 1 (rows), Prisoner 2 (cols.)	Prisoner 2 Tells	Prisoner 2 Doesn't Tell
Prisoner 1 Tells	-6, -6	0, -8
Prisoner 1 Doesn't Tell	-8, 0	-2, -2

Note: Prisoner 1's payoff is the first number in each cell (no pun intended), Prisoner 2's payoff is the second number.

The prosecutor meets the prisoners separately and offers to reduce the sentence by two years in return for implicating the other in the more serious crime. Thus, if one prisoner implicates his friend while the other remains silent, the one that turns state's evidence will get a suspended sentence (zero years), while the other will get eight years. If both prisoners implicate each other, both get six-year sentences. If both remain silent, both get two-year sentences.

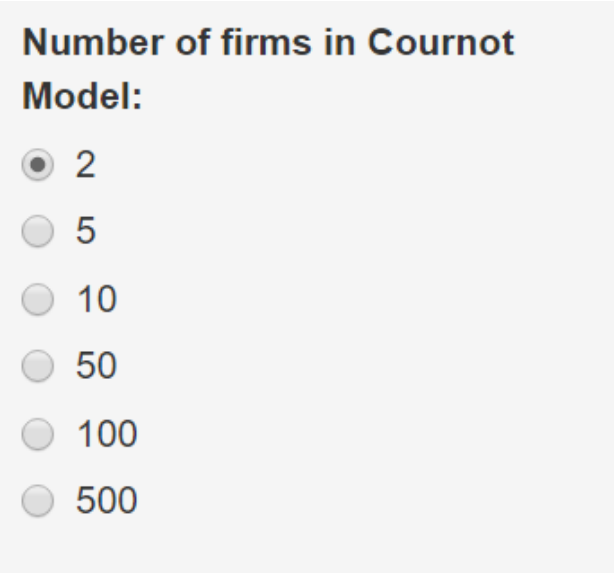
The Nash equilibrium in the prisoners' dilemma is for each prisoner to tell on the other. As a result, each prisoner gets six years. Had the prisoners kept quiet, they would have gotten only two years each, something better from their perspective. The reason the prisoners have a dilemma is that if I think you will tell on me, it is certainly in my best interest to tell on you. Similarly, if I think you will not tell on me, it is still in my interest to tell on you and get the suspended sentence. Moreover, I know that if I do not tell on you, your best course of action is to tell on me. Thus, each prisoner's best action given his expectation of the other's action is to tell.

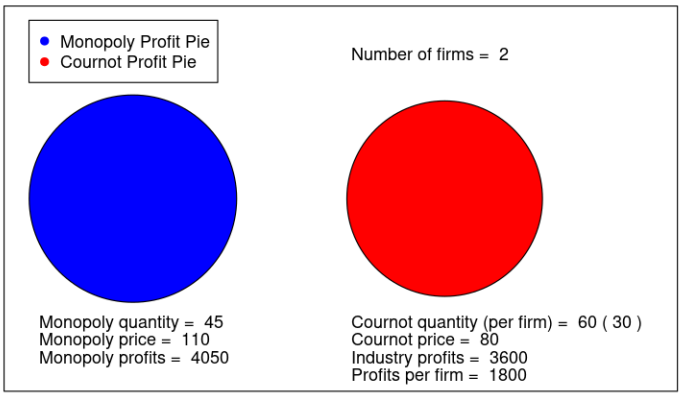
The Cournot model of oligopoly is like the prisoners' dilemma. In our example of the duopolists above, placing half of the monopoly quantity on the market is analogous to "not telling" in the prisoners' dilemma. Now, suppose that Firm B decides to do this and sets its quantity at $Q_B = 22.5$. Firm A uses its reaction function to set its quantity as

$$Q_A = 45\frac{1}{2}(22.5) = 33.75.$$

In this case, Firm B's profits above fixed costs are $1,518.75. Firm A's profits above fixed costs are $2,278.13. This is much better than what Firm A could get by matching Firm 2's quantity at 22.5 units and much worse for Firm B in comparison to what it could have achieved had it simply put its Cournot equilibrium quantity on the market. Thus, in a Cournot oligopoly, firms have an incentive to put more on the market than that which optimizes profits for the industry as a whole. This problem is compounded as more and more firms to the Cournot oligopoly. In fact, the market price approaches the competitive price ($P = MC$) and profits go to zero as the number of firms in a Cournot oligopoly becomes large. Demonstration 7.7.2 shows what happens to total industry profits at the Cournot Nash equilibrium as the number of firms in the industry increases. Notice that the prisoners' dilemma becomes even more pronounced as the number of firms increases.

Demonstration 7.7.2. Profitability of a Cournot Oligopoly Relative to a Monopoly as Number of Firms Change*





*In Demonstration 7.7.2, the market inverse demand curve is $P = 200 - 2\Sigma Q_i$ and $MC = 20$ for all firms.

Alternative Bertrand Version of the Oligopoly

In the Cournot model, firms compete by setting quantities. The Bertrand model is an alternative formulation of the oligopolists' problem and differs in that the firms compete by setting prices instead. This model is named after Joseph Bertrand, a mathematician who is credited with formalizing this model. Again, to keep things simple, assume that there are two firms. Furthermore, assume that the products produced by each firm are identical. This permits us to take the example above and adapt it to the Bertrand framework.

If Firm A sets its price lower than Firm B's price ($P_A < P_B$), then Firm A faces a direct demand function of

$$Q_A = 100 - \frac{1}{2}P_A.$$

If Firm A sets its price above Firm B's price, then Firm A's demand is

$$Q_A = 0$$

Finally, if Firm A's price matches Firm B's price ($P_A = P_B$), then consumers randomly choose to patronize Firm A or Firm B with equal probability. In this case, Firm A stands to get about half the market, so its demand is

$$Q_A = 0.5(100 - \frac{1}{2}P_A).$$

The demand facing Firm B is similarly structured. Firm B gets the entire market if $P_B < P_A$, sells nothing if $P_B > P_A$, and splits the market 50/50 with A if $P_B = P_A$. As before, assume that each firm faces a constant marginal cost of MC = $20.

The Bertrand Nash equilibrium outcome occurs where $P_A = P_B = MC$. In this case, profits to each firm are zero, and the oligopoly outcome is the same as that which would have occurred under perfect competition. Demonstration 7.7.3 reflects the scenario just described and shows why.

Suppose that Firm A and Firm B have each chosen the monopoly price of $110. Each makes $2,025. This cannot be a Nash equilibrium because $110 is not the best price for Firm A given that Firm B charges $110. Firm A could undercut Firm B by charging a price of $80, in which case Firm A's profits would go up to $3,600. Of course, Firm B would undercut Firm A and the process would continue until each firm's price fell to its marginal cost of $20. This is the Bertrand Nash Equilibrium. No firm would cut below its marginal cost.

Demonstration 7.7.3. Bertrand Duopoly



	Price	Quantity	Profits
Firm A	80.00	30.00	1800.00
Firm B	80.00	30.00	1800.00

The Folk Theorem

Both Cournot and Bertrand outcomes typify the prisoners' dilemma because equilibrium outcomes do not maximize industry profits. In each case, there is a feasible outcome (sharing the market at the monopoly price and quantity) that makes firms better off than the Nash equilibrium profits.

Might firms be able to coordinate tacitly on a quantity less than the Cournot quantity or on a price higher than the Bertrand price? Suppose, for sake of argument, that Firm A and B are in Bertrand competition and each has matched the others price at $80. This price is above the Bertrand Nash Equilibrium price of $20 per unit, but it corresponds to the market price the firms would get at the Cournot Nash Equilibrium. If, in the current period, Firm A raises its price from $80 to $110, the monopoly price, how should Firm B respond? Pretend that you are Firm B. You might reason as follows:

- If I keep my price at $80 and do not raise my price to match Firm A, I will have the entire market during this period. My profits will be $3,600. This is certainly better than $2,025 I would receive if I did match Firm A's higher price.
- However, if I do not match, I cannot expect that Firm A will not continue to keep its price high in the next period. When it sees that I have not matched its price increase and it loses market share, it will certainly cut is price back to $80 during the next period or possibly even lower. I will be back to getting $1,800 in profits (or possibly something worse).
- If I do match Firm A's price increase, Firm A will probably continue to keep its price high at $110. Thus I will be getting $2,025 each period as opposed to $1,800. Over the long-term, matching the price increase would pay off.

In this highly stylized example, the decision to match the price increase boils down to taking a one-time windfall of $3,600 (if Firm B does not match) or a $2,025 in profits in every period going forward (if Firm B does match).

The ***folk theorem*** states that for an indefinitely repeated prisoners' dilemma (such as Bertrand) and provided that discount rates are not too high, an outcome preferable to the Nash equilibrium (e.g., a price above the Bertrand price) can be sustained over time. One way firms reinforce the folk theorem is to match their competitors' pricing decisions ***tit-for-tat***. Tit-for-tat means that one agent responds in kind to another. In the Bertrand example, Firm B plays tit-for-tat if it cuts (raises) its price whenever Firm A cuts (raises) its price. Firm B would want Firm A to know that it intends to play tit-for-tat in setting its prices. Thus, it might advertise to make sure Firm A is aware that it will face tit-for-tat retaliation in the event it decides to cut its price.

Many advertisements that you see send a subtle message to competitors that they can expect tit-for-tat retaliation in the event of a price cut. For example, consider the following Walmart advertisement: go to youtube.com. The advertisement is designed to make you feel like you will be getting the best price if you shop at Walmart and that the whole supply chain is organized to keep prices low. However, this add could also sends a subtle message to competing retailers. The message is as follows: If you cut your price, Walmart will match it. In other words, think carefully before making a price cut because Walmart will respond tit-for-tat!

Oligopolists may appeal to the folk theorem and avoid the prisoners' dilemma inherent in the Cournot and Bertrand models provided certain conditions are met. The theorem itself mentions two conditions.

1. The first is that all firms expect the competitive interaction to continue indefinitely. The folk theorem works because future profits serve as an incentive not to undercut competitors today. If firms know that competition will be for this period and this period only, then there is no incentive not to undercut. Moreover, if firms know they will compete for a known and finite number of periods, the incentive not to undercut unravels. This is because all firms expect the others to undercut them in the last period, which means it would be best to undercut in the second-to-last period, which means it would best to undercut in the third-to-last period, and so forth. The folk theorem only works if firms expect to be in competition for the foreseeable future.
2. Another requirement is that discount rates not be too high. For the folk theorem to apply, future returns that result from not undercutting your competitor's price must be large enough to offset the immediate gains you will receive if you do undercut a competitor. If discount rates are high, then returns in the future have less value today and the folk theorem is less likely to apply.

The rapidity with which firms can respond to price changes of competitors also affect whether the folk theorem can hold. If firms play tit-for-tat, then when one firm undercuts, it can expect retaliation by other firms. If it takes a long time for other firms to retaliate, then undercutting becomes more attractive regardless of the discount rate.

It also helps if firms are similar. This is because it is illegal for firms to collude to fix prices. There must be some price point that all firms can agree upon tacitly, without formally colluding to fix a price. The existence of such a point will be more likely if firms are reasonably similar in terms of costs and product characteristics.

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7.8: Oligopoly, Collusion, and Game Theory

Collusion and Game Theory

Collusion occurs when oligopoly firms make joint decisions, and act as if they were a single firm. Collusion requires an agreement, either explicit or implicit, between cooperating firms to restrict output and achieve the monopoly price. This causes the firms to be interdependent, as the profit levels of each firm depend on the firm's own decisions and the decisions of all other firms in the industry. This strategic interdependence is the foundation of **game theory**.

Game Theory = A framework to study strategic interactions between players, firms, or nations.

A game is defined as:

Game = A situation in which firms make strategic decisions that take into account each others' actions and responses.

A game can be represented as a payoff matrix, which shows the payoffs for each possibility of the game, as will be shown below. A game has players who select strategies that lead to different outcomes, or payoffs. A Prisoner's Dilemma is a famous game theory example where two prisoners must decide separately whether to confess or not confess to a crime. This is shown in Figure 7.8.1.

		PRISONER B	
		CONFESS	NOT CONFESS
PRISONER A	CONFESS	(8,8)	(1, 15)
	NOT CONFESS	(15,1)	(3,3)

Figure 7.8.1: A Prisoner's Dilemma

The police have some evidence that the two prisoners committed a crime, but not enough evidence to convict for a long jail sentence. The police seek a confession from each prisoner independently to convict the other accomplice. The outcomes, or payoffs, of this game are shown as years of jail sentences in the format (A, B) where A is the number of years Prisoner A is sentenced to jail, and B is the number of years Prisoner B is sentenced to jail. The intuition of the game is that if the two Prisoners "collude" and jointly decide to not confess, they will both receive a shorter jail sentence of three years.

However, if either prisoner decides to confess, the confessing prisoner would receive only a single year sentence for cooperating, and the partner in crime (who did not confess) would receive a long 15-year sentence. If both prisoners confess, each receives a sentence of 8 years. This story forms the plot line of a large number of television shows and movies. The situation described by the prisoner's dilemma is also common in many social and business interactions, as will be explored in the next chapter.

The outcome of this situation is uncertain. If both prisoners are able to strike a deal, and "collude," or act cooperatively, they both choose to NOT CONFESS, and they each receive three year sentences, in the lower right hand outcome of Figure 7.8.1. This is the cooperative agreement: $(\text{NOT}, \text{NOT}) = (3, 3)$. However, once the prisoners are in this outcome, they have a temptation to "cheat" on the agreement by choosing to CONFESS, and reducing their own sentence to a single year at the expense of their partner. How should a prisoner proceed? One way is to work through all of the possible outcomes, given what the other prisoner chooses.

A Solution to the Prisoner's Dilemma: Dominant Strategy

(1) If B CONF, A should CONF $(8 < 15)$

(2) If B NOT, A should CONF $(1 < 3)$

...A has the same strategy no matter what B does: CONF.

(3) If A CONF, B should CONF $(8 < 15)$

(4) If A NOT, B should CONF $(1 < 3)$

...B has the same strategy no matter what A does: CONF.

Thus, A chooses to CONFESS no matter what. This is called a **Dominant Strategy**, since it is the best choice given any of the strategies selected by the other player. Similarly, CONFESS is the dominant strategy for prisoner B.

Dominant Strategy = A strategy that results in the highest payoff to a player regardless of the opponent's action.

The Equilibrium in Dominant Strategies for the Prisoner's Dilemma is $(\text{CONF}, \text{CONF})$. This is an interesting outcome, since each prisoner receives eight-year sentences: $(8, 8)$. If they could only cooperate, they could both be better off with much lighter sentences of three years.

A second example of a game is the decision of whether to produce natural beef or not. Natural beef is typically defined as beef produced without antibiotics or growth hormones. The definition is difficult, since it means different things to different people, and there is no common legal definition. This game is shown in Figure 7.8.2, where Cargill and Tyson decide whether to produce natural beef.

		TYSON	
		NATURAL	NO NATURAL
CARGILL	NATURAL	(10,10)	(12,8)
	NO NATURAL	(8,12)	(6,6)

Figure 7.8.2: The Decision to Produce Natural Beef

There are two players in the game: Cargill and Tyson. Each firm has two possible strategies: produce natural beef or not. The payoffs in the payoff matrix are profits (million USD) for the two companies: $(\pi_{Cargill}, \pi_{Tyson})$.

Strategy = Each player's plan of action for playing a game.

Outcome = A combination of strategies for players.

Payoff = The value associated with possible outcomes.

In this game, profits are made from the premium associated with natural beef. If only one firm produced natural beef,

Dominant Strategy for the Natural Beef Game

(1) If TYSON NAT, CARGILL should NAT $(10 > 8)$

(2) If TYSON NO, CARGILL should NAT $(12 > 6)$

...CARGILL has the same strategy no matter what TYSON does: NAT.

(3) If $\mathrm{CARGILL\ NAT}$, TYSON should NAT $(10 > 8)$

(4) If $\mathrm{CARGILL\ NO}$, TYSON should \text{NAT} (12 > 6)\)

...TYSON has the same strategy no matter what $\mathrm{CARGILL}$ does: NAT.

Both firms choose to produce natural beef, no matter what, so this is a Dominant Strategy for both firms. The Equilibrium in Dominant Strategies is $(\mathrm{NAT}, \mathrm{NAT})$. The outcome of this game demonstrates why all beef processors have moved quickly into the production of natural beef in the past few years, and are all earning higher levels of profits. Beef producers have also moved rapidly into organic beef, local beef, grass-fed beef, and even plant-based "beef."

Prisoner's Dilemmas are very common in oligopoly markets: gas stations, grocery stores, garbage companies are frequently in this situation. If all oligopolists in a market could agree to raise the price, they could all earn higher profits. Collusion, or the cooperative outcome, could result in monopoly profits. In the USA, explicit collusion is illegal. "Price setting" is outlawed to protect consumers. However, implicit collusion (tacit collusion) could result in monopoly profits for firms in a prisoner's dilemma. For example, if gas stations in a city such as Manhattan, Kansas all matched a higher price, they could all make more money. However, there is an incentive to cheat on this implicit agreement by cutting the price and attracting more customers away from the other firms to your own gas station. Firms in a cooperative agreement are always tempted to break the agreement to do better.

The Nash Equilibrium calculated for the three oligopoly models (Cournot, Bertand, and Stackelberg) is a noncooperative equilibrium, as the firms are rivals and do not collude. In these models, firms maximize profits given the actions of their rivals. This is common, since collusion is illegal and price wars are costly. How do real-world oligopolists deal with prisoner's dilemmas is the topic of the next section.

Rigid Prices: Kinked Demand Curve Model

Oligopolists have a strong desire for price stability. Firms in oligopolies are reluctant to change prices, for fear of a price war. If a single firm lowers its price, it could lead to the Bertrand equilibrium, where price is equal to marginal costs, and economic profits are equal to zero. The kinked demand curve model was developed to explain price rigidity, or oligopolist's desire to maintain price at the prevailing price, P^*.

The kinked demand model asserts that a firm will have an asymmetric reaction to price changes. Rival firms in the industry will react differently to a price change, which results in different elasticities for price increases and price decreases.

(1) If a firm increases price, $P > P^*$, other firms will not follow

... the firm will lose most customers, the demand is highly elastic above P^*

(2) If a firm decreases price, $P < P^*$, other firms will follow immediately

...each firm will keep the same customers, demand is inelastic below P^*

The kinked demand curve is shown in Figure $7.8.3$, where the different reactions of other firms leads to a kink in the demand curve at the prevailing price P^*.

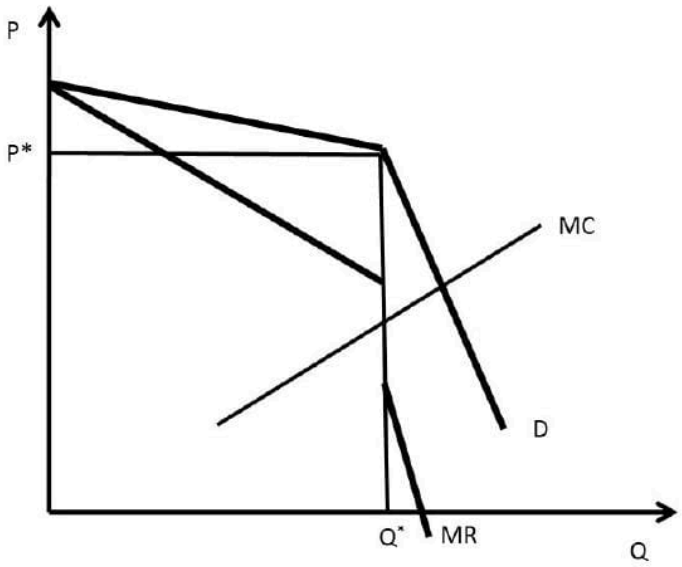


Figure 7.8.3: Kinked Demand Curve Model

In the kinked demand curve model, MR is discontinuous, due to the asymmetric nature of the demand curve. For linear demand curves, MR has the same y-intercept and two times the slope... resulting in two different sections for the MR curve when demand has a kink. The graph shows how price rigidity occurs: any changes in marginal cost result in the same price and quantity in the kinked demand curve model. As long as the MC curve stays between the two sections of the MR curve, the optimal price and quantity will remain the same.

One important feature of the kinked demand model is that the model describes price rigidity, but does not explain it with a formal, profit-maximizing model. The explanation for price rigidity is rooted in the prisoner's dilemma and the avoidance of a price war, which are not part of the kinked demand curve model. The kinked demand model is criticized because it is not based on profit-maximizing foundations, as the other oligopoly models.

Two additional models of pricing are price signaling and price leadership.

Price Signaling = A form of implicit collusion in which a firm announces a price increase in the hope that other firms will follow suit.

Price signaling is common for gas stations and grocery stores, where price are posted publically.

Price Leadership = A form of pricing where one firm, the leader, regularly announces price changes that other firms, the followers, then match.

There are many examples of price leadership, including General Motors in the automobile industry, local banks may follow a leading bank's interest rates, and US Steel in the steel industry.

Dominant Firm Model: Price Leadership

A dominant firm is defined as a firm with a large share of total sales that sets a price to maximize profits, taking into account the supply response of smaller firms. The dominant firm model is also known as the price leadership model. The smaller firms are referred to as the "fringe." Let $F =$ fringe, or many relatively small competing firms in the same industry as the dominant firm. Let $Dom =$ the dominant firm. The market demand for the good (D_{mkt}) is equal to the sum of the demand facing the dominant firm (D_{dom}) and the demand facing the fringe firms (D_F).

$$D_{dom} = D_{mkt} – D_F$$

Total quantity (Q_T) is also the sum of output produced by the dominant and fringe firms.

$$Q_T = Q_{dom} + Q_F$$

The dominant firm model is shown in Figure 7.8.4. The supply curve for the fringe firms is given by S_F, and the marginal cost of the dominant firm is MC_{dom}. Recall that the marginal cost curve is the firm's supply curve. The dominant firm has the advantage of lower costs due to economies of scale. In what follows, the dominant firm will set a price, allow the fringe firms to produce as much as they desire, and then find the profit-maximizing quantity and price with the remainder of the market.

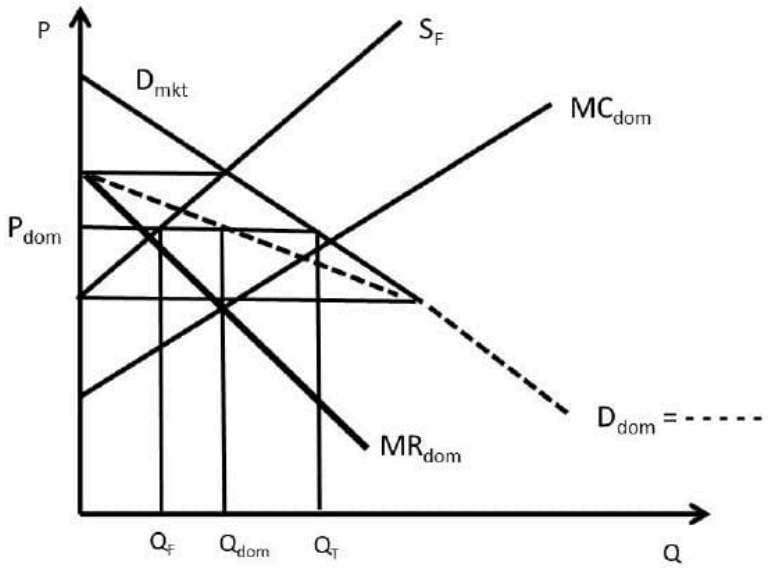


Figure 7.8.4: The Dominant Firm Model

To find the profit-maximizing level of output, the dominant firm first finds the demand curve facing the dominant firm (the dashed line in Figure 7.8.4), then sets marginal revenue equal to marginal cost. The dominant firm's demand curve is found by subtracting the supply of the fringe firms (S_F) from the total market demand (D_{mkt}).

$$D_{dom} = D_{mkt} – S_F$$

The dominant firm demand curve is found by the following procedure. The y-intercept of the dominant firm's demand curve occurs where S_F is equal to the D_{mkt}. At this point, the fringe firms supply the entire market, so the residual facing the dominant firm is equal to zero. Therefore, the demand curve of the dominant firm starts at the price where fringe supply equals market demand. The second point on the dominant firm demand curve is found at the y-intercept of the fringe supply curve (S_F). At any price equal to or below this point, the supply of the fringe firms is equal to zero, since the supply curve represents the cost of production. At this point, and all prices below this point, the market demand (D_{mkt}) is equal to the dominant firm demand (D_{dom}). Thus, the dashed line below the y-intercept of the fringe supply is equal to the market demand curve. The dominant firm demand curve for prices above this point is found by drawing a line from the y-intercept at price $(S_F = D_{mkt})$ to the point on the market demand curve at the price of the S_F y-intercept. This is the dashed line above the S_F y-intercept.

Once the dominant firm demand curve is identified, the dominant firm maximizes profits by setting marginal revenue equal to marginal cost at quantity Q_{dom}. This level of output is then substituted into the dominant firm demand curve to find the price P_{dom}. The fringe firms take this price as given, and produce Q_F. The sum of Q_{dom} and Q_F is the total output Q_T.

In this way, the dominant firm takes into account the reaction of the fringe firms while making the output decision. This is a Nash equilibrium for the dominant firm, since it is taking the other firms' behavior into account while making its strategic decision. The model effectively captures an industry with one dominant firm and many smaller firms.

Cartels

A **cartel** is a group of firms that have an explicit agreement to reduce output in order to increase the price.

Cartel = An explicit agreement among members to reduce output to increase the price.

Cartels are illegal in the United States, as the cartel is a form of collusion. The success of the cartel depends upon two things: (1) how well the firms cooperate, and (2) the potential for monopoly power (inelastic demand).

Cooperation among cartel members is limited by the temptation to cheat on the agreement. The Organization of Petroleum Exporting Countries (OPEC) is an international cartel that restricts oil production to maintain high oil prices. This cartel is legal, since it is an international agreement, outside of the American legal system. The oil cartel's success depends on how well each member nation adheres to the agreement. Frequently, one or more member nations increases oil production above the agreement, putting downward pressure on oil prices. The cartel's success is limited by the temptation to cheat. This cartel characteristic is that of a prisoner's dilemma, and collusion can be best understood in this way.

A collusive agreement, or cartel, results in a circular flow of incentives and behavior. When firms in the same industry act independently, they each have an incentive to collude, or cooperate, to achieve higher levels of profits. If the firms can jointly set the monopoly output, they can share monopoly profit levels. When firms act together, there is a strong incentive to cheat on the agreement, to make higher individual firm profits at the expense of the other members. The business world is competitive, and as a result oligopolistic firms will strive to hold collusive agreements together, when possible. This type of strategic decisions can be usefully understood with game theory, the subject of the next two Chapters.

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7.9: Concluding Comments- Effects of Imperfect Competition on Economic Welfare

In imperfectly competitive markets like monopoly, oligopoly, and monopolistic competition, it is often the case that sellers can increase profits at the expense of consumers through their ability to control quantity or price. This is good for the seller but is bad for society as a whole. To conclude this chapter, it is worthwhile to spend some time on the welfare implications of imperfect competition. When markets are imperfectly competitive, the results are that (1) too little is produced; (2) too high of a price is charged for what is produced; and (3) there is a resulting dead-weight loss to the economy. In short, imperfect competition costs the economy in terms of a misallocation of resources. The combined value of economic activity measured as the sum of producers' and consumers' surplus would be higher if imperfectly competitive markets behaved competitively. Table 7.9.1 illustrates this point using the Cournot Nash equilibrium example above. Notice that total surplus in the market increases as the market becomes more competitive. Producers' surplus declines but the gains in consumers' surplus more than offset the decline in producers' surplus.

*Table 7.9.1. Economic Welfare at Cournot Nash Equilibrium for Different Numbers of Firms**

Number of Firms	Producers' Surplus (Profits)	Consumers' Surplus	Total Surplus
1 (monopoly)	$4,050	$2,025	$6,075
2 (oligopoly)	$3,600	$3,600	$7,200
5 (oligopoly)	$2,250	$5,625	$7,875
10 (oligopoly)	$1,339	$6,694	$8,033
Many (approaching perfect competition)	$32	$8,068	$8,100

*In Table 7.9.3, the market inverse demand curve is $P = 200 - \Sigma Q_i$ and $MC = 20$ for all firms.

For the simple reason that total surplus increases with stronger competition, most governments have laws in place to encourage competition in markets. These are referred to as antitrust laws. Regulatory agencies evaluate mergers and acquisitions to determine whether they will adversely impact competition. A good example is provided by Hayenga and Wisner (2000). These authors describe antitrust issues that were evaluated in approving a merger between Cargill and Continental Grain, two entities with large grain merchandising businesses. Moreover, antitrust laws make it illegal to fix prices or form a cartel to limit quantity. A famous case of price fixing in agriculture involved lysine, an amino acid used in livestock and poultry feeds. ADM, a US company, conspired with Japanese and South Korean lysine manufacturers to keep the price of lysine above competitive levels. The conspirators faced criminal and civil penalties as a result of the price-fixing conspiracy. A very good overview of this case is presented by Connor (1997). In fact, there was even a movie made about this incident starring Matt Damon. See the trailer on youtube.com. The movie is titled *The Informant* and is based on a book by the same name. I am unable to recommend the movie one way or the other as I have not seen it, but it may be something you want to check out some weekend. If you do watch it, I will be interested to hear what you think. Both the Hayenga and Wisner (1997) and Connor (1997) articles are available through the University of Arkansas Libraries.

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7.10: References

Baumol, W. J., J. C. Panzar, and R. D. Willig. 1982. *Contestable Markets and the Theory of Industry Structure*. New York: Harcourt Brace Jovanovich.

Hayenga, M. and R. Wisner. 2000. Cargill's Acquisition of Continental Grain's Grain Merchandising Business. *Review of Agricultural Economics* 22:252-266

Connor, J. M. 1997. The Global Lysine Price-Fixing Conspiracy of 1992-1995. *Review of Agricultural Economics* 19:412-427

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7.11: Problem Sets

Problem Set 1. Profit Maximization for the Monopolist of Monopolistically Competitive Firm

Exercise 7.1

Given the following:

The inverse demand is P = 100-2Q.

Marginal cost is 20.

Average variable cost is 20.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.2

Given the following:

The inverse demand is P = 200-2.5Q.

Marginal cost is 20.

Average variable cost is 20.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.3

Given the following:

The inverse demand is P = 300-3Q.

Marginal cost is 30.

Average variable cost is 30.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.4

Given the following:

The inverse demand is P = 400-4Q.

Marginal cost is 40.

Average variable cost is 40.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.5

Given the following:

The inverse demand is P = 460-5Q.

Marginal cost is 50.

Average variable cost is 50.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.6

Given the following:

The inverse demand is P = 200-3Q.

Marginal cost is 20.

Average variable cost is 20.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.7

Given the following:

The inverse demand is P = 288-3Q.

Marginal cost is 30.

Average variable cost is 30.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.8

Given the following:

The inverse demand is P = 300-2.5Q.

Marginal cost is 30.

Average variable cost is 30.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.9

Given the following:

The inverse demand is P = 400-4Q.

Marginal cost is 80.

Average variable cost is 80.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 7.10

Given the following:

The inverse demand is P = 456-4.5Q.

Marginal cost is 42.

Average variable cost is 42.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Problem Set 2. Two-Firm Cournot Duopoly

Exercise 7.11

Given the following:

The inverse demand is P = 200-2Qa-2Qb.

Marginal cost for each firm is 20.

Average variable cost for each firm is 20.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.12

Given the following:

The inverse demand is P = 200-2.5Qa-2.5Qb.

Marginal cost for each firm is 20.

Average variable cost for each firm is 20.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.13

Given the following:

The inverse demand is P = 250-5Qa-5Qb.

Marginal cost for each firm is 25.

Average variable cost for each firm is 25.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.14

Given the following:

The inverse demand is P = 300-4Qa-4Qb.

Marginal cost for each firm is 36.

Average variable cost for each firm is 36.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.15

Given the following:

The inverse demand is P = 400-5Qa-5Qb.

Marginal cost for each firm is 40.

Average variable cost for each firm is 40.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.16

Given the following:

The inverse demand is P = 500-4Qa-4Qb.

Marginal cost for each firm is 80.

Average variable cost for each firm is 80.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.17

Given the following:

The inverse demand is P = 300-3Qa-3Qb.

Marginal cost for each firm is 30.

Average variable cost for each firm is 30.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.18

Given the following:

The inverse demand is P = 300-2.5Qa-2.5Qb.

Marginal cost for each firm is 30.

Average variable cost for each firm is 30.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.19

Given the following:

The inverse demand is P = 500-4Qa-4Qb.

Marginal cost for each firm is 80.

Average variable cost for each firm is 80.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 7.20

Given the following:

The inverse demand is P = 420-4.5Qa-4.5Qb.

Marginal cost for each firm is 42.

Average variable cost for each firm is 42.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Problem Set 3. Find the Monopolist's or Monopolistically Competitive Firm's Price

Exercise 7.21

Given the following:

The elasticity of demand facing the firm is -1.5.

The firm's marginal cost is 8.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.22

Given the following:

The elasticity of demand facing the firm is -2.5.

The firm's marginal cost is 30.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.23

Given the following:

The elasticity of demand facing the firm is -2.

The firm's marginal cost is 30.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.24

Given the following:

The elasticity of demand facing the firm is -3.

The firm's marginal cost is 20.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.25

Given the following:

The elasticity of demand facing the firm is -2.

The firm's marginal cost is 20.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.26

Given the following:

The elasticity of demand facing the firm is -1.5.

The firm's marginal cost is 20.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.27

Given the following:

The elasticity of demand facing the firm is -2.5.

The firm's marginal cost is 12.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.28

Given the following:

The elasticity of demand facing the firm is -2.

The firm's marginal cost is 20.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.29

Given the following:

The elasticity of demand facing the firm is -3.

The firm's marginal cost is 40.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 7.30

Given the following:

The elasticity of demand facing the firm is -2.

The firm's marginal cost is 40.

What price maximizes this firm's profits?

Answer available at the end of this section.

Problem Set 4. Multiple Choice

Exercise 7.31

1. **An industry with many sellers with differentiated products is classified as**

a) A monopoly

b) An oligopoly

c) Monopolistically competitive

d) Perfectly competitive

Answer available at the end of this section.

Exercise 7.32

2. **The folk theorem is of primary interest in understanding competition in an industry that is**

a) A monopoly

b) An oligopoly

c) Monopolistically competitive

d) Perfectly competitive

Answer available at the end of this section.

Exercise 7.33

3. **An industry where firms are price takers is**

a) A monopoly

b) A monopsony

c) Monopolistically competitive

d) Perfectly competitive

Answer available at the end of this section.

Exercise 7.34

4. **An industry where firms face an infinitely negative own-price elasticity is**

a) A monopoly

b) A monopsony

c) Monopolistically competitive

d) Perfectly competitive

Answer available at the end of this section.

Exercise 7.35

5. **In the Cournot model, competitors compete by choosing**

a) Prices

b) Quantities

c) Contracting methods

d) Management styles

Answer available at the end of this section.

Exercise 7.36

6. **In the Bertrand model, competitors compete by choosing**

a) Prices

b) Quantities

c) Contracting methods

d) Management styles

Answer available at the end of this section.

Exercise 7.37

7. **The Cournot or Bertrand Nash equilibrium is**

a) Analogous to the prisoner's dilemma outcome because there is a feasible outcome that is better for the firms involved.

b) Modeled using a hedonic pricing model

c) Similar to 1st degree price discrimination

d) Similar to 3rd degree price discrimination

Answer available at the end of this section.

Exercise 7.38

8. **Which is true of a price taking firm?**

a) It can sell all that it wants at the going price.

b) Its actions have a negligible impact on the market price.

c) It will maximize profits by producing where price is equal to marginal cost.

d) All of the above.

Answer available at the end of this section.

Exercise 7.39

9. **A profit maximizing firm will set price = marginal cost (p = MC) in which market structure?**

a) Perfect competition

b) Monopolistic competition

c) Oligopoly

d) Monopoly

e) All of the above

Answer available at the end of this section.

Exercise 7.40

10. **A profit maximizing firm will set marginal revenue = marginal cost (MR = MC) in which market structure?**

a) Perfect competition

b) Monopolistic competition

c) Oligopoly

d) Monopoly

e) All of the above

Answer available at the end of this section.

Exercise 7.41

11. **In which market structure are strategic interactions among firms of primary interest?**

a) Perfect competition

b) Monopolistic competition

c) Oligopoly

d) Monopoly

Answer available at the end of this section.

Exercise 7.42

12. **Which best describes a tit-for-tat response?**

a) The firm always prices lower than the competitor

b) The firm always prices a bit higher than the competitor to protect its margin

c) The firm cuts (raises) its price in response to a cut (raise) in price by its competitor

d) The firm chooses its Nash equilibrium price

Answer available at the end of this section.

Exercise 7.43

13. **A firm that advertises, "We will match any competitors price"**

a) Could be warning its competitors that it follows a tit-for-tat pricing strategy

b) Must have low costs

c) Is more worried about market share than profits

d) All of the above

Answer available at the end of this section.

Exercise 7.44

14. **Which factor makes it more likely that firms will be able to tacitly cooperate on a price above the Bertrand price?**

a) Discount rates are high

b) It takes a long time for firms to respond to a price change by a competitor

c) Firm's know that the competitive interaction will last for only three periods

d) Discount rates are low

e) There are major differences among firms in terms of costs and quality

Answer available at the end of this section.

Exercise 7.45

15. **Which best describes a Nash equilibrium?**

a) Tacit coordination on the monopoly price

b) A situation where MR < P

c) A situation where each agent is choosing its best strategy given the strategies of all other agents.

d) Cases where price is above the break-even point

Answer available at the end of this section.

Answers

Exercise 7.1

The quantity is 20 units.
The price is 60 dollars.
Profits above FC are 800 dollars.

Exercise 7.2

The quantity is 36 units.
The price is 110 dollars.
Profits above FC are 3240 dollars.

Exercise 7.3

The quantity is 45 units.
The price is 165 dollars.
Profits above FC are 6075 dollars.

Exercise 7.4

The quantity is 45 units.
The price is 220 dollars.
Profits above FC are 8100 dollars.

Exercise 7.5

The quantity is 41 units.
The price is 255 dollars.
Profits above FC are 8405 dollars.

Exercise 7.6

The quantity is 30 units.
The price is 110 dollars.
Profits above FC are 2700 dollars.

Exercise 7.7

The quantity is 43 units.
The price is 159 dollars.
Profits above FC are 5547 dollars.

Exercise 7.8

The quantity is 54 units.
The price is 165 dollars.
Profits above FC are 7290 dollars.

Exercise 7.9

The quantity is 40 units.
The price is 240 dollars.
Profits above FC are 6400 dollars.

Exercise 7.10

The quantity is 46 units.
The price is 249 dollars.
Profits above FC are 9522 dollars.

Exercise 7.11

Each firm's quantity is 30 units.
The market price is 80 dollars.
Each firm's profits above FC are 1800 dollars.

Exercise 7.12

Each firm's quantity is 24 units.
The market price is 80 dollars.
Each firm's profits above FC are 1440 dollars.

Exercise 7.13

Each firm's quantity is 15 units.
The market price is 100 dollars.
Each firm's profits above FC are 1125 dollars.

Exercise 7.14

Each firm's quantity is 22 units.
The market price is 124 dollars.
Each firm's profits above FC are 1936 dollars.

Exercise 7.15

Each firm's quantity is 24 units.
The market price is 160 dollars.
Each firm's profits above FC are 2880 dollars.

Exercise 7.16

Each firm's quantity is 35 units.
The market price is 220 dollars.
Each firm's profits above FC are 4900 dollars.

Exercise 7.17

Each firm's quantity is 30 units.
The market price is 120 dollars.
Each firm's profits above FC are 2700 dollars.

Exercise 7.18

Each firm's quantity is 36 units.
The market price is 120 dollars.
Each firm's profits above FC are 3240 dollars.

Exercise 7.19

Each firm's quantity is 35 units.
The market price is 220 dollars.
Each firm's profits above FC are 4900 dollars.

Exercise 7.20

Each firm's quantity is 28 units.
The market price is 168 dollars.
Each firm's profits above FC are 3528 dollars.

Exercise 7.21

The profit maximizing price is 24.

Exercise 7.22

The profit maximizing price is 50.

Exercise 7.23

The profit maximizing price is 60.

Exercise 7.24

The profit maximizing price is 30.

Exercise 7.25

The profit maximizing price is 40.

Exercise 7.26

The profit maximizing price is 60.

Exercise 7.27

The profit maximizing price is 20.

Exercise 7.28

The profit maximizing price is 40.

Exercise 7.29

The profit maximizing price is 60.

Exercise 7.30

The profit maximizing price is 80.

Exercise 7.31

c

Exercise 7.32

b

Exercise 7.33

d

Exercise 7.34

d

Exercise 7.35

b

Exercise 7.36

a

Exercise 7.37

a

Exercise 7.38

d

Exercise 7.39

a

Exercise 7.40

e

Exercise 7.41

c

Exercise 7.42

c

Exercise 7.43

a

Exercise 7.44

d

Exercise 7.45

c

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8: MONOPOLY, MARKET POWER, AND WELFARE

8.1: Overview and Objectives

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8.3: Considerations in Classifying a Market

8.4: Monopoly Profit-Maximizing Solution

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8.1: Overview and Objectives

Learning Objectives

- Define monopoly, oligopoly, and monopsony in agriculture.
- Compare competitive vs. concentrated market structures.
- Analyze market power in food processing and retail chains.
- Evaluate policy efforts to address concentration in agriculture.

Markets vary in ways that affect competition and pricing. In some markets, competition is fierce. In others, it is light. Some firms have broad discretion in setting prices, while others face take-it-or-leave-it market prices. Pricing and competition depend on the structural characteristics of the market. Economists classify markets as monopolies, oligopolies, monopolistically competitive, or perfectly competitive depending on the characteristics of selling firms in the market. A brief overview of each market structure is as follows:

A ***monopoly*** is a market with only one seller. The seller (called a monopolist) will often have quite a bit of control over the price that it charges. Earlier in the course, you examined a firm that was a price taker. A monopolist is not a price taker. As the only seller, the monopolist has an incentive to keep its price above its marginal cost. In so doing, it takes surplus from consumers and turns that surplus into profits for itself. Naturally, sellers like to have monopoly power. The problem for the monopolist is to get as much of the consumer surplus as it can. This problem is complicated in that the monopolist faces the market demand curve. Because of the law of demand, the monopolist must lower its price if it wants to sell more, which entails sacrificing its profit margin. On the other hand, if the monopolist attempts to raise price, and thereby increase its profit margin, it sacrifices volume. There is a balancing act here that you have seen before with demand elasticities in Chapter 3. In this chapter, you will see that the demand elasticity facing the monopolist is relevant and can help you solve the monopolist's problem.

An ***oligopoly*** is a market where there are a few sellers. There must be at least two sellers (a duopoly), and there is no magic number on what constitutes the upper limit of a "few" sellers. Like monopolists, oligopolists do have some discretion in setting their prices. However, the problem is further complicated by the fact that the oligopolist must pay attention to the actions of its competitors. Interactions among competitors are of primary interest in oligopoly models.

Monopolistic competition refers to situations where there are generally many sellers (again, there is no magic number that divides "few sellers" from "many sellers"). A key feature of monopolistic competition is that products are differentiated in the minds of consumers and/or transactions costs give rise to varied perceptions among consumers as to the advantages or disadvantages of patronizing one firm over another. Because products are differentiated, sellers are not price takers. Like the monopolist, firms in monopolistic competition face a downward sloping demand curve. In fact, you will see that the individual firm's problem in monopolistic competition has the same set-up as the monopolist's problem.

Perfect competition refers to situations where there are many sellers. Products are homogeneous or differ only in ways that readily apparent to all buyers. The actions of any single seller has no effect on the market price. Firms under perfect competition are price takers. The price taking assumption was introduced earlier in Chapter 2. This assumption is the one key feature of perfect competition. While the market demand curve slopes downward, the firm does not face the market demand curve; it only sees the prevailing market price. It can sell all that it wants (or all that it can produce) at the going market price. If the firm attempts to raise its price, there are no buyers. For this reason, it can be said that the firm faces an elasticity of demand that is negative infinity.

This chapter is about competition and market outcomes under these different market structures. The specific learning objectives for the chapter are as follows:

- Describe and explain characteristics of different market structures on the selling side of the market.
- Use the MR = MC profit maximizing condition to find profit maximizing solutions under different market structures.
- Explain the strategic interactions in duopoly models, distinguish between Cournot and Bertrand models of duopoly, and explain how each is an example of the prisoners' dilemma
- Explain the folk theorem and the ability of firms to avoid prisoners' dilemma outcomes in price competition over time.
- Understand the economic welfare implications of imperfectly competitive market structures relative to the perfectly competitive benchmark.

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8.2: Market Power Introduction

This chapter will explore firms that have market power, or the ability to set the price of the good that they produce.

Market Power = Ability of a firm to set the price of a good. Also called monopoly power.

A **monopoly** is defined as a single firm in an industry with no close substitutes. An industry is defined as a group of firms that produce the same good.

Monopoly = A single firm in an industry with no close substitutes.

The phrase, "no close substitutes" is important, since there are many firms that are the sole producer of a good. Consider McDonalds Big Mac hamburgers. McDonalds is the only provider of Big Macs, yet it is not a monopoly because there are many close substitutes available: Burger King Whoppers, for example.

Market power is also called monopoly power. A competitive firm is a "price taker." Thus, a competitive firm has no ability to change the price of a good. Each competitive firm is small relative to the market, so has no influence on price. On the other hand, firms with market power are also called "price makers."

Price Taker = A competitive firm with no ability to set the price of a good.

Price Maker = A noncompetitive firm with market power, defined as the ability to set the price of a good.

A monopolist is considered to be a price maker, and can set the price of the product that it sells. However, the monopolist is constrained by consumer willingness and ability to purchase the good, also called demand. For example, suppose that an agricultural chemical firm has a patent for an agricultural chemical used to kill weeds, a herbicide. The patent is a legal restriction that permits the patent holder to be the only seller of the herbicide, as it was invented by the company through their research program. In Figure 8.2.1, an agricultural chemical firm faces an inverse demand curve equal to: $P = 100–Q^d$, where P is the price of the agricultural chemical in dollars per ounce (USD/oz), and Q^d is the quantity demanded of the chemical in million ounces (m oz).

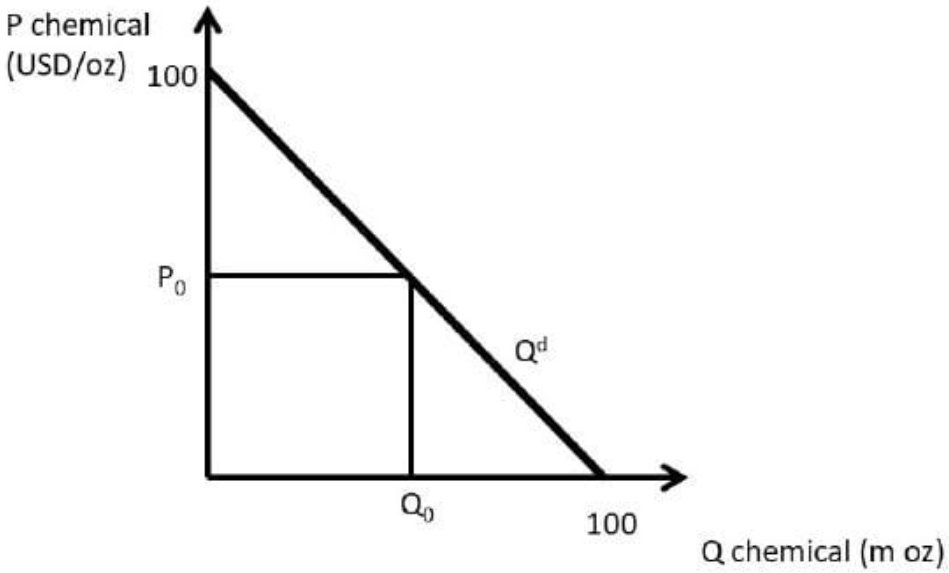


Figure 8.2.1: Demand Facing a Monopolist: Agricultural Chemical

The monopolist can set a price, but the resulting quantity is determined by the consumers' willingness to pay, or the demand curve. For example, if the price is set at P_0, consumers will purchase Q_0. Alternatively, the monopolist could set quantity at Q_0, and consumers would be willing to pay P_0 for Q_0 units of the chemical. Thus, a monopolist has the ability to set any price that it would like to, but with important limitation: the monopolist is constrained by consumer willingness to pay for the product.

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8.3: Considerations in Classifying a Market

How do you know whether a market is a monopoly, an oligopoly, monopolistically competitive, or perfectly competitive? To answer this question, it is useful to clarify the boundaries of the market you are considering. There are three dimensions of a market. These are the product, the time, and the place. You should think about market boundaries in terms of each of these three dimensions. In the product dimension, clarify how narrowly you are defining the product. For instance, are you interested in the market for herbicides broadly, or are you interested in the market for herbicides designed to control a specific weed or class of weeds? Once you have specified the product boundaries, you can then identify competitors that are operating in the market. The next dimension is time. Agricultural products are sometimes sourced from different locations at different times of the year. Because of this, the set of sellers who comprise the market could be different at different points in time. Finally, the place dimension is important because agricultural products are bulky and transportation costs are often an important consideration. Thus, sellers in one geographic area may be different than sellers in another. Moreover, there may be more sellers in one geographic area than another depending on demand conditions in the respective geographic areas. Having defined the boundaries of a market along these three dimensions (product, time, and place), you can use several characteristics of the market to classify its structure.

The first, and probably most obvious, characteristic is ***the number of firms that comprise the market***. The number of firms is central to the definitions of market structures above. In a monopoly, the market is comprised of one firm. In an oligopoly there are a few firms. If there are many firms, the market is either monopolistically or perfectly competitive, depending on the nature of the product.

Another issue of specific importance is ***whether the product of one seller is different from the product of another in the minds of consumers***. If so, the products are differentiated. If not, the products are homogeneous. If products are differentiated, it is useful to distinguish between two different types of product differentiation:

1. A product is vertically differentiated if there are clear quality differences that can be measured objectively. All buyers can agree upon the presence or absence of the quality attribute, regardless of whether the buyer actually places a value on the attribute in question. For example, in lumber, there are vertical differences between oak and pine. Buyers are knowledgeable about these differences and situations wherein one type of lumber is better suited than the other. Usually there are vertical differences among agricultural products. In many cases, grades and standards are used to convey information about these vertical quality differences.
2. Products are horizontally differentiated if there are less tangible quality differences among products that are nonetheless important to the consumer or some segments of consumers. Horizontal differences usually come down to a matter of taste. Most horizontal differences are conveyed through brand image. For example, if you were to compare the ingredient lists on two different brands of cola, you would see that they were nearly identical. It is hard to make the case that one brand is truly better than another for its intended purpose. However, some consumers are probably quite loyal to one of the brands and may even dislike the other.

If horizontal product differences exist, then brands can play a role in conveying these differences, and an industry comprised of many competitors will be monopolistically competitive, as opposed to being perfectly competitive. Vertical product difference can exist in either perfect or monopolistic competition. In a perfectly competitive market, the market price is augmented by a series of market-determined discounts or premiums to account for the vertical quality differences.

Finally, ***the ease with which new firms can enter the market*** is important to market structure and market outcomes. Entrants are latent or potential competitors. As you learned in Chapter 2, if an outside firm finds a market to be attractive, it will come into the market, cause supply to shift outwards and depress prices. Outcomes of some of the market structures depend on entry being difficult in one way or another. Entry can be difficult for several reasons:

1. *Economies of scale are large compared to the size of the market.* In some cases, production technology is such that a firm must produce a very large number of units in order to cover fixed costs. If demand is limited, there may only be room for one or two firms to operate at an efficient scale within a given market. This could foreclose entry because outside firms will not be able to achieve an efficient scale if the market is entered.
2. *Access to raw materials, technology, or distribution channels.* The inability to access key sources of raw materials, technology, or distribution channels can prevent entry, even if the production process is well understood and economies of scale are inconsequential. In some cases, access is limited by patents or other legal restrictions. This is common with some plant materials, seed varieties, and crop protectants.

3. *Network externalities.* A network externality exists if there are benefits when multiple consumers use the same platform. A livestock auction provides a good example. Buyers benefit when there are more sellers participating in the auction. Similarly, sellers benefit when there are more buyers participating in the auction. Software, such as a word processing package, provides another example of a network externality. You have an incentive to use the package that is most commonly used by other users. This way, if a colleague sends you a document, you will likely be able to open and edit it without problems. Once established, the existence of network externalities in a market can make entry difficult.

Usually, entry is impossible in a market that is a monopoly. The inability to enter the market is presumably why the market can remain a monopoly. There is one exception, however. This is the case of ***a contestable monopoly*** (Baumol, Panzar, and Willig 1982). A contestable monopoly exists in cases where the market can be served by one seller, but if this seller attempts to exploit its monopoly position by charging a high price, the market will be attacked by entrants who will cause the price to fall. If entrants can get in and out of the market easily, the monopolist will be attacked by entry whenever the monopolist attempts to raise its price. A contestable monopoly can exist if the fixed costs of entry can be recovered upon exit. An argument could be made that some food brands have characteristics of contestable monopolies.

Table 8.3.1. *Summary of Industry Characteristics and Market Structures*

Structure	Number of Firms	Horizontal Differences	Vertical Differences	Entry
Monopoly	One	Not Applicable	Possible, by product line	Difficult*
Oligopoly	Few	Possible	Possible	Difficult
Monopolistic Comp.	Many	Yes	Possible	Easy
Perfect Comp.	Many	No	Possible	Easy

* The exception is a contestable monopoly

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8.4: Monopoly Profit-Maximizing Solution

The profit-maximizing solution for the monopolist is found by locating the biggest difference between total revenues (TR) and total costs (TC), as in Equation 8.4.1.

$$\max \pi = TR–TC \tag{8.4.1}$$

Monopoly Revenues

Revenues are the money that a firm receives from the sale of a product.

Total Revenue [TR] = The amount of money received when the producer sells the product. $TR = PQ$

Average Revenue [AR] = The average dollar amount receive per unit of output sold $AR = \dfrac{TR}{Q}$

Marginal Revenue [MR] = the addition to total revenue from selling one more unit of output.

$$MR = \frac{\Delta TR}{\Delta Q} = \frac{\partial TR}{\partial Q}.$$

$$TR = PQ \text{ (USD)}$$

$$AR = \frac{TR}{Q} = P \text{ (USD/unit)}$$

$$MR = \frac{\Delta TR}{\Delta Q} = \frac{\partial TR}{\partial Q} \text{ (USD/unit)}$$

For the agricultural chemical company:

$$TR = PQ = (100–Q)Q = 100Q–Q^2$$

$$AR = P = 100–Q$$

$$MR = \frac{\partial TR}{\partial Q} = 100–2Q$$

Total revenues for the monopolist are shown in Figure 8.4.1. Total Revenues are in the shape of an inverted parabola. The maximum value can be found by taking the first derivative of TR, and setting it equal to zero. The first derivative of TR is the slope of the TR function, and when it is equal to zero, the slope is equal to zero.

$$\max TR = PQ\frac{\partial TR}{\partial Q} = 100–2Q = 0Q^* = 50 \tag{8.4.2}$$

Substitution of Q^* back into the TR function yields $TR =$ USD 2500, the maximum level of total revenues (Figure 8.4.1).

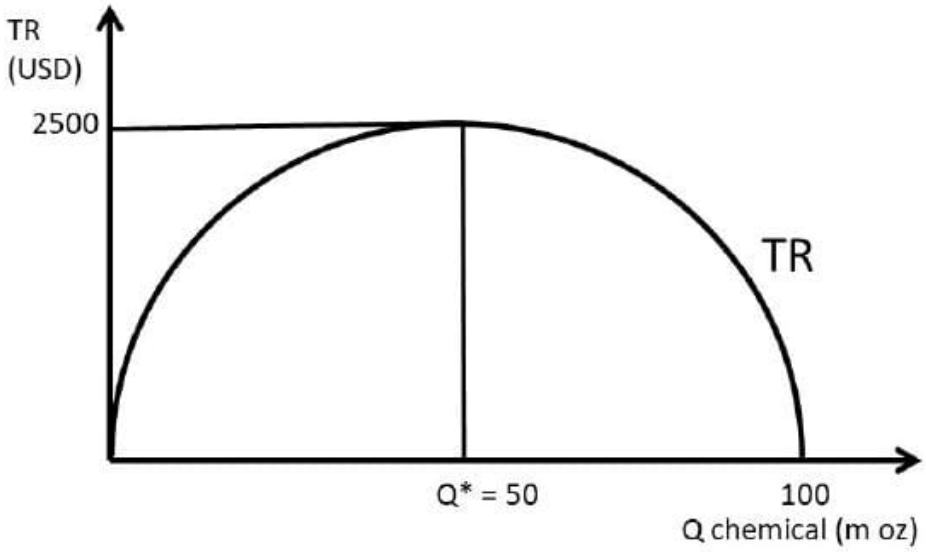


Figure 8.4.1: Total Revenues for a Monopolist: Agricultural Chemical

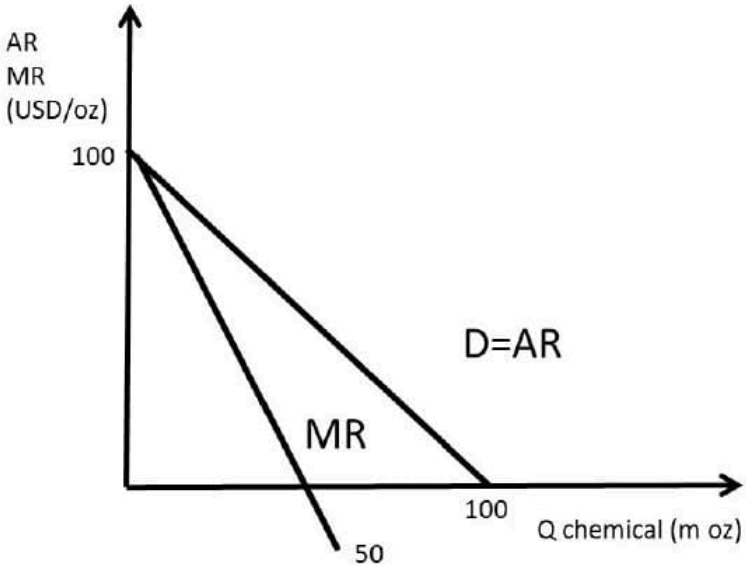


Figure 8.4.2: Per-Unit Revenues for a Monopolist: Agricultural Chemical

It is important to point out that the optimal level of chemical is not this level. The optimal level of chemical to produce and sell is the profit-maximizing level, which is revenues minus costs. If the monopolist were to maximize revenues instead of profits, it might cost too much relative to the gain in revenue. Profits include both revenues and costs.

Average revenue (AR) and marginal revenue (MR) are shown in Figure 8.4.2. The marginal revenue curve has the same y-intercept and twice the slope as the average revenue curve. This is always true for linear demand (average revenue) curves. This is one of the major take home messages of economics: maximize revenues may cost too much to make it worth it. For example, a corn farmer who maximizes yield (output per acre of land) may be spending too much on inputs such as fertilizer and chemicals make the higher yield payoff. From an economic perspective, the corn farmer should consider both revenues and costs.

Monopoly Costs

The costs for the chemical include total, average, and marginal costs.

Total Cost [TC] = The sum of all payments that a firm must make to purchase the factors of production. The sum of **Total Fixed Costs** and **Total Variable Costs**. $TC = C(Q) = TFC + TVC.$

Total Fixed Costs [TFC] = Costs that do not vary with the level of output.

Total Variable Costs [TVC] = Costs that do vary with the level of output.

Average Cost [AC] = total costs per unit of output. $AC = \frac{TC}{Q}$. Note that the terms, Average Costs and Average Total Costs are interchangeable.

Marginal Cost [MC] = the increase in total costs due to the production of one more unit of output. $MC = \frac{\Delta TC}{\Delta Q} = \frac{\partial TC}{\partial Q}$.

$$TC = C(Q) \text{ (USD)}$$
$$AC = \frac{TC}{Q} \text{ (USD/unit)}$$
$$MC = \frac{\Delta TC}{\Delta Q} = \frac{\partial TC}{\partial Q} \text{ (USD/unit)}$$

Suppose that the agricultural chemical firm is a constant cost industry. This means that the per-unit cost of producing one more ounce of chemical is the same, no matter what quantity is produced. Assume that the cost per unit is ten dollars per ounce (10 USD/oz).

$$TC = 10Q$$
$$AC = \frac{TC}{Q} = 10$$
$$MC = \frac{\Delta TC}{\Delta Q} = \frac{\partial TC}{\partial Q} = 10$$

The total costs are shown in Figure 8.4.3, and the per-unit costs are in Figure 8.4.4.

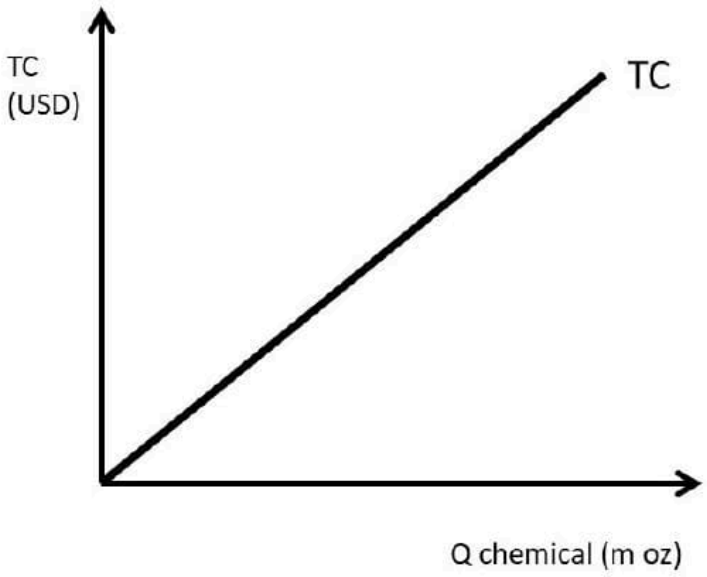


Figure 8.4.3: Total Costs for a Monopolist: Agricultural Chemical

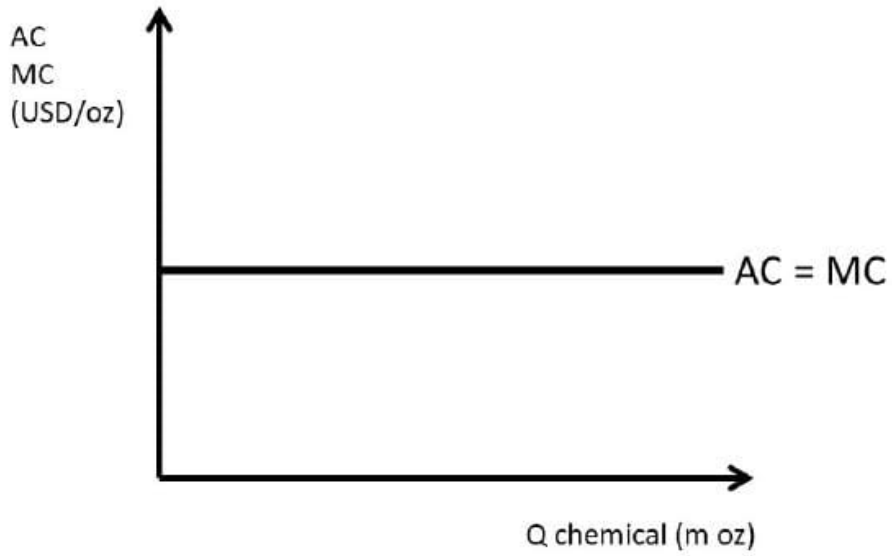


Figure 8.4.4: Per-Unit Costs for a Monopolist: Agricultural Chemical

Monopoly Profit-Maximizing Solution

There are three ways to communicate economics: verbally, graphically, and mathematically. The firm's profit maximizing solution is one of the major features and important conclusions of economics. The verbal explanation is that a firm should continue any activity as long as the additional (marginal) benefits are greater than the additional (marginal) costs. The firm should continue the activity until the marginal benefit is equal to the marginal cost. This is true for any activity, and for profit maximization, the firm will find the optimal, profit maximizing level of output where marginal revenues equal marginal costs $(MR = MC)$.

The graphical solution takes advantage of pictures that tell the same story, as in Figures 8.4.5 and 8.4.6. Figure 8.4.5 shows the profit maximizing solution using total revenues and total costs. The profit-maximizing level of output is found where the distance between TR and TC is largest: $\pi = TR–TC$. The solution is found by setting the slope of TR equal to the slope of TC: this is where the rates of change are equal to each other $(MR = MC)$.

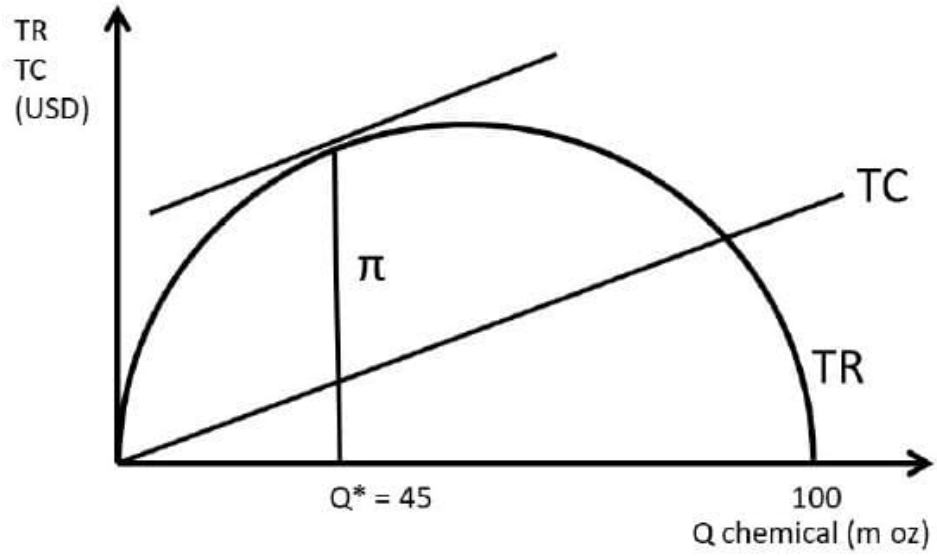


Figure 8.4.5: Total Profit Solution for a Monopolist: Agricultural Chemical

The same solution can be found using the marginal graph (Figure 8.4.6). The firm sets MR equal to MC to find the profit-maximizing level of output (Q^*), then substitutes Q^* into the consumers' willingness to pay (demand curve) to find the optimal price (P^*). The profit level is an area in Figure 8.4.6, defined by TR and TC. Total revenues are equal to price times quantity $(TR$

$= P^*Q$), so TR are equal to the rectangle from the origin to P^* and Q^*. Total costs are equal to the rectangle defined by the per-unit cost of ten dollars per ounce times the quantity produced, Q^*. If the TC rectangle is subtracted from the TR rectangle, the shaded profit rectangle remains: profits are the residual of revenues after all costs have been paid ($\pi = TR–TC$).

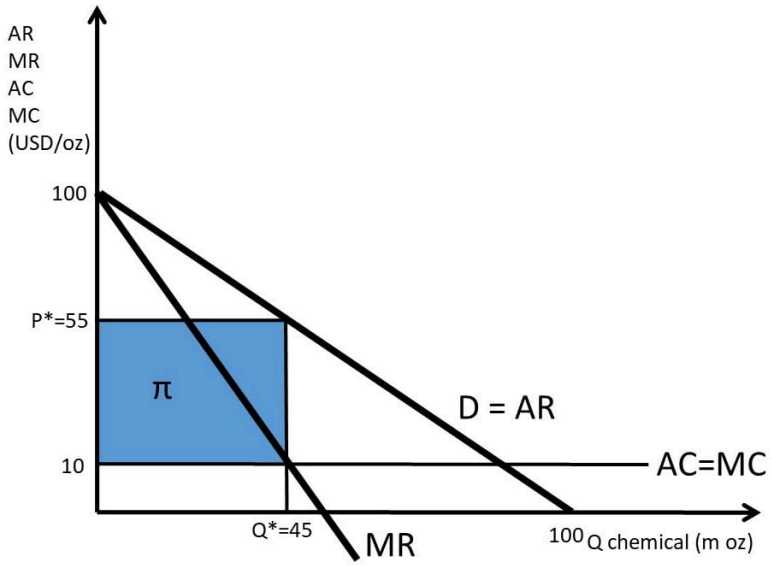


Figure 8.4.6: Marginal Profit Solution for a Monopolist: Agricultural Chemical

The math solution for profit maximization is found by using calculus. The maximum level of a function is found by taking the first derivative and setting it equal to zero. Recall that the inverse demand function facing the monopolist is $P = 100–Q^d$, and the per unit costs are ten dollars per ounce.

$$\begin{aligned}
\max \pi &= TR–TC \\
&= P(Q)Q–C(Q) \\
&= (100–Q)Q–10Q \\
&= 100Q–Q^2–10Q \\
\frac{\partial \pi}{\partial Q} &= 100–2Q–10 = 0 \\
2Q &= 90 \\
Q^* &= 45 \text{ million ounces of agricultural chemical}
\end{aligned}$$

The profit-maximizing price is found by substituting Q^* into the inverse demand equation:

$$P^* = 100–Q^* = 100–45 = 55 \text{ USD/ounce of agricultural chemical.}$$

The maximum profit level can be found by substitution of P^* and Q^* into the profit equation:

$$\pi = TR–TC = P(Q)Q–C(Q) = 55 \cdot 45–10 \cdot 45 = 45 \cdot 45 = 2025 \text{ million USD.}$$

This profit level is equal to the distance between the TR and TC curves at Q^* in Figure 8.4.5, and the profit rectangle identified in Figure 8.4.6. The profit-maximizing level of output and price have been found in three ways: verbally, graphically, and mathematically.

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8.5: Marginal Revenue for Imperfectly Competitive Markets

The basics of profit maximization were described in Chapter 2 for a price-taking firm. A price-taking firm falls under the perfectly competitive market structure. Let us now extend the concept to other market structures, situations where firms are not price takers. Recall that marginal revenue (MR) was defined as the increase in revenue that results from producing an additional unit of output. Recall also that marginal cost (MC) was defined as the increase in total cost that results from producing an additional unit of output. Profit is maximized where MR = MC. One way to prove this is to use the logic of contradiction.

To prove that the only situation where profit could be maximized is if MR = MC, let us suppose otherwise. Suppose MR > MC, could profit be maximized? The answer is no. If the firm produced on more unit, its revenue would increase by MR but its cost would increase by MC. Since MR > MC, its profit would go up as it produced more. Thus, profit could not be at a maximum if MR > MC. Now suppose that MR < MC, could profit be maximized? Again the answer is no. If the firm produced one less unit, its revenue would go down by MR and its cost would go down by MC. Since MR < MC, its profit would go up as it produced less. Thus profits could not be maximized if MR < MC.

In Chapter 2, you learned that MR = P for a firm that is in a perfectly competitive market (a firm that is a price taker). In imperfectly competitive markets like monopoly, oligopoly, or monopolistic competition, this is not the case. In fact, MR < P in imperfectly competitive markets. This is because the price that the firm receives is impacted by quantity that the firm places on the market. A general formula for marginal revenue that applies to all market structures is

$$MR = P + \frac{\Delta P}{\Delta Q}Q. \tag{8.5.1}$$

The law of demand indicates that $\frac{\Delta P}{\Delta Q} < 0$. If more is placed on the market, price will need to fall in order to induce additional consumers into the market and/or convince existing consumers to purchase larger amounts. Thus, marginal revenue depends on the quantity placed on the market so long as $\frac{\Delta P}{\Delta Q}$ does not equal zero.

Marginal Revenue if Inverse Demand is Linear

Look carefully at the MR formula above. The second term, $\frac{\Delta P}{\Delta Q}Q$, is the slope of the inverse demand curve facing the firm multiplied by quantity. The first term, P, is the inverse demand curve itself. Thus if you have a linear inverse demand curve of the form

$P = a + bQ$, you can use the fact that $b = \frac{\Delta P}{\Delta Q}$ and the general formula above to find a simple expression for marginal revenue:

$$MR = P + bQ = a + bQ + bQ \Rightarrow MR = a + 2bQ. \tag{8.5.2}$$

Thus, if the inverse demand curve is linear, then the marginal revenue curve will have the same intercept as the inverse demand curve and twice the slope. In the formula above, it is important to emphasize that the inverse demand curve in question is that which faces the firm. Unless the firm is a monopolist, the inverse demand curve facing the firm will be different than the inverse demand curve facing the market.

Marginal Revenue in Terms of the Elasticity of Demand Facing the Firm

Using the definition of the point elasticity and a little bit of algebra, you can use the general formula for marginal revenue above to show that

$$MR = P(1 + \frac{1}{\varepsilon}), \tag{8.5.3}$$

where ε is the price elasticity of demand facing the firm. It is important to emphasize that in this case, ε is the elasticity facing the firm, which is not the same as the market elasticity. Only if the firm is a monopolist will the elasticity of market demand be

the same as the elasticity of demand facing the firm.

There are two interesting implications of the elasticity version of the MR formula. First, if you know demand elasticity and assume profit maximizing behavior, you can arrive at an estimate of marginal cost because $MR = MC$ when profits are maximized. Second, given a non-negative marginal cost, a firm that faces a downward sloping demand curve will always price in a region where demand is elastic. This argument has been made before in Chapter 3. Here you see it again in terms of the firm's profit maximizing condition.

Elasticity of Demand Facing Firms in Perfect Competition

The difference between the elasticity of demand facing a firm and that facing the market is most pronounced in perfect competition. In perfect competition, there are many firms. Each firm is small relative to the size of the market. As a result, the firm can put more quantity on the market and not have a material effect on the market price. In this case, $\frac{\Delta P}{\Delta Q} = 0$ and the elasticity of demand facing the firm is $-\infty$. The market demand may be elastic or inelastic. However, the elasticity facing the firm is negative infinity (perfectly elastic). In other words, if the competitive firm attempts to raise its price, it loses all of its sales. Thus,

$$MR = P(1 + \frac{1}{-\infty}) = P. \tag{8.5.4}$$

This is the profit maximizing condition for price-taking firm that was presented earlier in Chapter 2.

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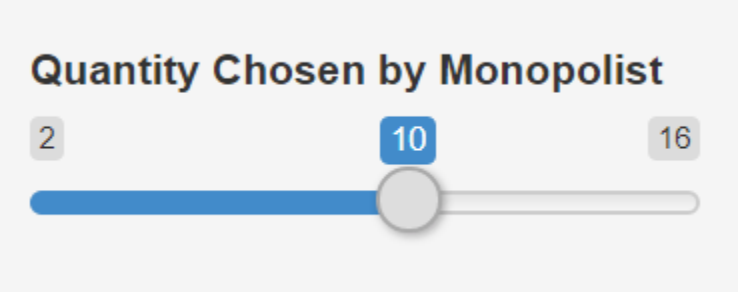
8.6: Profit Maximization for a Monopolist or Monopolistically Competitive Firm

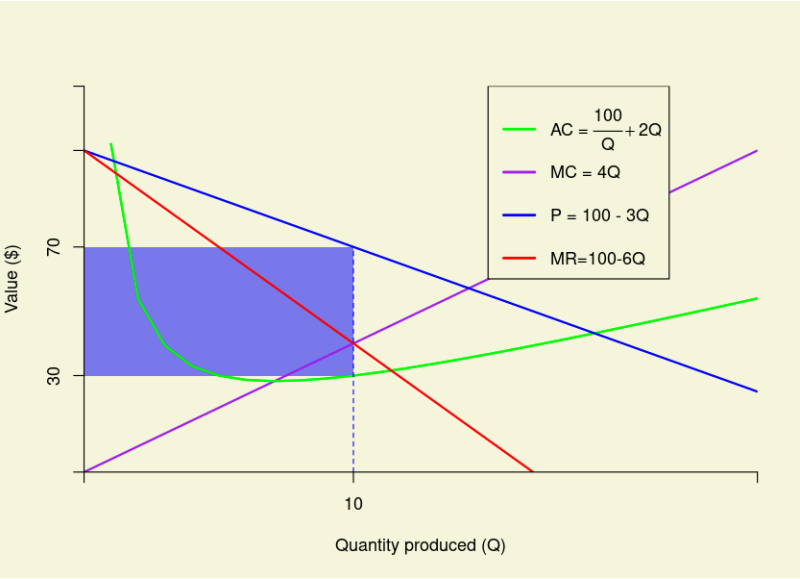
The profit maximizing condition can be used to solve the monopolist's problem. Suppose, as in Demonstration $8.6.1$ below, that the inverse demand curve facing the monopolist is $P = 100 - 3Q$. Since this inverse demand curve is linear, the marginal revenue curve has the same intercept and a slope that is twice as steep. Thus, $MR = 100 - 6Q$. Suppose further that marginal cost is equal to $4Q. Set $MR = MC$ or $100 - 6Q = 4Q$and solve for Q. You get Q = 10 units. This is the profit maximizing quantity.

Next, use the inverse demand curve to find the profit maximizing price. Although the monopolist equates marginal revenue with marginal cost, it uses the inverse demand curve (not the marginal revenue curve) to set the price. Substituting the profit maximizing quantity into the inverse demand curve, you get a price of $100 - 3(10) = \$70$.

Notice in the demonstration that the area of the blue rectangle represents profits. Use Demonstration 1 to verify that profits go down if the monopolist does no set the quantity so that $MR = MC$.

Demonstration $8.6.1$. Profit Maximization Problem for a Monopolist





Marginal Cost (MC) = $40.00

Average Total Cost (AC) = $30.00

Profit = (P - AC)Q =$400.00

The steps involved in finding the solution to the firm's problem under monopolistic competition are exactly the same as the monopolist's problem above. The primary difference between monopoly and monopolistic competition is that entry is possible in

monopolistic competition. If profits are positive, new firms will enter the market and/or existing firms will mimic the successful practices of competitors. When economic profits are zero, there is no additional entry, and the market is at an equilibrium. In a no-entry equilibrium under monopolistic competition, the rectangular area that represents profits will be just equal to the sunk costs that would need to be incurred if the market were to be entered by a new firm. New firms would see entry into the market as unattractive since the profits to be gained would be consumed by the sunk costs of entry.

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8.7: Marginal Revenue and the Elasticity of Demand

We have located the profit-maximizing level of output and price for a monopoly. How does the monopolist know that this is the correct level? How is the profit-maximizing level of output related to the price charged, and the price elasticity of demand? This section will answer these questions. The firm's own price elasticity of demand captures how consumers of a good respond to a change in price. Therefore, the own price elasticity of demand captures the most important thing that a firm can know about its customers: how consumers will react if the good's price is changed.

The Monopolist's Tradeoff between Price and Quantity

What happens to revenues when output is increased by one unit? The answer to this question reveals useful information about the nature of the pricing decision for firms with market power, or a downward sloping demand curve. Consider what happens when output is increased by one unit in Figure 8.7.1.

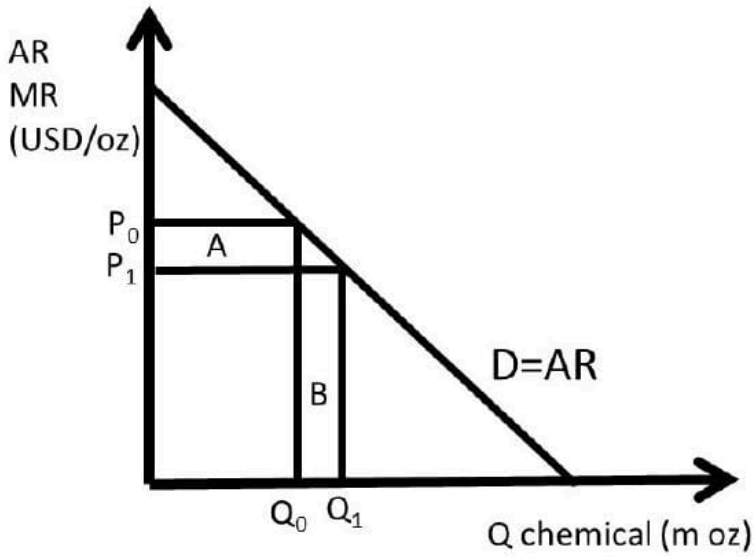


Figure 8.7.1: Per-Unit Revenues for a Monopolist: Agricultural Chemical

Increasing output by one unit from Q_0 to Q_1 has two effects on revenues: the monopolist gains area B, but loses area A. The monopolist can set price or quantity, but not both. If the output level is increased, consumers' willingness to pay decreases, as the good becomes more available (less scarce). If quantity increases, price falls. The benefit of increasing output is equal to $\Delta Q \cdot P_1$, since the firm sells one additional unit (ΔQ) at the price P_1 (area B). The cost associated with increasing output by one unit is equal to $\Delta P \cdot Q_0$, since the price decreases (ΔP) for all units sold (area A). The monopoly cannot increase quantity without causing the price to fall for all units sold. If the benefits outweigh the costs, the monopolist should increase output: if $\Delta Q \cdot P_1 > \Delta P \cdot Q_0$, increase output. Conversely, if increasing output lowers revenues $(\Delta Q \cdot P_1 < \Delta P \cdot Q_0)$, then the firm should reduce output level.

The Relationship between MR and E_d

There is a useful relationship between marginal revenue (MR) and the price elasticity of demand (E^d). It is derived by taking the first derivative of the total revenue (TR) function. The product rule from calculus is used. The product rule states that the derivative of an equation with two functions is equal to the derivative of the first function times the second, plus the derivative of the second function times the first function, as in Equation 8.7.1.

$$\frac{\partial(yz)}{\partial x} = \left(\frac{\partial y}{\partial x}\right) z + \left(\frac{\partial z}{\partial x}\right) y \tag{8.7.1}$$

The product rule is used to find the derivative of the TR function. Price is a function of quantity for a firm with market power. Recall that $MR = \frac{\partial TR}{\partial Q}$, and the equation for the elasticity of demand:

$$E^d = \frac{(\partial Q/\partial P)P}{Q}$$

This will be used in the derivation below.

$$\begin{aligned} TR &= P(Q)Q \\ \frac{\partial TR}{\partial Q} &= \left(\frac{\partial P}{\partial Q}\right)Q + \left(\frac{\partial Q}{\partial Q}\right)P \\ MR &= \left(\frac{\partial P}{\partial Q}\right)Q + P \end{aligned}$$

next, divide and multiply by P:

$$\begin{aligned} MR &= [\frac{(\partial P/\partial Q)Q}{P}]P + P \\ &= [\frac{1}{E_d}]P + P \\ &= P\left(1 + \frac{1}{E_d}\right) \end{aligned}$$

This is a useful equation for a monopoly, as it links the price elasticity of demand with the price that maximizes profits. The relationship can be seen in Figure 8.7.2.

$$MR = P\left(1 + \frac{1}{E_d}\right) \tag{8.7.2}$$

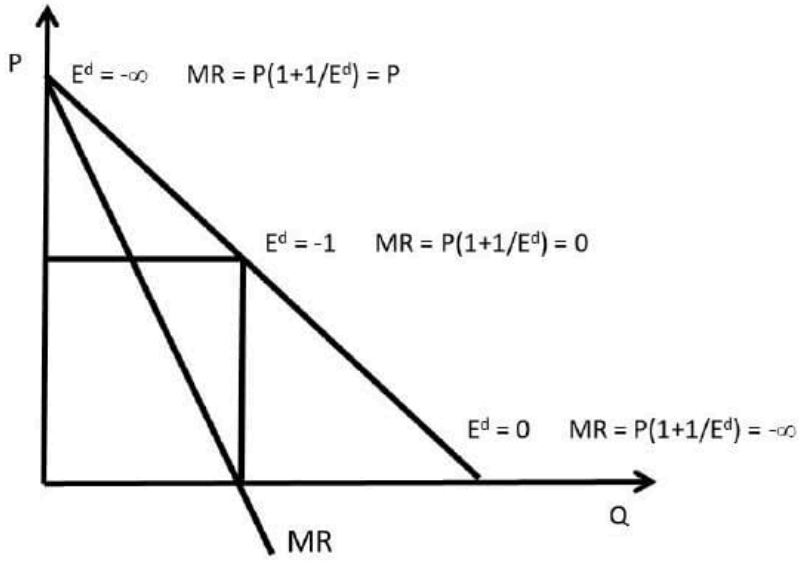


Figure 8.7.2: The Relationship between MR and E^d

At the vertical intercept, the elasticity of demand is equal to negative infinity (section 1.4.8). When this elasticity is substituted into the MR equation, the result is $MR = P$. The MR curve is equal to the demand curve at the vertical intercept. At the horizontal intercept, the price elasticity of demand is equal to zero (Section 1.4.8, resulting in MR equal to negative infinity. If the MR curve were extended to the right, it would approach minus infinity as Q approached the horizontal intercept. At the midpoint of the demand curve, P is equal to Q, the price elasticity of demand is equal to -1, and $MR = 0$. The MR curve intersects the horizontal axis at the midpoint between the origin and the horizontal intercept.

This highlights the usefulness of knowing the elasticity of demand. The monopolist will want to be on the elastic portion of the demand curve, to the left of the midpoint, where marginal revenues are positive. The monopolist will avoid the inelastic portion of

the demand curve by decreasing output until MR is positive. Intuitively, decreasing output makes the good more scarce, thereby increasing consumer willingness to pay for the good.

Pricing Rule I

The useful relationship between MR and E_d in Equation 8.7.2 can be used to derive a pricing rule.

$$MR = P\left(1 + \frac{1}{E_d}\right)$$

$$MR = P + \frac{P}{E_d}$$

Assume profit maximization [$MR = MC$]

$$MC = P + \frac{P}{E_d}$$

$$-\frac{P}{E_d} = P\text{–}MC$$

$$-\frac{1}{E_d} = \frac{P\text{–}MC}{P}$$

$$\frac{P\text{–}MC}{P} = -\frac{1}{E_d}$$

This pricing rule relates the price markup over the cost of production $(P\text{–}MC)$ to the price elasticity of demand.

$$\frac{P\text{–}MC}{P} = -\frac{1}{E_d} \tag{8.7.3}$$

A competitive firm is a price taker, as shown in Figure 8.7.3. The market for a good is depicted on the left hand side of Figure 8.7.3, and the individual competitive firm is found on the right hand side. The market price is found at the market equilibrium (left panel), where market demand equals market supply. For the individual competitive firm, price is fixed and given at the market level (right panel). Therefore, the demand curve facing the competitive firm is perfectly horizontal (elastic), as shown in Figure 8.7.3.

The price is fixed and given, no matter what quantity the firm sells. The price elasticity of demand for a competitive firm is equal to negative infinity: $E_d = -\inf$. When substituted into Equation 8.7.3, this yields $(P\text{–}MC)P = 0$, since dividing by infinity equals zero. This demonstrates that a competitive firm cannot increase price above the cost of production: $P = MC$. If a competitive firm increases price, it loses all customers: they have perfect substitutes available from numerous other firms.

Monopoly power, also called market power, is the ability to set price. Firms with market power face a downward sloping demand curve. Assume that a monopolist has a demand curve with the price elasticity of demand equal to negative two: $E_d = -2$. When this is substituted into Equation 8.7.3, the result is: $\frac{P\text{–}MC}{P} = 0.5$. Multiply both sides of this equation by price (P): $(P\text{–}MC) = 0.5P$, or $0.5P = MC$, which yields: $P = 2MC$. The markup (the level of price above marginal cost) for this firm is two times the cost of production. The size of the optimal, profit-maximizing markup is dictated by the elasticity of demand. Firms with responsive consumers, or elastic demands, will not want to charge a large markup. Firms with inelastic demands are able to charge a higher markup, as their consumers are less responsive to price changes.

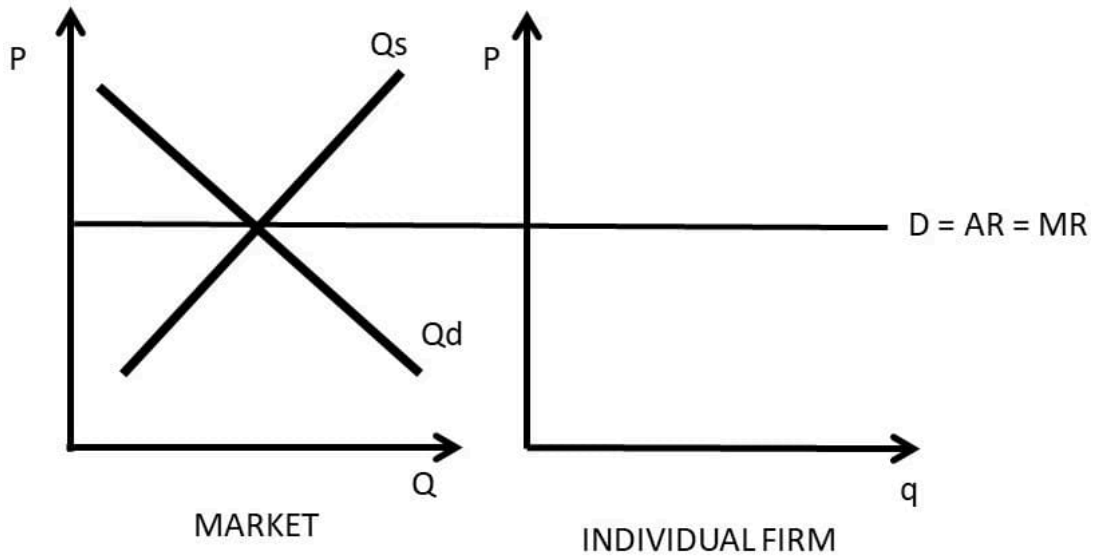


Figure 8.7.3: The Demand Curve of a Competitive Firm

In the next section, we will discuss several important features of a monopolist, including the absence of a supply curve, the effect of a tax on monopoly price, and a multiplant monopolist.

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8.8: Monopoly Characteristics

The Absence of a Supply Curve for a Monopolist

There is no supply curve for a monopolist. This differs from a competitive industry, where there is a one-to-one correspondence between price (P) and quantity supplied (Q^s). For a monopoly, the price depends on the shape of the demand curve, as shown in Figure $8.8.1$. A mathematical "function" is defined as a one-to-one correspondence between each point in the range (x) and the domain (y). A supply curve, then, requires a single price (P) for each quantity (Q). This graph shows that there is more than one price associated with each quantity. At quantity Q_0, for demand curve D_1, the monopolist maximizes profits by setting $MR_1 = MC$, which results in price P_1. However, for demand curve D_2, the monopolist would set $MR_2 = MC$, and charge a lower price, P_2. Since there is more than one price associated with a single quantity (Q_0), there is no one-to-one correspondence between price and quantity supplied, and no supply curve for a monopolist.

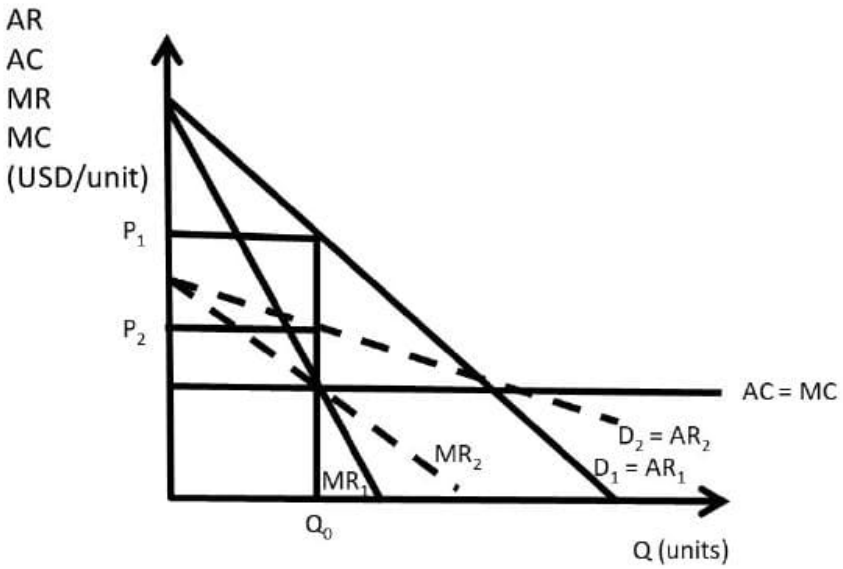


Figure $8.8.1$: Absence of a Supply Curve for a Monopolist

The Effect of a Tax on a Monopolist's Price

In a competitive industry, a tax results in an increase in price that is based on the incidence of the tax. The price increase is a fraction of the tax, less than the tax amount. The tax incidence depends on the magnitude of the elasticities of supply and demand. In a monopoly, it is possible that the price increase from a tax is greater than the tax itself, as shown in Figure $8.8.2$. This is an interesting and nonintuitive result!

Before the tax, the monopolist sets $MR = MC$ at Q_0, and sets price at P_0. After the tax is imposed, the marginal costs increase to $C + t$. The monopolist sets $MR = MC = C + t$, produces quantity Q_1, and charges price P_1. The increase in price $(P_1–P_0)$ is larger than the tax rate (t), the vertical distance between the $C + t$ and MC lines. In this case, consumers of the monopoly good are paying more than 100 percent of the tax rate. This is because of the shape of the demand curve: it is profitable for the monopoly to reduce quantity produced to increase the price.

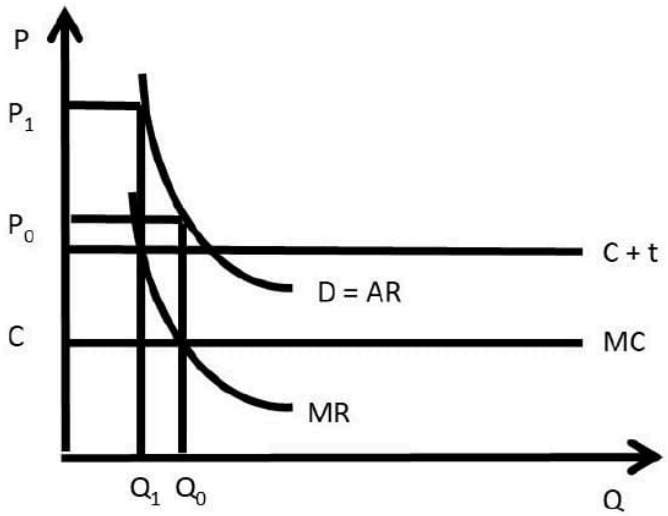


Figure 8.8.2: The Effect of a Tax on a Monopolist's Price

Multiplant Monopolist

Suppose that a monopoly has two or more plants (factories). How does the monopolist determine how much output should be produced at each plant? Profit-maximization suggests two guidelines for the multiplant monopolist. Suppose that the monopolist operates n plants.

1. Set MC equal across all plants: $MC_1 = MC_2 = ... = MC_n$, and
2. Set $MR = MC$ in all plants.

A mathematical model of a multiplant monopolist demonstrates profit-maximization. The result is interesting and important, as it shows that multiplant firms will not always close older, less efficient plants. This is true even if the older plants have higher production costs than newer, more efficient plants.

Suppose that a monopolist has two plants, and total output (Q_T) is the sum of output produced in plant 1 (Q_1) and plant 2 (Q_2).

$$Q_1 + Q_2 = Q_T \tag{8.8.1}$$

The profit-maximizing model for the two-plant monopolist yields the solution. The costs of producing output in each plant differ. Assume that the old plant (plant 1) is less efficient than the new plant (plant 2): $C_1 > C_2$.

$$\begin{aligned} \max \pi &= TR\text{–}TC \\ &= P(Q_T)Q_T\text{–}C_1(Q_1)\text{–}C_2(Q_2) \\ \frac{\partial \pi}{\partial Q_1} &= \frac{\partial TR}{\partial Q_1}\text{–}C_1'(Q_1) = 0 \\ \frac{\partial \pi}{\partial Q_2} &= \frac{\partial TR}{\partial Q_2}\text{–}C_2'(Q_2) = 0 \end{aligned}$$

The profit-maximizing solution is:

$$MR = MC_1 = MC_2 \tag{8.8.2}$$

The multiplant monopolist solution is shown in Figure 8.8.3. The marginal cost curve for plant 1 is higher than the marginal cost curve for plant 2, reflecting the older, less efficient plant. Rather than shutting the less efficient plant down, the monopolist should produce some output in each plant, and set the MC of each plant equal to MR, as shown in the graph. Let MC_T be the total (sum) of the marginal cost curves: $M_T = MC_1 + MC_2$. The profit maximizing quantity (Q_T) is found by setting MR equal to MC_T. At the profit maximizing quantity (Q_T), the monopolist sets price equal to P, found by plugging Q_T into the consumers' willingness to pay, or the demand curve (D).

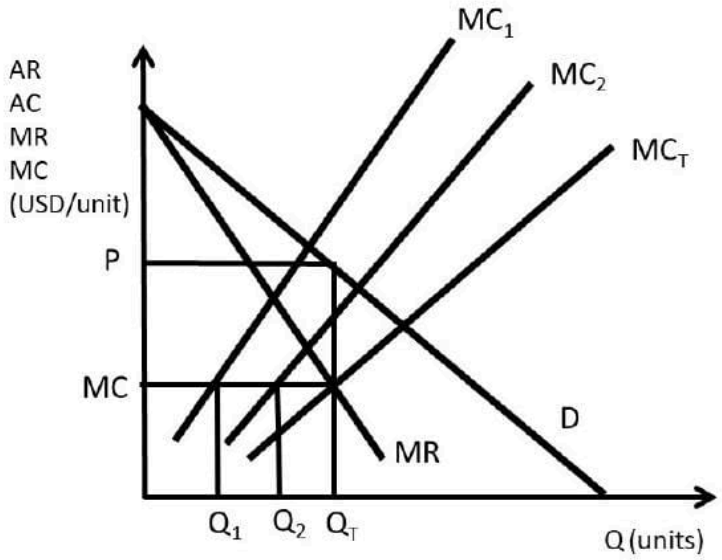


Figure 8.8.3: Multiplant Monopolist

To find the quantity to produce in each plant, the firm sets $MC_1 = MC_2 = MC_T$ to find the profit-maximizing level of output in each plant: Q_1 and Q_2. The outcome of the multiplant monopolist yields useful conclusions for any firm: continue using any input, plant, or resource until marginal costs equal marginal revenues. Less efficient resources can be usefully employed, even if more efficient resources are available. The next section will explore the determinants and measurement of monopoly power, also called market power.

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8.9: Monopoly Power

In this section, the determinants and measurement of monopoly power are examined.

The Lerner Index of Monopoly Power

Economists use the Lerner Index to measure monopoly power, also called market power. The index is the percent markup of price over marginal cost.

$$L = \frac{P–MC}{P} \tag{8.9.1}$$

The Lerner Index is a positive number $(L \geq 0)$, increasing in the amount of market power. A perfectly competitive firm has a Lerner Index equal to zero $(L = 0)$, since price is equal to marginal cost $(P = MC)$. A monopolist will have a Lerner Index greater than zero, and the index will be determined by the amount of market power that the firm has. A larger Lerner Index indicates more market power. In Section 3.3.3, a Pricing Rule was derived: $\frac{P–MC}{P} = -\frac{1}{E^d}$, where E^d is the price elasticity of demand. Substitution of this pricing rule into the definition of the Lerner Index provides the relationship between the percent markup and the price elasticity of demand.

$$L = \frac{P–MC}{P} = -\frac{1}{E^d} \tag{8.9.2}$$

An example of a Lerner Index might be Big Macs. There are substitutes available for Big Macs, so if the price increases, consumers can buy a competing brand such as Whoppers. In the case of a good with close substitutes, the price elasticity of demand is larger (more elastic), causing the percent markup to be smaller: the Lerner Index is relatively small. A monopoly is defined as a single seller in an industry with no close substitutes. Therefore, a monopoly that produces a good with no close substitutes would have a higher Lerner Index.

A second pricing rule can be derived from Equation 8.9.2, if we assume that the firm maximizes profits $(MR = MC)$. In that case, the relationship between price and marginal revenue is equal to: $MR = P(1 + \frac{1}{E^d})$. If profit-maximization $(MR = MC)$ is assumed, then:

$$MC = P\left(1 + \frac{1}{E^d}\right) \tag{8.9.3}$$

Rearranging:

$$P = \frac{MC}{1 + \frac{1}{E^d}} \tag{8.9.4}$$

This is a useful equation, as it relates price to marginal cost. For example, a perfectly competitive firm has a perfectly elastic demand curve ($E^d =$ negative infinity). Substitution of this elasticity into the pricing rule yields $P = MC$. For a monopoly that has a price elasticity equal to –2, $P = 2MC$. The price is two times the production costs in this case. To summarize:

1. if E^d is large, the firm has less market power, and a small markup
2. if E^d is small, the firm has more market power, and a large markup.

A monopoly example is useful to review monopoly and the Lerner Index. Suppose that the inverse demand curve facing a monopoly is given by: $P = 500–10Q$. The monopoly production costs are given by: $C(Q) = 10Q^2 + 100Q$. Profit-maximization yields the optimal monopoly price and quantity.

$$\begin{aligned}
\max \pi &= TR–TC \\
&= P(Q)Q–C(Q) \\
&= (500–10Q)Q–(10Q^2 + 100Q) \\
&= 500Q–10Q^2–10Q^2–100Q \\
\frac{\partial \pi}{\partial Q} &= 500–20Q–20Q–100 = 0 \\
40Q &= 400 \\
Q^* &= 10 \text{ units} \\
P^* &= 500–10Q^* = 500–100 = 400 \text{ USD/unit.}
\end{aligned}$$

To calculate the value of the Lerner Index, price and marginal cost are needed (Equation 8.9.2).

$$\begin{aligned}
MC &= C'(Q) = 20Q + 100. \\
MC^* &= 20(10) + 100 = 300 \text{ units} \\
L &= \frac{P–MC}{P} = \frac{400–300}{400} = \frac{100}{400} = 0.25
\end{aligned}$$

This result can be checked with the pricing rule: $\frac{P–MC}{P} = –\frac{1}{E^d}$.

$$E^d = \left(\frac{\partial Q}{\partial P}\right)\left(\frac{P}{Q}\right)$$

For this monopoly, $\frac{\partial P}{\partial Q} = –10$. This is the first derivative of the inverse demand function. Therefore, $\frac{\partial Q}{\partial P} = –\frac{1}{10}$.

$$\begin{aligned}
E^d &= \left(\frac{\partial Q}{\partial P}\right)\left(\frac{P}{Q}\right) = \left(–\frac{1}{10}\right)\left(\frac{400}{10}\right) = –\frac{400}{100} = –4. \\
L &= \frac{P–MC}{P} = –\frac{1}{E^d} = \frac{–1}{–4} = 0.25.
\end{aligned}$$

The same result was achieved using both methods, so the Lerner Index for this monopoly is equal to 0.25.

Welfare Effects of Monopoly

The welfare effects of a market or policy change are summarized as, “who is helped, who is hurt, and by how much.” To measure the welfare impact of monopoly, the monopoly outcome is compared with perfect competition. In competition, the price is equal to marginal cost $(P = MC)$, as in Figure 8.9.1. The competitive price and quantity are P_c and Q_c. The monopoly price and quantity are found where marginal revenue equals marginal cost $(MR = MC)$: P_M and Q_M. The graph indicates that the monopoly reduces output from the competitive level in order to increase the price $(P_M > P_c$ and $Q_M < Q_c)$. The welfare analysis of a monopoly relative to competition is straightforward.

$$\begin{aligned}
\Delta CS &= –AB \\
\Delta PS &= +A–C \\
\Delta SW &= –BC \\
DWL &= BC
\end{aligned}$$

Consumers are losers, and the benefits of monopoly depend on the magnitudes of areas A and C. Since a monopolist faces an inelastic supply curve (no close substitutes), area A is likely to be larger than area C, making the net benefits of monopoly positive.

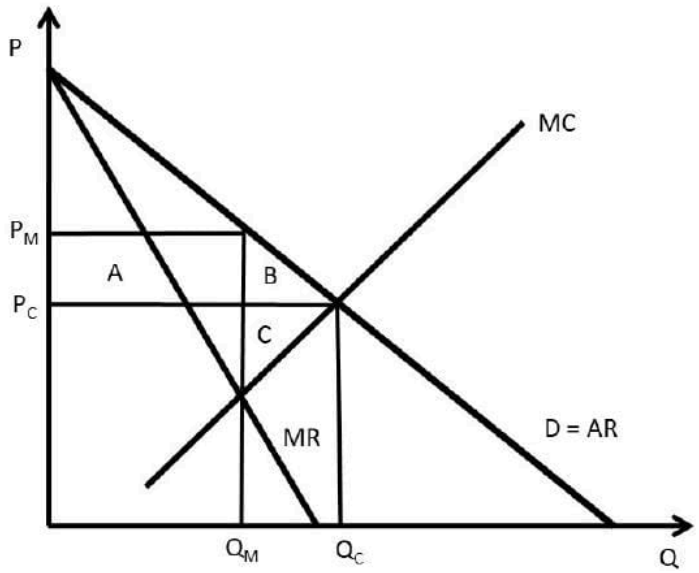


Figure 8.9.1: Welfare Effects of Monopoly

The monopoly example from the previous section 3.5.1 shows the magnitude of the welfare changes. From above, the inverse demand curve is given by $P = 500–10Q$, and the costs are given by $C(Q) = 10Q^2 + 100Q$. In this case, $P_M = 400$ USD/unit and $Q_M = 10$ units (see section 3.5.1 above). The competitive solution is found where the demand curve intersects the marginal cost curve.

$$\begin{aligned}
500–10Q &= 20Q + 100 \\
30Q &= 400 \\
Q_c &= 13.3 \text{ units} \\
P_c &= 500–10(13.3) = 500–133 = 367 \text{ USD/unit} \\
\Delta CS &= –AB = –(400–367)10–(0.5)(400–367)(13.3–10) = –330–54.5 = –384.5 \text{ USD} \\
\Delta PS &= +A–C = +330–(0.5)(367–300)(13.3–10) = +330–110.5 = +219.5 \text{ USD} \\
\Delta SW &= –BC = (0.5)(100)(3.3) = –165 \text{ USD} \\
DWL &= BC = 165 \text{ USD}
\end{aligned}$$

The welfare analysis of monopoly has been used by the government to justify breaking up monopolies into smaller, competing firms. In food and agriculture, many individuals and groups are opposed to large agribusiness firms. One concern is that these large firms have monopoly power, which results in a transfer of welfare from consumers to producers, and deadweight loss to society. It will be shown below that outlawing or banning monopolies would have both benefits and costs. There is some economic justification for the existence of large firms due to economies of scale and natural monopoly, as will be explored below. Next, the sources of monopoly power will be listed and explained.

Sources of Monopoly Power

There are three major sources of monopoly power:

1. the price elasticity of demand (E^d),
2. the number of firms in a market, and
3. interaction among firms.

The price elasticity of demand is the most important determinant of market power, due to the pricing rule: $L = \frac{P–MC}{P} = –\frac{1}{E^d}$. When the price elasticity is large $(\mid E^d \mid > 1)$, demand is relatively elastic, and the firm has less market power. When the price elasticity is small $(\mid E^d \mid < 1)$, demand is relatively inelastic, and the firm has more market power.

The price elasticity of demand depends on how large the firm is relative to the market. The firm's price elasticity of demand is always more elastic than the market demand:

$$| E^d_{firm} | > | E^d_{market} | . \tag{8.9.5}$$

If the price of the firm's output is increased, consumers can substitute into outputs produced by other firms. However, if all firms in the market increase the price of the good, consumers have no close substitutes, so must pay the higher price (Figure $8.9.2$). Therefore, the firm's price elasticity of demand is more elastic than the market demand. The firm's price elasticity of demand depends on how large the firm is relative to the other firms in the market.

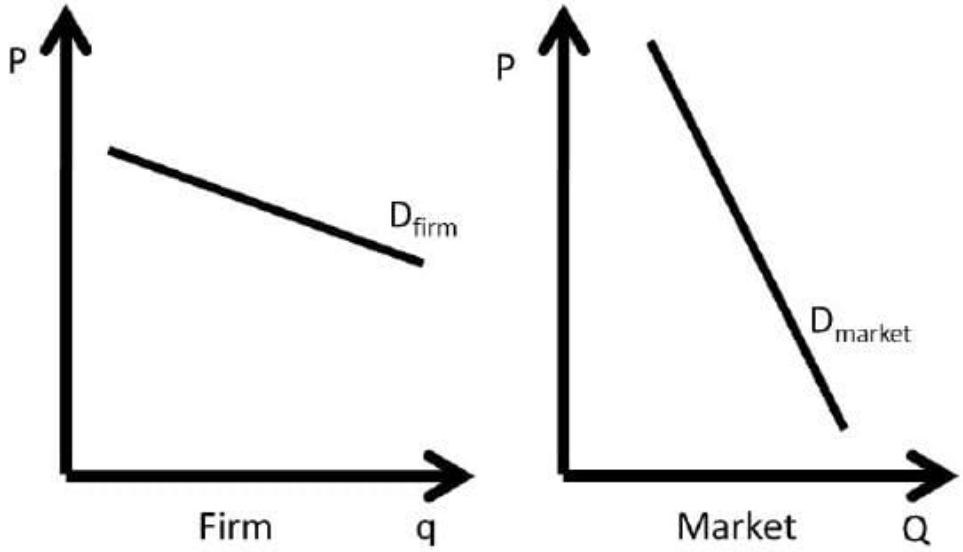


Figure $8.9.2$: Price Elasticity of Demand for Firm and Industry

The second determinant of market power is the number of firms in an industry. This is related to Figure $8.9.2$. If a firm is the only seller in an industry, then the firm is the same as the market, and the price elasticity of demand is the same for both the firm and the market. The more firms there are in a market, the more substitutes a consumer has available, making the price elasticity of demand more elastic as the number of firms increases. In the extreme case, a perfectly competitive firm has numerous other firms in the industry, causing the demand curve to be perfectly elastic, $P = MC$, and $L = 0$. To summarize, the more firms there are in an industry, the less market power the firm has.

The number of firms in an industry is determined by the ease or difficulty of entry. This market feature is captured by the concept of, "Barriers to Entry." Barriers to entry include:

1. patents,
2. copyrights,
3. contracts,
4. economies to scale (natural monopoly),
5. excess capacity, and
6. licenses.

Each of these barriers to entry increases the difficulty of entering a market when positive economic profits exist. Economies to scale and natural monopoly are defined and described in the next section. The number of firms is important, but the number of "major firms" is also important. Some industries are characterized by one or two dominant firms. These large firms often exert market power.

The third source of market power is interaction among firms. This will be extensively discussed in Chapter 5, "Oligopoly." If firms compete aggressively with each other, less market power results. On the other hand, if firms cooperate and act together, the firms can have more market power. When firms join together, they are said to "collude," or act as if they were a single firm. These strategic interactions between firms form the heart of the discussion in Chapter 5, and the foundation for game theory, explored in Chapters 6 and 7.

Natural Monopoly

A **natural monopoly** is a firm that has a high level of costs that do not vary with output.

Natural Monopoly = A firm characterized by large fixed costs.

Recall that total costs are the sum of total variable costs and total fixed costs $(TC = TVC + TFC)$. The fixed costs are those costs that do not vary with the level of output. When fixed costs are high, then average total costs are declining, as seen in Figure $8.9.3$.

Another way of describing high fixed costs is the term, "economies of scale."

Economies of Scale = Per-unit costs of production decrease when output is increased.

Figure $8.9.3$ shows the defining characteristic of a natural monopoly: declining average costs (AC). This means that the demand curve intersects the AC curve while it is declining. At some point, the average costs will increase, but for firms characterized by economies of scale, the relevant range of the AC curve is the declining portion, of the left side of a typical "U-shaped" cost function.

The reason for the name, "natural monopoly" can also be found in Figure $8.9.3$. The demand curve has a portion above the AC curve, so positive profits are possible. Suppose that the monopoly was making positive economic profits, and attracted a competitor into the industry. The second firm would cause the demand facing each of the two firms to be cut in half. This possibility can be seen in Figure $8.9.3$: if two firms served the customers, each firm would have a demand curve equal to the MR curve. This is because for a linear demand curve, the MR curve has the same y-intercept and twice the slope. Notice the position of the MR curve for a natural monopoly: it lies everywhere below the AC curve. Therefore, positive profits are not possible for two firms serving this market. The demand is not large enough to cover the fixed costs.

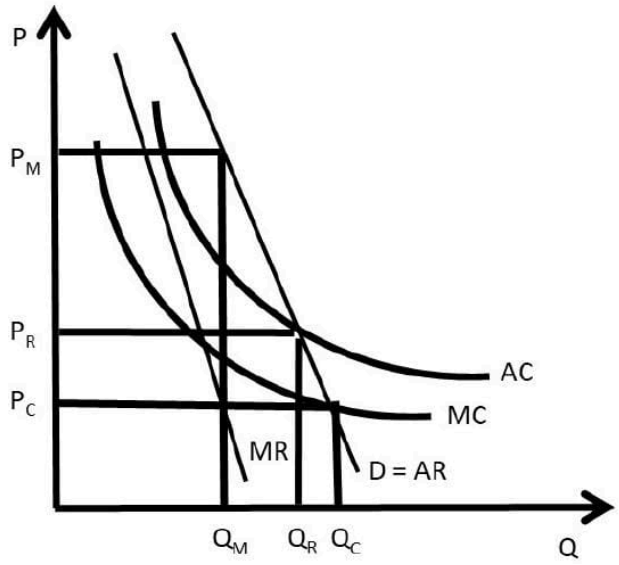


Figure $8.9.3$: Natural Monopoly

The fixed costs are typically large investments that must be made before the good can be sold. For example, an electricity company must build both a huge generating plant and a distribution network that connects all residences and businesses to the power grid. These enormous costs do not vary with the level of output: they must be paid whether the firm sells zero kilowatt hours or one million kilowatt hours. The average fixed costs decline as they are spread out over larger quantities $(AFC = \frac{TFC}{Q})$. As the output (Q) increases, average costs $(AC = \frac{TC}{Q})$ decline.

This feature is true for many large businesses, and provides economic justification for large firms: the per-unit costs of production are smaller, providing lower costs to consumers. There is a tradeoff for consumers who purchase goods from large firms: the cost is lower due to economies of scale, but the firm may have market power, which can result in higher prices. This tradeoff makes

the economic analysis of large firms both fascinating and important to society. Current examples include the giant technology companies Microsoft, Apple, Google, and Amazon.

Natural monopolies have important implications for how large businesses provide goods to consumers, as is explicitly shown in Figure $8.9.3$. The industry in Figure $8.9.3$ is a natural monopoly, since demand intersects average costs while they are declining. If a single firm was in the depicted industry, it would set marginal costs equal to marginal revenues $(MR = MC)$, and produce and sell Q_M units of output at a price equal to P_M. The price is high: consumers lose welfare and society is faced with deadweight losses.

If competition were possible, price would be set at marginal cost $(P = MC)$. The resulting price and quantity under competition would be P_C and Q_C (Figure $8.9.3$. This is a desirable outcome for the consumers. However, there is a major problem with this outcome: price is below average costs, and any business firm that charged the competitive price P_C would be forced out of business. In this case, the firm does not have enough revenue to cover the fixed costs. The natural monopoly is considered a "market failure" since there is no good market-based solution. A single monopoly firm could earn enough revenue to stay in business, but consumers would pay a high monopoly price P_M. If competition occurred, the consumers would pay the cost of production (PC), but the firms would not cover their costs.

One solution to a natural monopoly is government regulation. If the government intervened, it could set the regulated price equal to average costs $(P_R = AC)$, and the regulated quantity equal to Q_R. This solves the problem of natural monopoly with a compromise: consumers pay a price just high enough to cover the firm's average costs. This analysis explains why the government regulates many public utilities for electricity, natural gas, water, sewer, and garbage collection.

The next section will investigate monopsony, or a single buyer with market power.

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8.10: Monopsony

A monopsony is defined as a market characterized by a single buyer.

Monopsony = single buyer of a good.

Monopsony power is market power of buyers. A firm with monopsony power is a buyer that is large enough relative to the market to influence the price of a good. Competitive firms are price takers: prices are fixed and given, no matter how little or how much they buy. In food and agriculture, beef packers are often accused of having market power, and pay lower prices for cattle than the competitive price. This section will explore the causes and consequences of monopsony power.

Terminology of Monopsony

Consider any decision from an economic point of view. Thinking like an economist results in comparing the benefits and costs of any decision. This section will apply economic thinking to the quantity and price of a purchase. It will follow the same economic approach that has been emphasized, but will define new terminology to distinguish the buyer's decision (monopsony) from the seller's decision (monopoly). It is useful to recall the meaning of supply and demand curves. The demand curve represents the consumers' willingness and ability to pay for a good. The demand curve is downward sloping, reflecting scarcity: larger quantities are less scarce, and thus less valuable. The supply curve represents the producers' cost of production, and is upward sloping. As more of a good is produced, the marginal costs of production increase, since it requires more resources to produce larger quantities. These economic principles will be useful in what follows, an analysis of a buyer's decision to purchase a good.

The economic approach to the purchase of a good is to employ marginal decision making by continuing to purchase a good as long as the marginal benefits outweigh the marginal costs. The following terms are defined to aid in our analysis of buyer's market power.

Marginal Value (MV) = The additional benefits of buying one more unit of a good.

Marginal Expenditure (ME) = The additional costs of buying one more unit of a good.

Average Expenditure (AE) = The price paid per unit of a good.

A review of competitive buyers and sellers is a good starting point for our analysis.

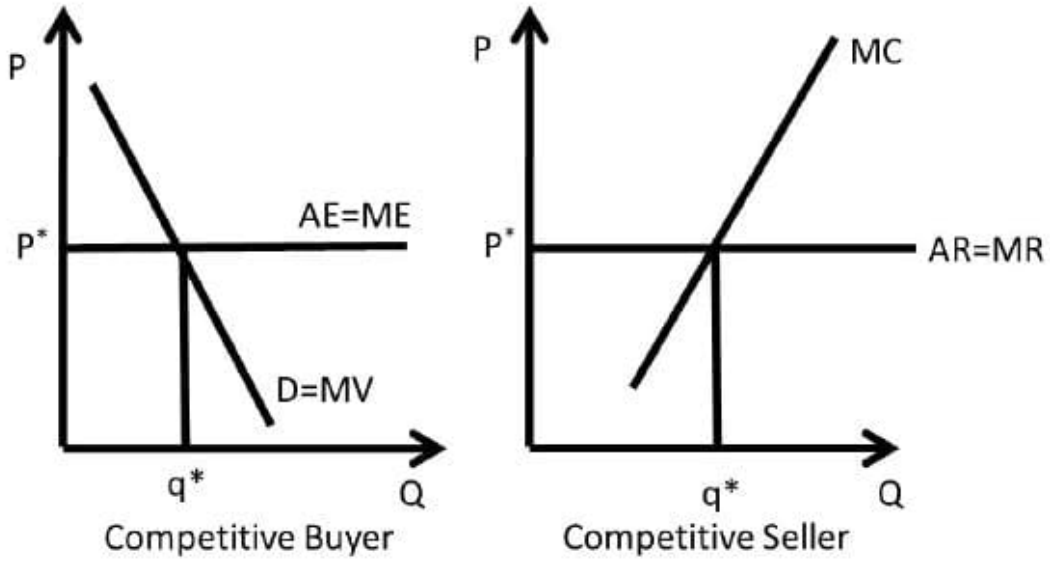


Figure 8.10.1: Competitive Buyer and Seller

Figure 8.10.1 demonstrates the competitive solution for a competitive buyer and a competitive seller. The competitive buyer faces

a price that is fixed and given (P^*). The price is constant because the buyer is so small relative to the market that her purchases do not affect the price. Average expenditures (AE) and marginal expenditures (ME) for this buyer are constant and equal $(AE = ME)$. The buyer will continue purchasing the good until the marginal benefits, defined to be the marginal value (MV) are equal to marginal expenditures (ME) at q^*, the optimal, profit-maximizing level of good to purchase.

A competitive seller takes the price as fixed and given (P^*). The price is constant because the seller is so small relative to the market that his sales do not affect the price. Average revenues (AR) and marginal revenues (MR) for this seller are constant and equal $(AR = MR)$. The seller will continue producing and selling the good until the marginal benefits, defined to be the marginal revenues (MR) are equal to marginal costs (MC) at q^*, the optimal, profit-maximizing level of good to produce.

A monopsony uses the same decision making framework, comparing marginal benefits and marginal costs. The distinction is that a monopsony is large enough relative to the market to influence the price. Thus, the monopsony faces an upward-sloping supply curve: as the monopsony purchases more of the good, it drives the price up (Figure $8.10.2$).

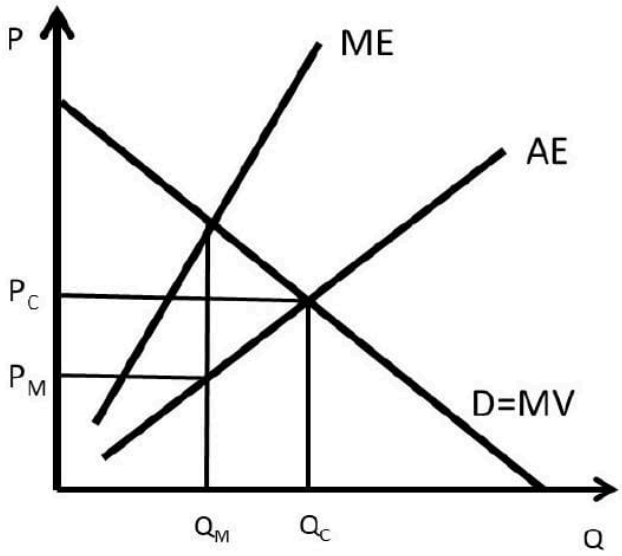


Figure $8.10.2$: Monopsony

Since the firm is large, when it purchases more of a good, it drives the price higher. The average expenditure (AE) curve is the supply curve of the good faced by a monopsony. An example might be Ford Motor Company. When Ford purchases more steel (or glass or tires), the firm is so large relative to the market for steel that it drives the price up. Steel companies will need to buy more resources to produce more steel, and it will cost them more, since Ford is so large a buyer in the steel market.

The profit-maximizing solution is found by setting $MV = ME$, and purchasing the corresponding quantity Q_M. Note that the monopsony is restricting quantity, as a monopoly restricts output to drive the price up. However, a monopsony restricts quantity in order to drive the price down to P_M. The monopsony is buying less than the competitive output (Q_C) and paying a price $P_M)$ lower than the competitive price $(P_M < P_C)$.

It is worth answering the question, "why is $ME > AE$?" The monopsony faces an upward-sloping supply curve (AE). This reflects the higher cost of bringing more resources into the production of the good purchased by the monopsony. This can be seen in Figure $8.10.3$. Next, the relationship between AE and ME is derived. This derivation will be familiar, as it is the same as the relationship between AR and MR from section 3.3.2 above. The derivation of ME uses the product rule.

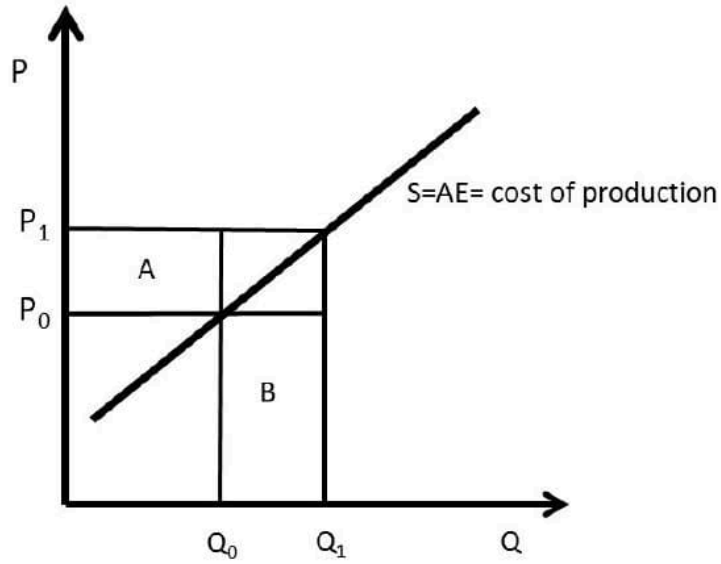


Figure 8.10.3: Monopsony Supply Curve

$$AE = P(Q)$$
$$TE = P(Q)Q$$
$$ME = \frac{\partial TE}{\partial Q} = \left(\frac{\partial P}{\partial Q}\right) Q + P$$
$$ME = AE + (\partial P / \partial Q)Q$$

The first term in the expression for ME is AE, which corresponds to area B in Figure 8.10.3 $(P_0 \Delta Q)$. Average expenditure is equal to P_0 at quantity Q_0. The second term, $\left(\frac{\partial P}{\partial Q}\right) Q$, is equal to area A in the diagram. This area represents the change in price given a small change in quantity $\left(\frac{\partial P}{\partial Q}\right)$, multiplied by the quantity (Q). For a competitive firm, $\left(\frac{\partial P}{\partial Q}\right) = 0$, since the competitive firm is a price taker. For a competitive firm, $AE = ME$, as shown in the left of Figure 8.10.1. For a monopsony, the firm pays the initial price plus the increase in price caused by an increase in output. The monopsony must pay this new price (P_1 in Figure 8.10.3) for all units purchased (Q). This causes ME to be above AE.

It is instructive to view the monopoly graph next to the monopsony graph (Figure 8.10.4).

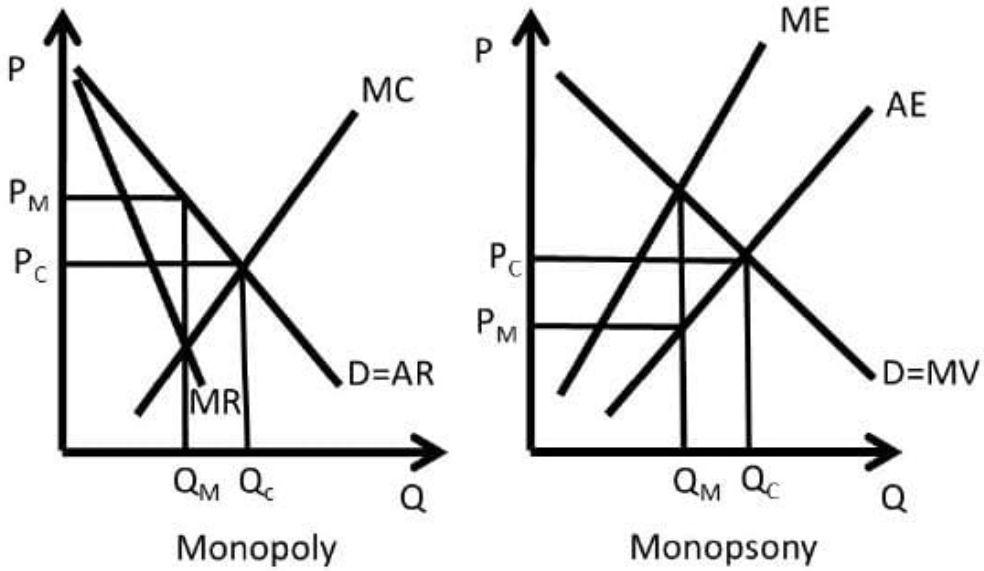


Figure 8.10.4: Monopoly and Monopsony

The monopoly in the left panel of Figure $8.10.4$ restricts output to drive up the price. The monopoly output is less than the competitive output $(Q_M < Q_C)$, and the monopoly price is higher than the competitive price $(P_M > P_C)$. The monopsony in the right panel of Figure $8.10.4$ restricts output to drive down the price $(P_M < P_C)$. Both firms are maximizing profit by using the market characteristics that they face.

Welfare Effects of Monopsony

To measure the welfare impact of monopsony, the monopsony outcome is compared with perfect competition. In competition, the price is equal to marginal cost $(P_C = MC)$, as in Figure $8.10.5$. The competitive price and quantity are P_c and Q_c. The monopsony price and quantity are found where marginal value (MV) equals marginal expenditure $(MV = ME)$: P_M and Q_M. The graph indicates that the monopsony reduces output from the competitive level in order to decrease the price $(P_M < P_c$ and $Q_M < Q_c)$. The welfare analysis of a monopsony relative to competition is straightforward.

$$\Delta CS = +A–B$$
$$\Delta PS = –AC$$
$$\Delta SW = –BC$$
$$DWL = BC$$

Consumers are winners, and the benefits of monopsony depend on the magnitudes of areas A and B.

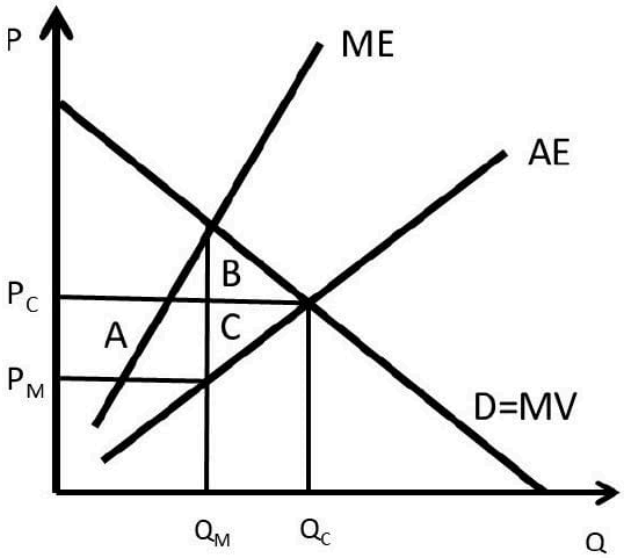


Figure $8.10.5$: Welfare Effects of Monopsony

Sources of Monopsony Power

There are three major sources of monopsony power, analogous to the three determinants of monopoly power:

1. the price elasticity of market supply (E^s),
2. the number of buyers in a market, and
3. interaction among buyers.

The price elasticity of supply is the most important determinant of monopsony power, and the monopsony benefits from an inelastic supply curve. When the price elasticity is large $(E^s > 1)$, the supply is relatively elastic, and the firm has less market power. When the price elasticity is small $(E^s < 1)$, the demand is relatively inelastic, and the firm has more market power. This is shown in Figure $8.10.6$.

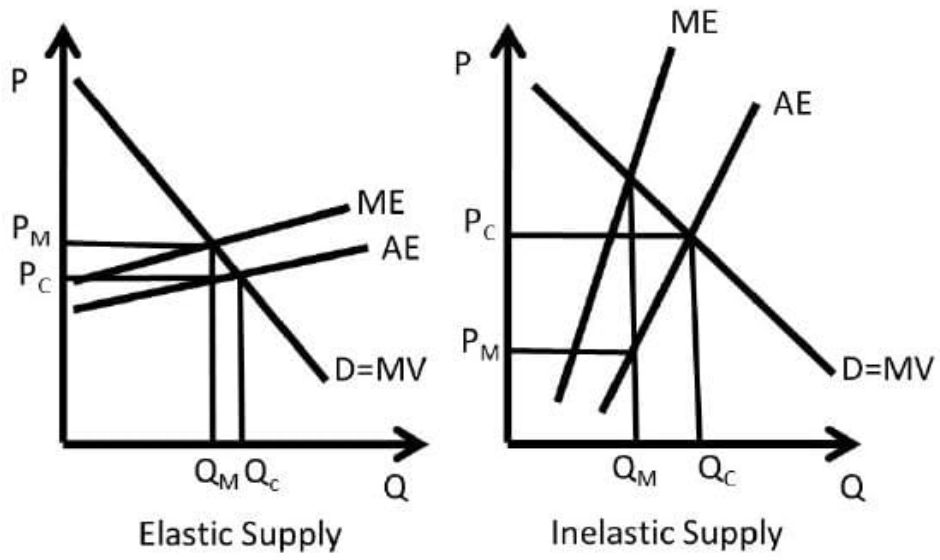


Figure 8.10.6: Price Elasticity of Supply Impact on Monopsony

The second determinant of monopsony power is the number of firms in an industry. If a firm is the only buyer in an industry, the firm is a monopsony, and has market power. The more firms there are in a market, the more competition the firm faces, and the less market power.

The third source of monopsony power is interaction among firms. If firms compete aggressively with each other, less monopsony power results. On the other hand, if firms cooperate and act together, the firms can have more monopsony power. The next Chapter will explore how firms with market power determine optimal prices.

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8.11: Concluding Comments- Effects of Imperfect Competition on Economic Welfare

In imperfectly competitive markets like monopoly, oligopoly, and monopolistic competition, it is often the case that sellers can increase profits at the expense of consumers through their ability to control quantity or price. This is good for the seller but is bad for society as a whole. To conclude this chapter, it is worthwhile to spend some time on the welfare implications of imperfect competition. When markets are imperfectly competitive, the results are that (1) too little is produced; (2) too high of a price is charged for what is produced; and (3) there is a resulting dead-weight loss to the economy. In short, imperfect competition costs the economy in terms of a misallocation of resources. The combined value of economic activity measured as the sum of producers' and consumers' surplus would be higher if imperfectly competitive markets behaved competitively. Table 8.11.1 illustrates this point using the Cournot Nash equilibrium example above. Notice that total surplus in the market increases as the market becomes more competitive. Producers' surplus declines but the gains in consumers' surplus more than offset the decline in producers' surplus.

*Table 8.11.1. Economic Welfare at Cournot Nash Equilibrium for Different Numbers of Firms**

Number of Firms	Producers' Surplus (Profits)	Consumers' Surplus	Total Surplus
1 (monopoly)	$4,050	$2,025	$6,075
2 (oligopoly)	$3,600	$3,600	$7,200
5 (oligopoly)	$2,250	$5,625	$7,875
10 (oligopoly)	$1,339	$6,694	$8,033
Many (approaching perfect competition)	$32	$8,068	$8,100

*In Table 8.11.3, the market inverse demand curve is $P = 200 - \Sigma Q_i$ and $MC = 20$ for all firms.

For the simple reason that total surplus increases with stronger competition, most governments have laws in place to encourage competition in markets. These are referred to as antitrust laws. Regulatory agencies evaluate mergers and acquisitions to determine whether they will adversely impact competition. A good example is provided by Hayenga and Wisner (2000). These authors describe antitrust issues that were evaluated in approving a merger between Cargill and Continental Grain, two entities with large grain merchandising businesses. Moreover, antitrust laws make it illegal to fix prices or form a cartel to limit quantity. A famous case of price fixing in agriculture involved lysine, an amino acid used in livestock and poultry feeds. ADM, a US company, conspired with Japanese and South Korean lysine manufacturers to keep the price of lysine above competitive levels. The conspirators faced criminal and civil penalties as a result of the price-fixing conspiracy. A very good overview of this case is presented by Connor (1997). In fact, there was even a movie made about this incident starring Matt Damon. See the trailer on youtube.com. The movie is titled *The Informant* and is based on a book by the same name. I am unable to recommend the movie one way or the other as I have not seen it, but it may be something you want to check out some weekend. If you do watch it, I will be interested to hear what you think. Both the Hayenga and Wisner (1997) and Connor (1997) articles are available through the University of Arkansas Libraries.

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8.12: References

Baumol, W. J., J. C. Panzar, and R. D. Willig. 1982. *Contestable Markets and the Theory of Industry Structure*. New York: Harcourt Brace Jovanovich.

Hayenga, M. and R. Wisner. 2000. Cargill's Acquisition of Continental Grain's Grain Merchandising Business. *Review of Agricultural Economics* 22:252-266

Connor, J. M. 1997. The Global Lysine Price-Fixing Conspiracy of 1992-1995. *Review of Agricultural Economics* 19:412-427

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8.13: Problem Sets

Problem Set 1. Profit Maximization for the Monopolist of Monopolistically Competitive Firm

Exercise 8.13.1

Given the following:

The inverse demand is P = 100-2Q.

Marginal cost is 20.

Average variable cost is 20.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.2

Given the following:

The inverse demand is P = 200-2.5Q.

Marginal cost is 20.

Average variable cost is 20.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.3

Given the following:

The inverse demand is P = 300-3Q.

Marginal cost is 30.

Average variable cost is 30.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.4

Given the following:

The inverse demand is P = 400-4Q.

Marginal cost is 40.

Average variable cost is 40.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.5

Given the following:

The inverse demand is P = 460-5Q.

Marginal cost is 50.

Average variable cost is 50.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.6

Given the following:

The inverse demand is P = 200-3Q.

Marginal cost is 20.

Average variable cost is 20.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.7

Given the following:

The inverse demand is P = 288-3Q.

Marginal cost is 30.

Average variable cost is 30.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.8

Given the following:

The inverse demand is P = 300-2.5Q.

Marginal cost is 30.

Average variable cost is 30.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.9

Given the following:

The inverse demand is P = 400-4Q.

Marginal cost is 80.

Average variable cost is 80.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Exercise 8.13.10

Given the following:

The inverse demand is P = 456-4.5Q.

Marginal cost is 42.

Average variable cost is 42.

Assume a profit maximizing monopolist or monopolistically competitive firm.

Find the quantity, price and profits above fixed costs (FC).

Answer available at the end of this section.

Problem Set 2. Two-Firm Cournot Duopoly

Exercise 8.13.1

Given the following:

The inverse demand is P = 200-2Qa-2Qb.

Marginal cost for each firm is 20.

Average variable cost for each firm is 20.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.2

Given the following:

The inverse demand is P = 200-2.5Qa-2.5Qb.

Marginal cost for each firm is 20.

Average variable cost for each firm is 20.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.3

Given the following:

The inverse demand is P = 250-5Qa-5Qb.

Marginal cost for each firm is 25.

Average variable cost for each firm is 25.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.4

Given the following:

The inverse demand is P = 300-4Qa-4Qb.

Marginal cost for each firm is 36.

Average variable cost for each firm is 36.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.5

Given the following:

The inverse demand is P = 400-5Qa-5Qb.

Marginal cost for each firm is 40.

Average variable cost for each firm is 40.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.6

Given the following:

The inverse demand is P = 500-4Qa-4Qb.

Marginal cost for each firm is 80.

Average variable cost for each firm is 80.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.7

Given the following:

The inverse demand is P = 300-3Qa-3Qb.

Marginal cost for each firm is 30.

Average variable cost for each firm is 30.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.8

Given the following:

The inverse demand is P = 300-2.5Qa-2.5Qb.

Marginal cost for each firm is 30.

Average variable cost for each firm is 30.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.9

Given the following:

The inverse demand is P = 500-4Qa-4Qb.

Marginal cost for each firm is 80.

Average variable cost for each firm is 80.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Exercise 8.13.10

Given the following:

The inverse demand is P = 420-4.5Qa-4.5Qb.

Marginal cost for each firm is 42.

Average variable cost for each firm is 42.

Qa and Qb are quantities Firms A and B place on the market, respectively.

Find the Cournot Nash equilibrium quantity for each firm.

Calculate the market price at this equilibrium.

Calculate the resulting profits above fixed costs (FC) for each firm.

Answer available at the end of this section.

Problem Set 3. Find the Monopolist's or Monopolistically Competitive Firm's Price

Exercise 8.13.1

Given the following:

The elasticity of demand facing the firm is -1.5.

The firm's marginal cost is 8.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.2

Given the following:

The elasticity of demand facing the firm is -2.5.

The firm's marginal cost is 30.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.3

Given the following:

The elasticity of demand facing the firm is -2.

The firm's marginal cost is 30.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.4

Given the following:

The elasticity of demand facing the firm is -3.

The firm's marginal cost is 20.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.5

Given the following:

The elasticity of demand facing the firm is -2.

The firm's marginal cost is 20.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.6

Given the following:

The elasticity of demand facing the firm is -1.5.

The firm's marginal cost is 20.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.7

Given the following:

The elasticity of demand facing the firm is -2.5.

The firm's marginal cost is 12.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.8

Given the following:

The elasticity of demand facing the firm is -2.

The firm's marginal cost is 20.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.9

Given the following:

The elasticity of demand facing the firm is -3.

The firm's marginal cost is 40.

What price maximizes this firm's profits?

Answer available at the end of this section.

Exercise 8.13.10

Given the following:

The elasticity of demand facing the firm is -2.

The firm's marginal cost is 40.

What price maximizes this firm's profits?

Answer available at the end of this section.

Problem Set 4. Multiple Choice

Exercise 8.13.1

1. **An industry with many sellers with differentiated products is classified as**

a) A monopoly

b) An oligopoly

c) Monopolistically competitive

d) Perfectly competitive

Answer available at the end of this section.

Exercise 8.13.2

2. **The folk theorem is of primary interest in understanding competition in an industry that is**

a) A monopoly

b) An oligopoly

c) Monopolistically competitive

d) Perfectly competitive

Answer available at the end of this section.

Exercise 8.13.3

3. **An industry where firms are price takers is**

a) A monopoly

b) A monopsony

c) Monopolistically competitive

d) Perfectly competitive

Answer available at the end of this section.

Exercise 8.13.4

4. **An industry where firms face an infinitely negative own-price elasticity is**

a) A monopoly

b) A monopsony

c) Monopolistically competitive

d) Perfectly competitive

Answer available at the end of this section.

Exercise 8.13.5

5. **In the Cournot model, competitors compete by choosing**

a) Prices

b) Quantities

c) Contracting methods

d) Management styles

Answer available at the end of this section.

Exercise 8.13.6

6. **In the Bertrand model, competitors compete by choosing**

a) Prices

b) Quantities

c) Contracting methods

d) Management styles

Answer available at the end of this section.

Exercise 8.13.7

7. **The Cournot or Bertrand Nash equilibrium is**

a) Analogous to the prisoner's dilemma outcome because there is a feasible outcome that is better for the firms involved.

b) Modeled using a hedonic pricing model

c) Similar to 1st degree price discrimination

d) Similar to 3rd degree price discrimination

Answer available at the end of this section.

Exercise 8.13.8

8. **Which is true of a price taking firm?**

a) It can sell all that it wants at the going price.

b) Its actions have a negligible impact on the market price.

c) It will maximize profits by producing where price is equal to marginal cost.

d) All of the above.

Answer available at the end of this section.

Exercise 8.13.9

9. **A profit maximizing firm will set price = marginal cost (p = MC) in which market structure?**

a) Perfect competition

b) Monopolistic competition

c) Oligopoly

d) Monopoly

e) All of the above

Answer available at the end of this section.

Exercise 8.13.10

10. **A profit maximizing firm will set marginal revenue = marginal cost (MR = MC) in which market structure?**

a) Perfect competition

b) Monopolistic competition

c) Oligopoly

d) Monopoly

e) All of the above

Answer available at the end of this section.

Exercise 8.13.11

11. **In which market structure are strategic interactions among firms of primary interest?**

a) Perfect competition

b) Monopolistic competition

c) Oligopoly

d) Monopoly

Answer available at the end of this section.

Exercise 8.13.12

12. **Which best describes a tit-for-tat response?**

a) The firm always prices lower than the competitor

b) The firm always prices a bit higher than the competitor to protect its margin

c) The firm cuts (raises) its price in response to a cut (raise) in price by its competitor

d) The firm chooses its Nash equilibrium price

Answer available at the end of this section.

Exercise 8.13.13

13. **A firm that advertises, "We will match any competitors price"**

a) Could be warning its competitors that it follows a tit-for-tat pricing strategy

b) Must have low costs

c) Is more worried about market share than profits

d) All of the above

Answer available at the end of this section.

Exercise 8.13.14

14. **Which factor makes it more likely that firms will be able to tacitly cooperate on a price above the Bertrand price?**

a) Discount rates are high

b) It takes a long time for firms to respond to a price change by a competitor

c) Firm's know that the competitive interaction will last for only three periods

d) Discount rates are low

e) There are major differences among firms in terms of costs and quality

Answer available at the end of this section.

Exercise 8.13.15

15. **Which best describes a Nash equilibrium?**

a) Tacit coordination on the monopoly price

b) A situation where MR < P

c) A situation where each agent is choosing its best strategy given the strategies of all other agents.

d) Cases where price is above the break-even point

Answer available at the end of this section.

Answers

Exercise 8.13.1

The quantity is 20 units.
The price is 60 dollars.
Profits above FC are 800 dollars.

Exercise 8.13.2
The quantity is 36 units.
The price is 110 dollars.
Profits above FC are 3240 dollars.

Exercise 8.13.3
The quantity is 45 units.
The price is 165 dollars.
Profits above FC are 6075 dollars.

Exercise 8.13.4
The quantity is 45 units.
The price is 220 dollars.
Profits above FC are 8100 dollars.

Exercise 8.13.5
The quantity is 41 units.
The price is 255 dollars.
Profits above FC are 8405 dollars.

Exercise 8.13.6
The quantity is 30 units.
The price is 110 dollars.
Profits above FC are 2700 dollars.

Exercise 8.13.7
The quantity is 43 units.
The price is 159 dollars.
Profits above FC are 5547 dollars.

Exercise 8.13.8
The quantity is 54 units.
The price is 165 dollars.
Profits above FC are 7290 dollars.

Exercise 8.13.9
The quantity is 40 units.
The price is 240 dollars.
Profits above FC are 6400 dollars.

Exercise 8.13.10
The quantity is 46 units.
The price is 249 dollars.
Profits above FC are 9522 dollars.

Exercise 8.13.1
Each firm's quantity is 30 units.
The market price is 80 dollars.
Each firm's profits above FC are 1800 dollars.

Exercise 8.13.2
Each firm's quantity is 24 units.
The market price is 80 dollars.
Each firm's profits above FC are 1440 dollars.

Exercise 8.13.3
Each firm's quantity is 15 units.
The market price is 100 dollars.
Each firm's profits above FC are 1125 dollars.

Exercise 8.13.4
Each firm's quantity is 22 units.
The market price is 124 dollars.
Each firm's profits above FC are 1936 dollars.

Exercise 8.13.5
Each firm's quantity is 24 units.
The market price is 160 dollars.
Each firm's profits above FC are 2880 dollars.

Exercise 8.13.6
Each firm's quantity is 35 units.
The market price is 220 dollars.
Each firm's profits above FC are 4900 dollars.

Exercise 8.13.7

Each firm's quantity is 30 units.
The market price is 120 dollars.
Each firm's profits above FC are 2700 dollars.

Exercise 8.13.8

Each firm's quantity is 36 units.
The market price is 120 dollars.
Each firm's profits above FC are 3240 dollars.

Exercise 8.13.9

Each firm's quantity is 35 units.
The market price is 220 dollars.
Each firm's profits above FC are 4900 dollars.

Exercise 8.13.10

Each firm's quantity is 28 units.
The market price is 168 dollars.
Each firm's profits above FC are 3528 dollars.

Exercise 8.13.1

The profit maximizing price is 24.

Exercise 8.13.2

The profit maximizing price is 50.

Exercise 8.13.3

The profit maximizing price is 60.

Exercise 8.13.4

The profit maximizing price is 30.

Exercise 8.13.5

The profit maximizing price is 40.

Exercise 8.13.6

The profit maximizing price is 60.

Exercise 8.13.7

The profit maximizing price is 20.

Exercise 8.13.8

The profit maximizing price is 40.

Exercise 8.13.9

The profit maximizing price is 60.

Exercise 8.13.10

The profit maximizing price is 80.

Exercise 8.13.1

c

Exercise 8.13.2

b

Exercise 8.13.3

d

Exercise 8.13.4

d

Exercise 8.13.5

b

Exercise 8.13.6

a

Exercise 8.13.7

a

Exercise 8.13.8

d

Exercise 8.13.9

a

Exercise 8.13.10

e

Exercise 8.13.11

c

Exercise 8.13.12

c

Exercise 8.13.13

a

Exercise 8.13.14

d

Exercise 8.13.15

c

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9: PRICE STRATEGIES AND DISCRIMINATION

Learning Objectives

- **Distinguish** between first-degree, second-degree, and third-degree price discrimination.
- **Explain** the logic of bundle pricing and access fees to capture consumer surplus.
- **Characterize** the self-selection problem inherent in second-degree price discrimination.
- **Explain** third-degree price discrimination and provide examples encountered in everyday commerce.
- **Describe** conditions that are necessary for the various types of discriminatory pricing strategies described in this chapter.
- **Explain** the logic of package pricing (bundling across products), contractual tie-in sales, and captive-product pricing.

Price discrimination is a way for firms to turn consumer surplus into profits by charging different consumers different prices based on their willingness to pay. A number of pricing schemes are encountered in everyday commerce, which are discriminatory in one way or another. Such schemes are common in food and agricultural markets as well. The goal of this chapter is to explain the economic logic of these pricing schemes.

Price discrimination occurs when consumers or groups of consumers are charged different prices even though the cost of providing the product or service to each consumer or each group of consumers is the same. For example, it would be price discrimination if a cafe offers a senior-citizen discount for its coffee. The cost of providing the cup of coffee is the same regardless of whether the customer is 25-years old or 75-years old. Nevertheless, the 25-year-old customer is being charged more. As you will learn below, the cafe owner probably has evidence that senior citizens have more elastic demands than young or middle-aged customers. Because of these differences in elasticity, the cafe can make more money by charging a different price to seniors than it charges to everyone else. It is important to reiterate that price discrimination occurs when different prices are charged even though the cost of providing the good or service is the same. There are non-discriminatory situations where some customers are charged more than others. For example, parents of teenage drivers pay more for automobile insurance. This, however, is not price discrimination because teenage drivers are more likely to be in accidents and are more costly to insure.

Some forms of price discrimination are illegal under anti-trust laws. Specifically, price discrimination that reduces competition is illegal under the Robinson-Patman Act (Lieberman and Siedel 1989). Also, the kinds of discrimination covered in this chapter are discriminatory in that different prices are based on differences in consumer willingness to pay. The different prices are not based on dislike or ill will towards a consumer or group of consumers. For example, in the senior-citizen example, the cafe owner offers the senior discount because seniors have more elastic demands for coffee. Seniors are not given the discount because the cafe owner dislikes middle-aged or young adults.

9.1: Introduction to Pricing with Market Power

9.2: Price Discrimination

9.3: Intertemporal Price Discrimination

9.4: Peak Load Pricing

9.5: Two-Part Pricing

9.6: Bundling

9.7: Advertising

9.8: Perfect or First-Degree Price Discrimination

9.9: Second-Degree Price Discrimination

9.10: Third-Degree Price Discrimination

9.11: Some Other Pricing Schemes

9.12: Concluding Comments

9.13: References
9.14: Problem Sets

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9.1: Introduction to Pricing with Market Power

In economics, the firm's objective is assumed to be to maximize profits. Firms with market power do this by capturing consumer surplus, and converting it to producer surplus. In Figure $9.1.1$, a monopoly finds the profit-maximizing price and quantity by setting MR equal to MC. This strategy maximizes profits for a firm setting a single price (P_M) and charging all customers the same price. In some situations, it is possible for a monopolist to increase profits beyond the single price monopoly solution. Figure $9.1.1$ shows that there are two sources of consumer willingness to pay that the monopoly has not taken advantage of by producing a quantity of Q_M and selling it at price P_M.

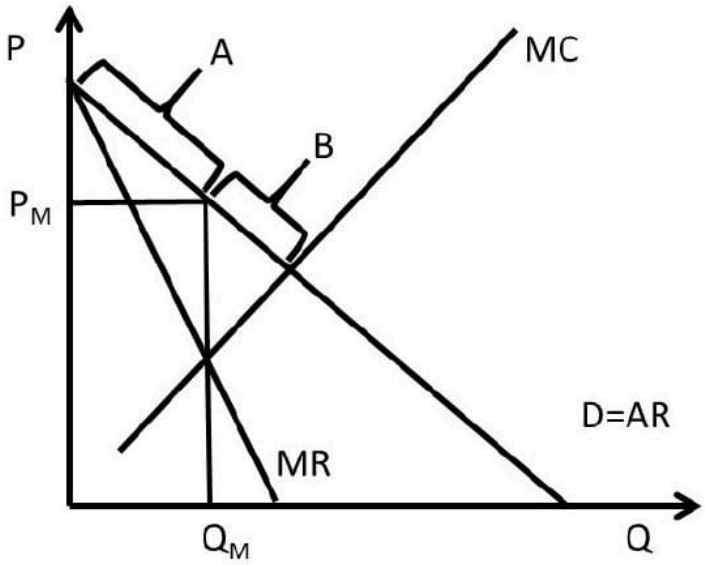


Figure $9.1.1$: Pricing Strategy for Firms with Market Power

Area A along the demand curve represents consumers with a higher willingness to pay than the monopoly price P_M. Area B represents consumers who have been priced out of the market, since the monopoly price is higher than their willingness to pay. These two groups of consumers represent two areas of untapped consumer surplus for a monopoly.

The monopoly price P_M represents the profit-maximizing price if the monopolist is constrained to set only a single price, and charge all customers the same single price. However, if the monopolist could charge more than one price, it may be able to capture more consumer surplus (willingness to pay) and convert it into producer surplus (profits). This Chapter describes and explains several pricing strategies for firms with market power. These strategies enhance profits over and above the single price profit level shown in Figure $9.1.1$. The strategies include price discrimination, peak-load pricing, and two-part pricing.

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9.2: Price Discrimination

Price discrimination is the practice of charging different prices to different customers. There are three forms of price discrimination, defined and explained in what follows.

Price Discrimination = charging different prices to different customers.

First Degree Price Discrimination

First degree price discrimination is the extreme form of charging different prices to different consumers, and makes use of the concept of "reservation price." A consumer's maximum willingness to pay is defined to be their reservation price.

Reservation Price = The maximum price that a consumer is willing to pay for a good.

First Degree Price Discrimination = Charging each consumer her reservation price.

First degree price discrimination is shown in Figure 9.2.1, where the initial levels of consumer surplus (CS_0) and producer surplus (PS_0) are defined for the competitive equilibrium. The competitive quantity is Q_C, and the competitive price is P_C. A monopoly could charge a price P_M at quantity Q_M to maximize profits with a single price.

Each individual's willingness to pay is given by a point on the demand curve. If the firm knows each consumer's maximum willingness to pay, or reservation price, it can transfer all consumer surplus to producer surplus. The firm extracts every dollar of surplus available in the market by charging each consumer the maximum price that they are willing to pay. First degree price discrimination results in levels of producer surplus and consumer surplus PS_1 and CS_1, as shown in Equation 9.2.1.

$$PS_1 = PS_0 + CS_0; CS_1 = 0. \tag{9.2.1}$$

Every dollar of consumer surplus has been transferred to the firm. First degree price discrimination is also called, "Perfect Price Discrimination."

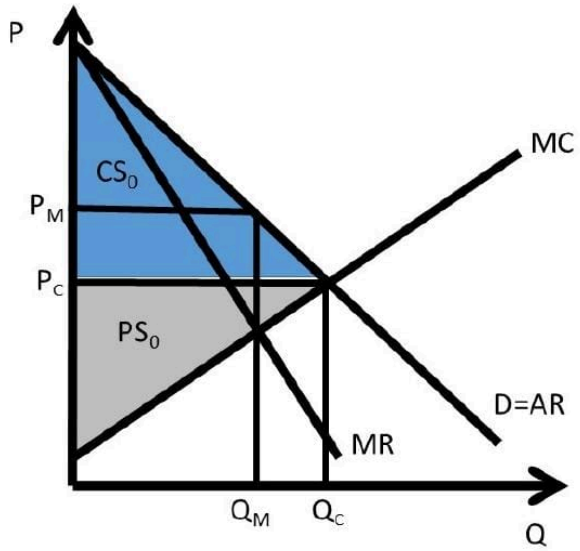


Figure 9.2.1: First Degree Price Discrimination

In most circumstances, it is difficult for the firm to practice first degree price discrimination. First, it is difficult to charge different prices to different consumers. In many cases, it is illegal to charge different prices to different people. Second, it is difficult and costly to elicit reservation prices from every consumer. Therefore, first degree price discrimination is an extreme, idealized case of charging different prices to different consumers. It is rare in the real world.

“Imperfect Price Discrimination” is a term used to describe markets that approach perfect price discrimination. Examples of imperfect price discrimination include car sales and college tuition rates for students in college. Car dealerships often post a “sticker price” and then lower the actual price, depending on how much the consumer is willing to pay. Successful car sales people are often those who have exceptional abilities to discern exactly how much each consumer is willing to pay, or their reservation price. Colleges and universities use imperfect price discrimination by offering scholarships and financial aid packages to students based on their willingness to enroll and attend an institution.

Imperfect price discrimination is shown in Figure $9.2.2$, where different groups of consumers are charged different prices based on their willingness to pay. Price P_1 is a high price to capture consumers with high willingness to pay, price P_2 is the monopoly price (P_M), and price P_3 is the competitive price. If a firm can distinguish different consumer groups’ willingness to pay, it can enhance profits through this form of price discrimination.

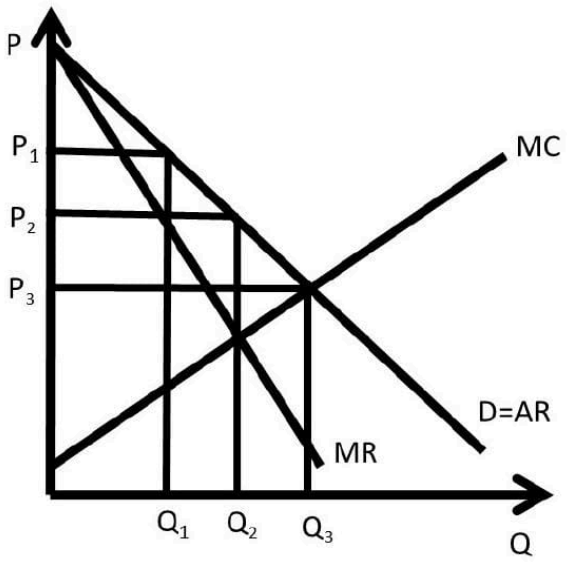


Figure $9.2.2$: Imperfect Price Discrimination

Second Degree Price Discrimination

Second Degree Price Discrimination is a quantity discount.

Second Degree Price Discrimination = Charging different per-unit prices for different quantities of the same good.

Second degree price discrimination is a common form of pricing and packaging. Consider an example of two different sized packages of salsa with different prices per unit. Suppose that consumers have different preferences for different sized salsa packages, and different demand curves reflect this.

For simplicity, assume that there are two consumers (consumer 1 and consumer 2) and two choices of package size (A and B).

A: 8 oz jar, price $= 2$ USD, price per unit $= 0.25$ USD/oz

B: 32 oz jar, price $= 4.80$ USD, price per unit $= 0.15$ USD/oz

Figure $9.2.3$ shows consumer demand for each of the two consumers.

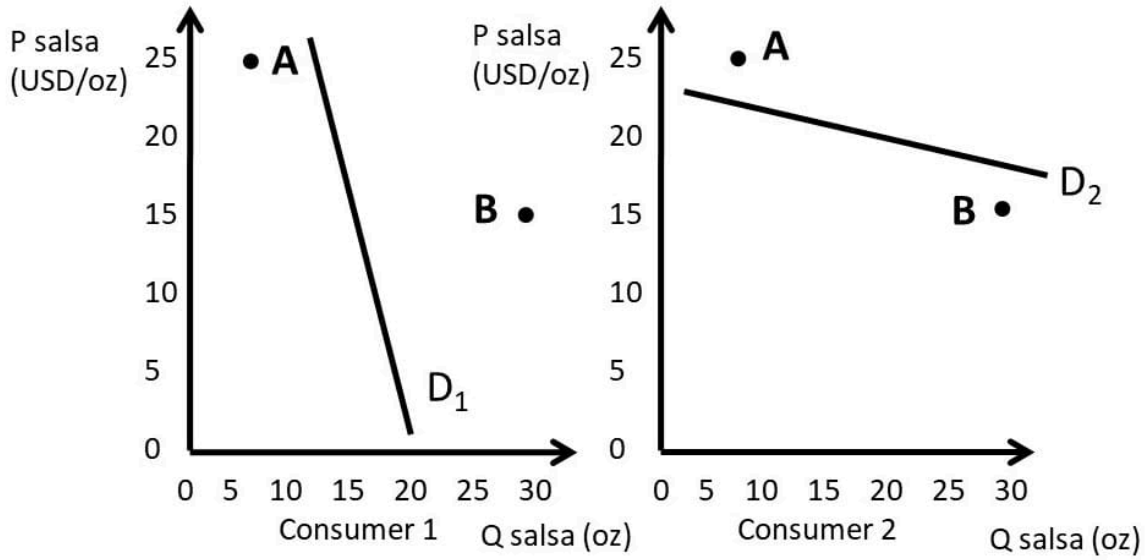


Figure 9.2.3: Second Degree Price Discrimination

Consumer 1 has a preference for smaller quantities. This consumer could be a single person who desires to purchase a small jar of salsa. Consumer 1's demand curve demonstrates that she is willing to pay for the 8 ounce jar of salsa (A), but not the 32 ounce jar (B). This is because A lies below demand curve D_1, but not B. On the other hand, consumer 2 desires the large jar of salsa, perhaps this is a family of four persons. Consumer 2 is willing to purchase the 32 ounce jar (B), but not the 8 ounce jar (A). This is because B lies below the demand curve D_2, but not A.

It can be shown that the salsa firm can enhance profits by offering both sizes A and B. Assume that the costs of producing salsa are equal to ten cents per ounce:

$$MC = 0.10 \text{ USD/oz}.$$

Situation One. Firm sells 8-ounce jar only.

Consumer 1 buys, Consumer 2 does not buy.

$$Q = 8oz; P = 0.25 \text{ USD/oz}; MC = 0.10 \text{ USD/oz}$$
$$\pi_1 = (P–MC)Q = (0.25–0.10)8 = (0.15)8 = 1.20 \text{ USD}$$

Situation Two. Firm sells 32-ounce jar only.

Consumer 2 buys, Consumer 1 does not buy.

$$Q = 32 \text{ oz}; P = 0.15 \text{ USD/oz}; MC = 0.10 \text{ USD/oz}$$
$$\pi_2 = (P–MC)Q = (0.15–0.10)32 = (0.05)32 = 1.60 \text{ USD}$$

Situation Three. Firm sells both 8-ounce and 32-ounce jars.

Consumer 1 buys 8 ounce jar, Consumer 2 buys 32 ounce jar.

$$\pi_3 = (0.25–0.10)8 + (0.15–0.10)32 = (0.15)8 + (0.05)32 = 2.80 \text{ USD} \tag{9.2.2}$$

Profits are larger if different sized packages are sold at the same time. Second degree price discrimination takes advantage of differences between consumers, and is usually more profitable than offering a good in only one package size. This explains the huge diversity of package sizes available for a large number of consumer goods.

Third Degree Price Discrimination

Third degree price discrimination is a practice of charging different prices to different consumer groups.

Third Degree Price Discrimination = Charging different prices to different consumer groups.

A firm that faces more than one group of consumers can increase profits by offering a good at different prices to groups of consumers with different levels of willingness to pay. The firm will maximize profits by setting the marginal revenue (MR) for each consumer group equal to the marginal cost of production (MC). This solution is shown in Equation 9.2.3 for two consumer groups:

$$MR_1 = MR_2 = MC. \tag{9.2.3}$$

Two things are interesting about this result. First, the firm practicing third degree price discrimination is simply following the profit-maximizing strategy of continuing any activity as long as the benefits outweigh the costs. The firm will stop when marginal benefits from selling the good to both groups are equal to the marginal costs of producing the good. Second, this solution is similar to the solution for the multiplant monopoly: $MC_1 = MC_2 = MR$. Profit-maximizing firms use the same strategy for multiple plants and multiple consumers groups: set MR equal to MC in all circumstances.

Movie theaters often offer a student discount to students, as well as discounts for children, senior citizens, and military personnel. It may seem as if the theaters and other firms that offer these discounts are being nice to these groups. In reality, however, the firms are practicing third degree price discrimination to maximize profits! These groups of consumers have more elastic demands for movies, and would purchase a smaller number of movie tickets if the price was not discounted for them. A numerical example will demonstrate how third degree price discrimination works. Suppose that movie tickets are in thousands.

$$\begin{aligned}\text{Movie ticket price } &= 12 \text{ USD/ticket}\\ \text{Student ticket price } &= 7 \text{ USD/ticket}\end{aligned}$$

Inverse Demand for movies: $P_1 = 20–4Q_1$

Inverse Demand for students: $P_2 = 10–Q_2$

$$\begin{aligned}MC &= 4 \text{ USD/ticket}\\ \max \pi &= TR–TC\\ &= TR_1–TC_1 + TR_2–TC_2\\ &= P_1Q_1–4Q_1 + P_2Q_2–4Q_2\\ &= (20–4Q_1)Q_1–4Q_1 + (10–Q_2)Q_2–4Q_2\\ &= 20Q_1–4Q_1^2–4Q_1 + 10Q_2–Q_2^2–4Q_2\\ \frac{\partial \pi}{\partial Q_1} &= 20–8Q_1–4 = 0\\ 8Q_1 &= 16\\ Q_1^* &= 2 \text{ thousand movie tickets}\\ P_1^* &= 20–4(2) = 12 \text{ USD/ticket}\\ \frac{\partial \pi}{\partial Q_2} &= 10–2Q_2–4 = 0\\ 2Q_2 &= 6\\ Q_2^* &= 3 \text{ thousand student movie tickets}\\ P_2^* &= 10–(3) = 7 \text{ USD/ticket for students}\end{aligned}$$

The third degree price discrimination strategy is graphed in Figure 9.2.4.

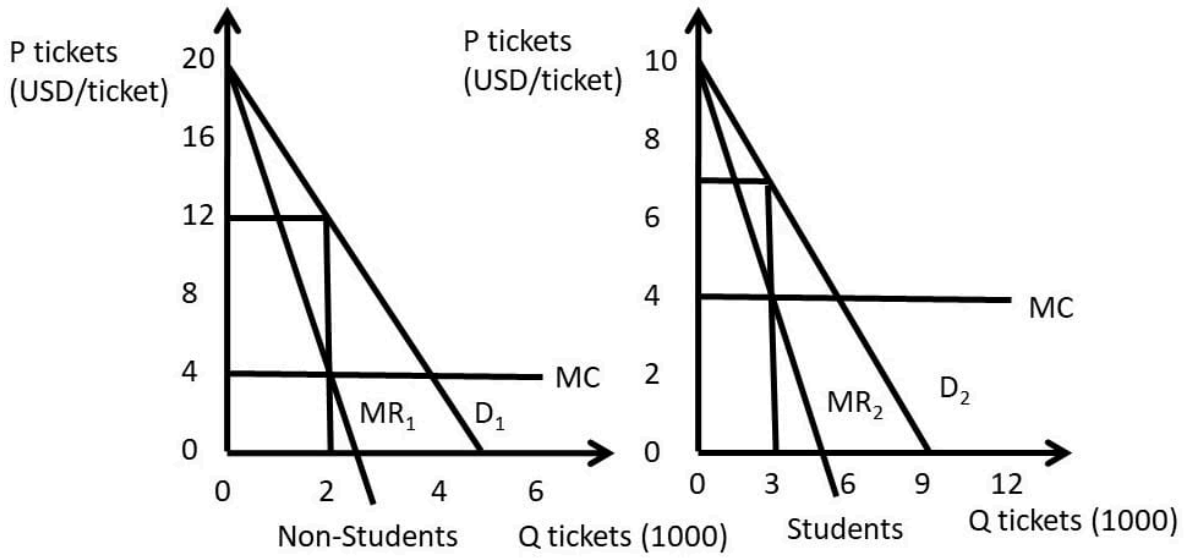


Figure 9.2.4: Third Degree Price Discrimination

A pricing rule for third degree price discrimination can be derived. Recall the pricing rule that was derived for a monopoly in Chapter 3:

$$MR = P\left(1 + \frac{1}{E^d}\right) \tag{9.2.4}$$

This pricing rule can be extended to include two groups of consumers, as follows.

$$MR_1 = MR_2 = MC$$
$$P_1\left(1 + \frac{1}{E_1}\right) = P_2\left(1 + \frac{1}{E_2}\right)$$
$$\frac{P_1}{P_2} = \frac{1 + \frac{1}{E_2}}{1 + \frac{1}{E_1}}$$

The pricing rule for the third degree price discriminating firm shows that the highest price is charged to the consumer group with the smallest (most inelastic) price elasticity of demand (E^d). This follows what we have learned about the elasticity of demand: consumers with an elastic demand will switch to a substitute good if the price increases, whereas consumers with an inelastic demand are more likely to pay the price increase.

The next section will present intertemporal price discrimination, or charging different prices at different times.

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9.3: Intertemporal Price Discrimination

Intertemporal price discrimination provides a method for firms to separate consumer groups based on willingness to pay. The strategy involves charging a high price initially, then lowering price after time passes. Many technology products and recently-released products follow this strategy.

Intertemporal Price Discrimination = charging a high price initially, then lowering price after time passes.

Intertemporal price discrimination is similar to second degree price discrimination, but charges a different price across time. Second degree price discrimination charges a different price for different quantities at the same time. Intertemporal price discrimination is shown in Figure $9.3.1$.

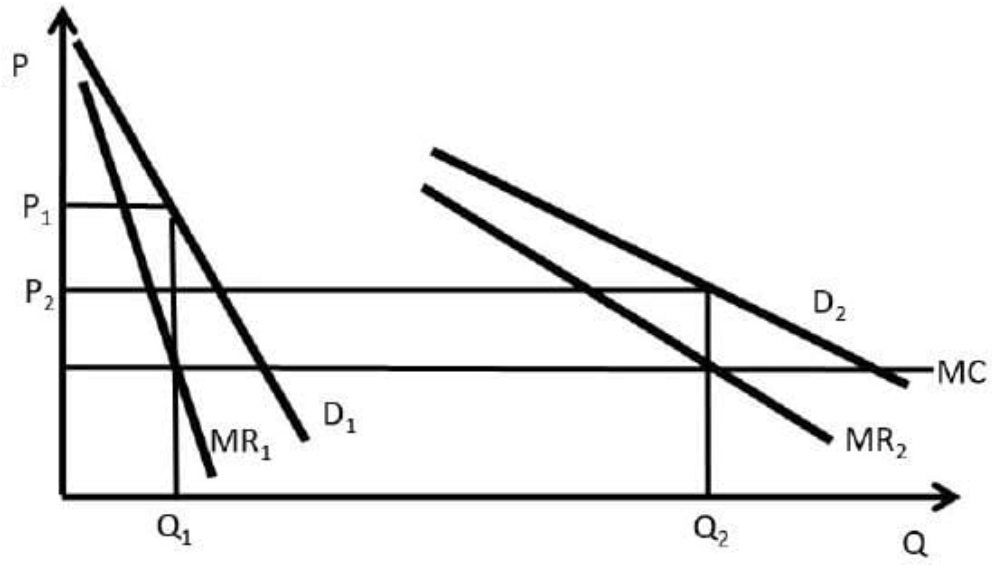


Figure $9.3.1$: Intertemporal Price Discrimination, Graph One

The first group has a higher willingness to pay for the good, as shown by demand curve D_1. This group will pay the higher initial price charged by the firm. A new iPhone release is a good example. Over time, Apple will lower the price to capture additional consumer groups, such as group two in Figure $9.3.1$. In this fashion, the firm will extract a larger amount of consumer surplus than with a single price.

Intertemporal price discrimination can also be shown in a slightly different graph. The key feature of intertemporal price discrimination is a high initial price, followed by lower prices charged over time, as shown in Figure $9.3.2$. In this graph, the firm initially charges price Pt to capture the high willingness to pay of some consumers. Over time, the firm lowers price to P_{t+1}, and later to P_{t+2} to capture consumer groups with lower willingness to pay.

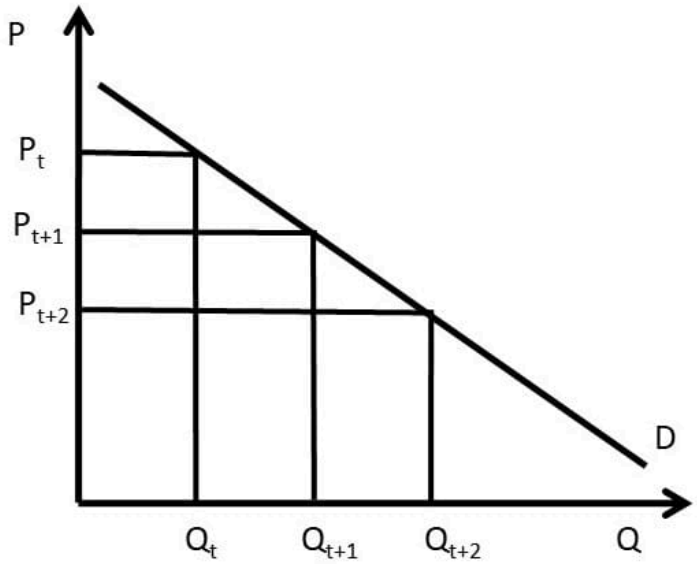


Figure 9.3.2: Intertemporal Price Discrimination, Graph Two

The concept of intertemporal price discrimination explains why new products are often priced at high prices, and the price is lowered over time. In the next section, peak-load pricing will be introduced.

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9.4: Peak Load Pricing

The demand for many goods is larger during certain times of the day or week. For example, roads are congested during rush hours during the morning and evening commutes. Electricity has larger demand during the day than at night. Ski resorts have large (peak) demands during the weekends, and smaller demand during the week.

Peak Load Pricing = Charging a high price during demand peaks, and a lower price during off-peak time periods.

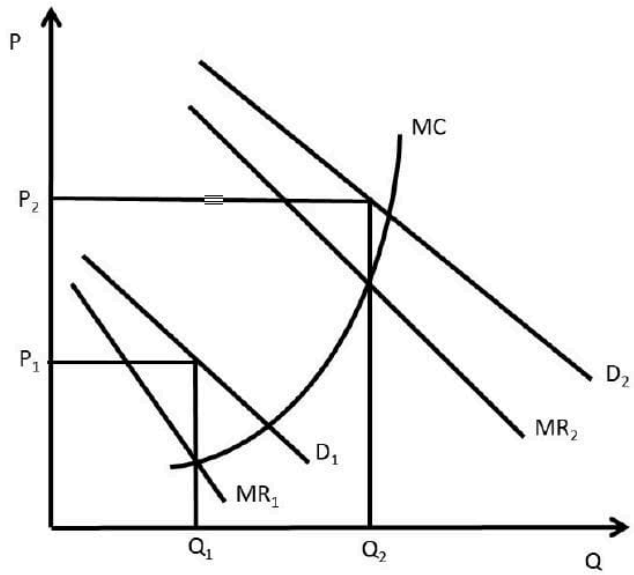


Figure 9.4.1: Peak Load Pricing

Figure 9.4.1 demonstrates the demand for electricity during the day. Demand curve D_1 represents demand at off-peak hours at night. The electricity utility company will charge a price P_1 for the off-peak hours. The costs of producing electricity increase dramatically during peak hours. Electricity generation reaches the capacity of the generating plants, causing larger quantities of electricity to be expensive to produce. For large coal-fired plants, when capacity is reached, the firm will use natural gas to generate the peak demand. To cover these higher costs, the firm will charge the higher price P_2 during peak hours. The same graph represents a large number of other goods that have peak demand at different times during a day, week, or year (ski resorts, toll roads, parking lots, etc.).

Economic efficiency is greatly improved by charging higher prices during peak times. If the utility were required to charge a single price at all times, it would lose the ability to charge consumers an appropriate price during peak demand periods. Charging a higher price during peak hours provides an incentive for consumers to switch consumption to off-peak hours. This saves society resources, since costs are lower during those times.

An example is electricity consumption. If consumers are charged higher prices during peak hours, they are able to shift some electricity demand to night, the off-peak hours. Dishwashers, laundry, and bathing can be shifted to off-peak hours, saving the consumer money and saving society resources. Electricity companies also promote “smart grid” technology that automatically turns thermostats down when individuals and families are not at home... saving the consumer and society money.

The next section will discuss a two-part tariff, or charging consumers a fixed fee for the right to purchase a good, and a per-unit fee for each unit purchased.

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9.5: Two-Part Pricing

A monopoly or any firm with market power can increase profits by charging a price structure with a fixed component, or entry fee, and a variable component, or usage fee.

Two-Part Pricing (also called Two Part Tariff) = A form of pricing in which consumers are charged both an entry fee (fixed price) and a usage fee (per-unit price).

Examples of two-part pricing include a phone contract that charges a fixed monthly charge and a per-minute charge for use of the phone. Amusement parks often charge an admission fee and an additional price per ride. Golf clubs typically charge an initiation fee and then usage fees based on meals eaten and golf rounds played. College football tickets usually require a “donation” to the athletic department, used for scholarships, and a per-ticket charge for the tickets.

Two-part pricing is shown in Figure $9.5.1$, where a monopoly graph is presented.

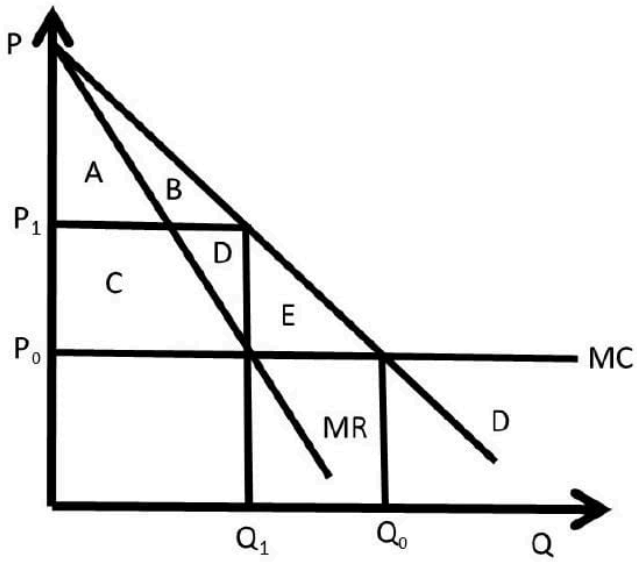


Figure $9.5.1$: Two-Part Pricing

Suppose that the graph represents an individual consumer’s demand. In competitive equilibrium (subscript 0), price is equal to MC, output is equal to Q_0, and producer and consumer surplus are given by:

$$PS_0 = 0$$
$$CS_0 = +ABCDE$$

The firm charges a price equal to the constant marginal cost $(P = MC)$, and there is no producer surplus. Consumers receive the total area between the demand curve (willingness to pay) and the price line (price paid), equal to area $ABCDE$.

A profit-maximizing firm (subscript 1) that charged a single price would maximize profits by producing Q_1 units of the good, and charging a price of P_1. Surplus levels would be:

$$PS_1 = +CD$$
$$CS_1 = +AB$$

In this case, consumers have transferred areas C and D to producers, but still have surplus equal to area AB. Producers interested in increasing profits could devise a two-part pricing strategy that transfers more consumer surplus into producer surplus. Since $CS > 0$, consumers are willing to pay more than the monopoly price, and firms can extract a greater level of consumer surplus. The firm could charge an entry fee (T), and consumers would be willing to pay as long as the fee was less than their consumer surplus at the monopoly level $(CS_1 = AB)$.

Consider the following two-part pricing scheme (subscript 2):

Usage fee: $P_2 = MC$

Entry fee: $T = A + B + C + D + E$ [T is set equal $CS_0 = CS$ under competition]

$$PS_2 = +ABCDE$$
$$CS_2 = 0$$

With a two-part pricing scheme, the firm has extracted every dollar of willingness to pay from consumers. The total amount of producer surplus under two-part pricing is given by:

$$PS_2 = T + (P_2–MC)Q_2 = ABCDE$$

Notice that the firm earns zero profit from the usage fee (P_2 = per-unit fee), since it sets the usage fee equal to the cost of production ($P_2 = MC$). All of the profits come from the entry fee (T = fixed price) in this case.

To summarize, a two-part tariff for consumers with identical demands would (1) set usage fee (price per unit) equal to $MC(P = MC)$, and (2) set a membership fee (entry fee) equal to consumer surplus at this price ($T = CS$ at $P = MC$). The two-part price will result in (1) $CS = 0$, and (2) $PS = T + (P–MC)Q = T$.

A numerical example will further elucidate the two-part price. Assume that an individual's inverse demand curve is given by: $P = 20–2Q$, and the cost function is $C(Q) = 2Q$. The firm seeks to find the optimal, profit-maximizing two-part tariff. The situation is shown in Figure $9.5.2$.

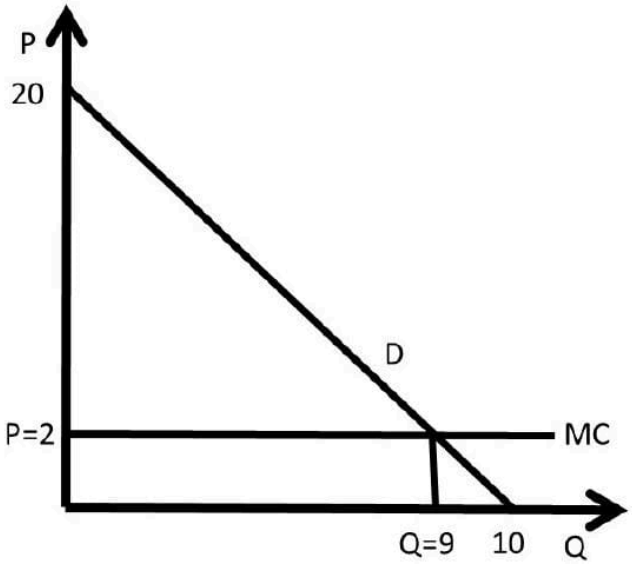


Figure $9.5.2$: Two-Part Pricing Example

The firm will set the usage fee (per-unit price) equal to marginal cost: $P^* = MC = 2$. At this price, the quantity sold is found by substitution of the price into the inverse demand function: $2 = 20–2Q$, or $2Q = 18, Q^* = 9$ units, as shown in Figure $9.5.2$. Next, the firm will determine the entry fee (fixed price), by calculating the area of consumer surplus at this price: $CS = 0.5(20–2)(9–0) = 0.5(18)(9) = 9 \cdot 9 = 81$ USD. Therefore, the firm sets the usage fee: $T = 81$ USD. The resulting levels of surplus are $CS = 0$ and $PS = 81$ USD. To summarize, the optimal two-part tariff is to set the usage fee equal to marginal cost and the entry fee equal to the level of consumer surplus at that price: $P^* = 2$ USD/unit, $T^* = 81$ USD.

In our investigation of two-part pricing, identical consumer demands have been assumed. In the real world, consumer demands may differ quite markedly across individuals. Given this possibility, the two-part pricing strategy can be summarized as follows.

1. If consumer demands are nearly identical, a two-part pricing scheme could increase profits by charging a price close to marginal cost and an entry fee.
2. If consumer demands are different, a two-part pricing scheme or a single price scheme could be utilized by setting a price

well above marginal cost and a lower entry fee to capture all consumers. Or, set a single price.

In the next section, commodity bundling will be explained and explored.

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9.6: Bundling

The practice of bundling is that of selling two or more goods together as a package.

Bundling = The practice of selling two or more goods together as a package.

Bundling is a widely-practiced sales strategy that takes advantage of differences in consumer willingness to pay for different goods. McDonalds Happy Meals are an example of bundling, since the customer purchases a hamburger, French fries, beverage, and toy as a single purchase. McDonalds was an innovator in bundling, and has expanded the practice to include “Value Meals.” Communication companies often package internet service, cable television, and phone service together into a package.

Bundling Examples

A simple example of bundling is a value meal at a fast food restaurant. To make things simple, assume that there are two consumers (A and B), two products (burger and fries) and marginal costs are equal to zero. The zero-cost assumption is not realistic, but the model results do not change when we assume zero costs.

Table 4.1 shows the reservation prices (willingness to pay) for both consumers for each good.

Table 4.1 Reservations Prices for Two Different Consumers.

	Reservation Prices (USD/unit)		
Consumer	Burger	Fries	Bundle
A	6	2	8
B	4	3	7

Recall that the reservation price is the maximum amount that a consumer is willing to pay for a good. The reservation price for the bundle (shown in the right column of table 4.1) is simply the sum of the two reservation prices for the burger and fries. Next, a comparison is made between selling the two good individually versus selling them as a bundle.

CASE ONE: Sell each product individually.

Π_{burger}

1. If set $P_{burger} = 6$ USD/unit, A buys, $\Pi_{burger} = 6 \cdot 1 = 6$ USD
2. If set $P_{burger} = 4$ USD/unit, A and B buy, $\Pi_{burger} = 4 \cdot 2 = 8$ USD

$\rightarrow$ Set $P^*_{burger} = 4$ USD/unit; $\Pi_{burger} = 8$ USD

Π_{fries}

1. If set $P_{fries} = 2$ USD/unit, A and B buy, $\Pi_{fries} = 2 \cdot 2 = 4$ USD
2. If set $P_{fries} = 3$ USD/unit, B buys, $\Pi_{fries} = 3 \cdot 1 = 3$ USD

$\rightarrow$ Set $P^*_{fries} = 2$ USD/unit; $\Pi_{fries} = 4$ USD

$\Pi_{\text{total individual}}$

$\Pi_{\text{total individual}} = P_b Q_b + P_f Q_f = 4 \cdot 2 + 2 \cdot 2 = 8 + 4 = 12 \text{ USD}$

CASE TWO: Bundle burger and fries into a single package.

Π_{bundle}

1. If set $P_{bundle} = 8 \text{ USD/unit}$, A buys, $\Pi_{bundle} = 8 \cdot 1 = 8 \text{ USD}$

2. If set $P_{bundle} = 7 \text{ USD/unit}$, A and B buy, $\Pi_{bundle} = 7 \cdot 2 = 14 \text{ USD}$

$\rightarrow$ Set $P^*_{bundle} = 7 \text{ USD/unit}$; $\Pi_{bundle} = 14 \text{ USD}$

Bundling increases profit from 12 to 14 USD. This result will occur if the reservation prices are inversely correlated. To see this, work out the profits for selling goods individually and as a bundle for the reservation prices that appear in Table 4.2.

Table 4.2 Reservations Prices for Two Consumers with Correlated Reservation Prices.

	Reservation Prices (USD/unit)		
Consumer	Burger	Fries	Bundle
A	6	3	9
B	4	2	6

Bundling enhances profits only when consumers have uncorrelated reservation prices. In this way, bundling takes advantage of differences in consumer willingness to pay.

Many firms have used “Green Bundling” to tie goods with environmental or sustainable goods (natural, organic, local, etc.). As long as consumer preferences for the good and the sustainability goal are uncorrelated, this strategy will increase profits.

Tying

A practice related to bundling is tying.

Tying = The practice of requiring a customer to purchase one good in order to purchase another.

Tying is a specific form of bundling. An example is Microsoft selling Windows software together with Internet Explorer, a web browser. A second example is printers and ink cartridges. Many hardware companies make a great deal of profit from selling ink cartridges for printers. The cartridges do not have a universal shape, so must be purchased specifically for each printer. The next section will discuss advertising.

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9.7: Advertising

Advertising is a huge industry, with billions spent every year on marketing products. Are these enormous expenditures worth it? The benefits of increased sales and revenues must be at least as large as the increased costs to make it a good investment. In this section, the profit-maximizing level of advertising will be identified and evaluated.

One important point about advertising is the costs associated with advertising expenditures. If advertising works, it increases sales of the product. There are two major costs, the direct costs of advertising and the additional costs associated with increasing production if the advertising is effective. A typical analysis sets the marginal revenues of advertising equal to the marginal costs of advertising

$$MR_A = MC_A. \tag{9.7.1}$$

This would be correct if the level of output remained constant. However, the output level will increase if advertising works, and the additional costs of increased output must be taken into account for a comprehensive and correct analysis, as will be shown below.

Graphical Analysis of Advertising

The graph for advertising is shown in Figure $9.7.1$. Notice the two major effects of advertising and marketing efforts:

1. an increase in demand, in this case from D_0 to D_A, and
2. an increase in costs, shown here as the movement from ATC_0 to ATC_A.

In the analysis shown here, advertising costs are considered to be fixed costs that do not vary with the level of output. This is true for a billboard, or television commercial. Note that the marginal costs do not change, since marginal costs are variable costs. The analysis could be easily extended to include variable advertising costs.

Economic analysis of advertising and marketing is straightforward: continue to advertise as long as the benefits outweigh the costs. In Figure $9.7.1$, the optimal level of advertising occurs at quantity Q_A and price P_A. Profits with advertising are shown by the rectangle π_A. If profits with advertising are larger than profits without advertising $(\pi_A > \pi_0)$, then advertising should be undertaken.

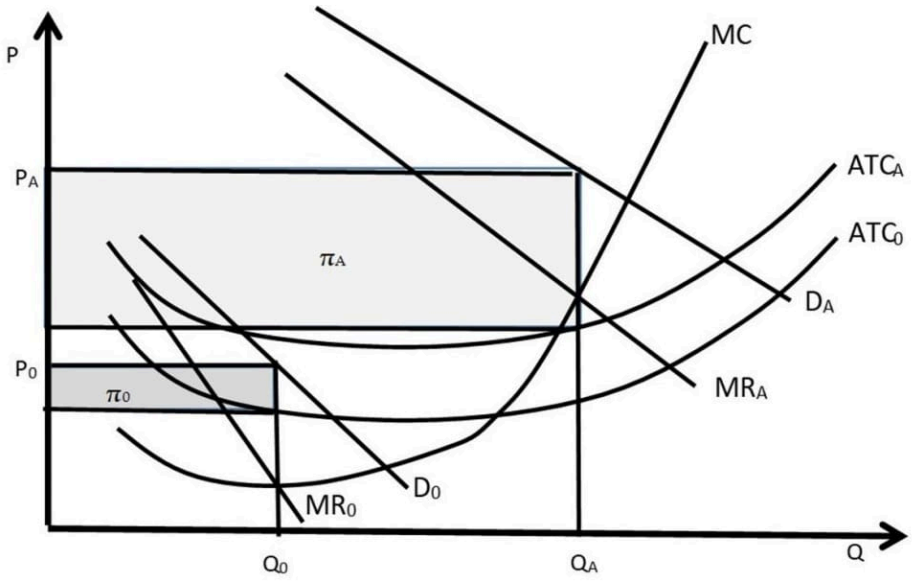


Figure $9.7.1$: Economic analysis of advertising and marketing.

In general, if the increase in sales $(D_A–D_0)$ is larger than the increase in costs, advertising should be undertaken. The optimal level of advertising can be found using marginal economic analysis, as described in the next section.

General Rule for Advertising

The profit-maximizing level of advertising can be derived, and the outcome is interesting and important, since it diverges from setting the marginal costs of advertising equal to the marginal revenues of advertising. Note that the graphical and mathematical analyses of advertising presented here could be used for any marketing program, not only advertising campaigns.

Assume that the demand for a product is given in Equation 9.7.2, where quantity demanded (Q^d) is a function of price (P) and the level of advertising (A).

$$Q^d = Q(P, A) \tag{9.7.2}$$

This demand equation differs from the usual approach of using an inverse demand equation. For this model, it is more useful to use the actual demand equation instead of an inverse demand equation $[P = P(Q^d)]$. The profit equation is shown in Equation 9.7.3, where the cost function is given by $C(Q)$.

$$\max \pi = TR–TC \tag{9.7.3}$$

$$\max \pi = PQ(P, A)–C(Q)–A \tag{9.7.4}$$

The profit-maximizing level of advertising (A^*) is found by taking the first derivative of the profit function, and setting it equal to zero. This derivative is slightly more complex than usual, since the quantity that appears in the cost function depends on advertising, as shown in Equation 9.7.2. Therefore, to find the first derivative, we will need to use the chain rule from calculus, which is used to differentiate a composition of functions, such as the derivative of the function $f(g(x))$ shown in Equation 9.7.5.

$$\text{If } f(g(x)) \text{ then} \frac{\partial f}{\partial x} = f'(g(x)) \cdot g'(x) \tag{9.7.5}$$

The chain rule simply says that to differentiate a composition of functions, first differentiate the outer layer, leaving the inner layer unchanged [the term $f'(g(x))$], then differentiate the inner layer [the term $g'(x)$].

In Equation 9.7.3, the cost function is a composition of the cost function and the demand function: $C(Q(P, A))$. So the derivative

$$\frac{\partial C}{\partial A} = C'(Q(A)) \cdot Q'(A) = \left(\frac{\partial C}{\partial Q}\right) \cdot \left(\frac{\partial Q}{\partial A}\right). \tag{9.7.6}$$

Thus, the first derivative of the profit equation with respect to advertising is given by:

$$\frac{\partial \pi}{\partial A} = P\left(\frac{\partial Q}{\partial A}\right) - \left(\frac{\partial C}{\partial Q}\right) \cdot \left(\frac{\partial Q}{\partial A}\right) - 1 = 0 \tag{9.7.7}$$

Rearranging, the first derivative can be written as in Equation 9.7.8:

$$P\left(\frac{\partial Q}{\partial A}\right) = MC \cdot \left(\frac{\partial Q}{\partial A}\right) + 1. \tag{9.7.8}$$

The term on the left hand side is marginal revenues of advertising (MR_A), and the term on the right hand side is the marginal cost of advertising $(MC_A = 1)$, plus the additional costs associated with producing a larger output to meet the increased demand resulting from advertising $[MC \cdot \left(\frac{\partial Q}{\partial A}\right)]$.

This result can be used to find an optimal "rule of thumb" for advertising, or a "General Rule for Advertising." There are three preliminary definitions that will be useful in deriving this important result. First, the advertising to sales ratio is given by $\frac{A}{PQ}$, and reflects the percentage of advertising in total revenues (price multiplied by quantity, PQ). Second, the advertising elasticity of demand is defined.

Advertising Elasticity of Demand (E^A) = The percentage change in quantity demanded resulting from a one percent change in advertising expenditure.

$$E^A = \frac{\%\Delta Q^d}{\%\Delta A} = \left(\frac{\partial Q}{\partial A}\right)\left(\frac{A}{Q}\right). \tag{9.7.9}$$

Third, recall the Lerner Index (L), a measure of monopoly power. We derived the relationship between the Lerner Index and the price elasticity of demand, shown in Equation 9.7.10:

$$L = \frac{P–MC}{P} = -\frac{1}{E^d}. \tag{9.7.10}$$

With these three preliminary equations, we can derive a relatively simple and very useful general rule of advertising from the profit-maximizing condition for advertising, given in Equation 9.7.8.

$$\begin{aligned} P\left(\frac{\partial Q}{\partial A}\right) &= MC \cdot \left(\frac{\partial Q}{\partial A}\right) + 1 \\ (P–MC)\left(\frac{\partial Q}{\partial A}\right) &= 1 \\ \frac{P–MC}{P} \cdot \left(\frac{\partial Q}{\partial A}\right)\left(\frac{A}{Q}\right) &= \left(\frac{A}{PQ}\right) \\ \frac{A}{PQ} &= -\frac{E^A}{E^d} \end{aligned}$$

This simple rule states that the profit-maximizing advertising to sales ratio (A/PQ) is equal to minus the elasticity of advertising (E^A) divided by the price elasticity of demand $(-E^d)$. The result is simple and powerful: (1) if the elasticity of advertising is large, increase the advertising to sales ratio, and (2) if the price elasticity of demand is large, decrease the advertising to sale ratio. A firm with monopoly power, or a higher Lerner Index, will want to advertise more (E^d small), since the marginal profit from each additional dollar of advertising or marketing expenditure is greater.

Most business firms have at least crude approximations of the two elasticities needed to use this simple rule. Many firms advertise less than the optimal rate, since marketing can appear to be expensive if it is a large percentage of sales. However, simple economic principles can be used to determine the optimal, profit-maximizing level of advertising and/or marketing expenditures using this simple rule.

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9.8: Perfect or First-Degree Price Discrimination

If a seller can perfectly price discriminate, he or she is able to charge the buyer's maximum willingness to pay for each unit. This is discriminatory because the price depends on the consumer's willingness to pay not the cost of providing the product. If demand is downward sloping, the seller will charge a high price for the first unit purchased and progressively lower prices for additional units until willingness to pay reaches the seller's marginal cost. By pricing in this manner, the seller leaves no consumer surplus. What would have been consumer surplus has been turned into profits. Perfect price discrimination is also called first-degree price discrimination.

To effectively employ first-degree price discrimination, the seller needs to know the demand curve of each individual. Fortunately for consumers, this is something that the seller is not likely to know. However, there are some sales situations where the seller may attempt to ascertain the consumer's reservation price and charge him or her accordingly. One example is a car dealership. Most car buyers do not expect to pay the full sticker price. The sticker price is simply a reference point. The salesperson interacts with the buyer, attempts to ascertain his or her reservation price, and then charges accordingly. Thus, it is in your interest to not appear overly eager when buying new car.

Schemes that Approximate First-Degree Price Discrimination

Even though sellers are not likely to know the consumers' demand schedules, there are pricing schemes that can come close to first-degree price discrimination. These can occur if consumer demands are very similar, i.e., each consumer has about the same demand for the product. Before explaining why, it is useful to emphasize a couple of points about the models used to understand these pricing schemes and some that will follow later in the chapter:

1. The models that follow use individual-level demands as opposed to the market demand. An individual demand schedule reflects the demand for a given consumer (or the demand from a given segment of consumers). The market demand is the sum of these individual demands.
2. It will be assumed that marginal cost is constant with volume. In addition to simplifying the analysis, a constant marginal cost is probably not unreasonable given output changes necessary to respond to demand at the scale of the individual consumer.

In addition to these two points, it is useful to revisit the difference between consumer surplus under a competitive ($P = MC$) outcome relative to the monopolist ($MR = MC$) outcome. Consider a case where all individual demand curves can be expressed in inverse form as

$$P = 5 - 0.5Q,$$

and marginal cost is given by MC=3MC=3.

If the market is competitive ($P = MC$), each consumer buys four units at a price of $3 each and receives consumer surplus of $4. This is shown in Panel A of Figure 1. If, on the other hand, quantity is set so that marginal revenue from each consumer equals marginal cost (the monopolist's solution), the monopolist gets economic profits of $2 from each consumer, $1 is left for each consumer as surplus, and $1 is lost because of the resource distortion inherent in the monopoly solution. This is shown in Panel B of Figure $9.8.1$.

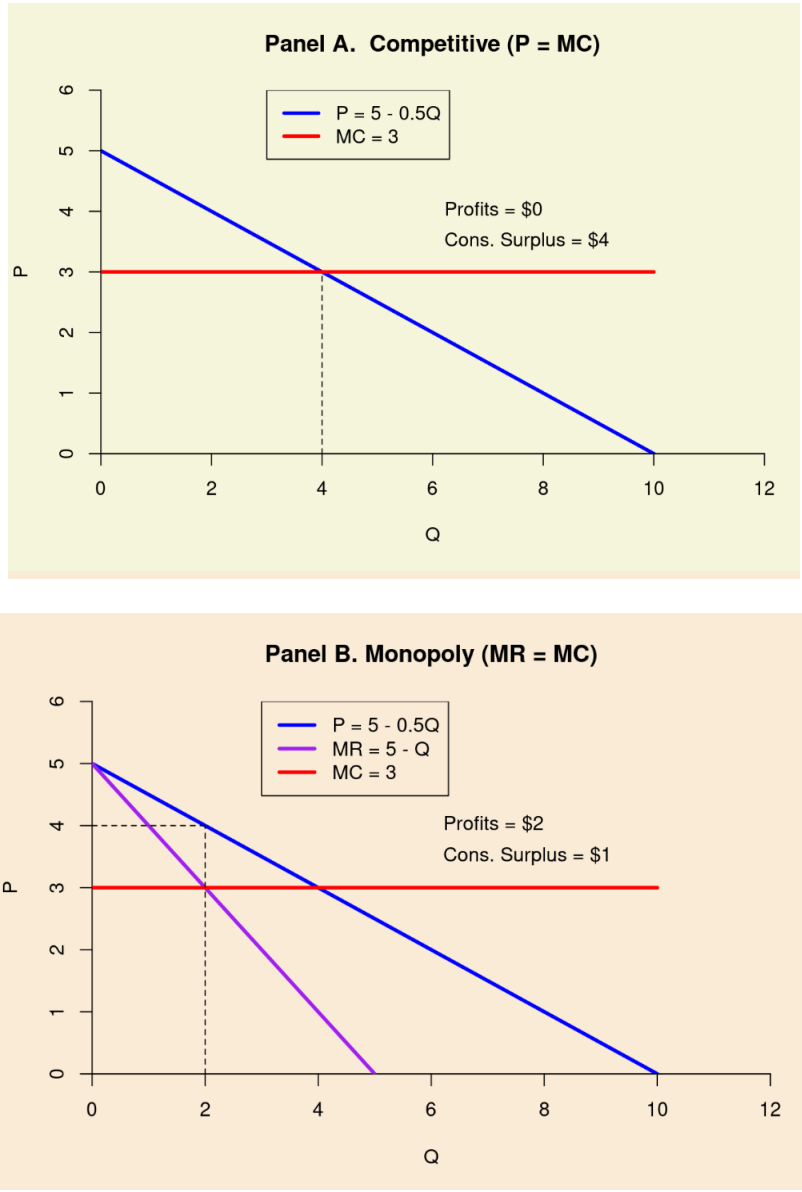


Figure 9.8.1: **By pricing as a monopolist the firm can appropriate some but not all of the potentially available consumer surplus.**

Could the firm do better then simply pricing as a monopolist? After all, the monopolist in this example leaves half of the potential surplus on the table. Specifically, $1 remains with the consumer and $1 goes away in the form of a dead-weight loss. It turns out that the answer to this question is yes. Because each consumer has the same demand curve, the firm can do much better. The firm can implement one of two pricing schemes:

1. Bundle the goods and sell bundles.
2. Charge an access fee that is equal to consumer surplus then set the price per unit equal to marginal cost.

Bundle Pricing

The seller that faced the consumers each with the individual demand curve in Figure 1 could sell four-unit bundles and charge a bundle price. The bundle price would equal to the consumer's maximum willingness to pay for the four units, which is the entire area under the demand curve as we move from zero to four units. This is $16/bundle and is computed as the consumer surplus of $4 in Panel A of Figure 1 plus the $12 cost of producing the four-unit bundle.

With the bundle pricing scheme, the firm only offers bundles for sale. Consumers cannot buy individual units. They must buy bundles of four and pay the $16 price or not buy the product at all. The bundle price is set at the consumer's maximum willingness

to pay. No surplus is left for the consumer. In this example the bundle pricing scheme results in $4 in economic profits, double the profits that could be obtained by pricing as a monopolist.

Access Fees

Alternatively, the firm could charge an access fee of $4. Again, this is equal to the consumer surplus shown in Panel A of Figure 9.8.1. The price per unit is then set at MC or $3/unit. The consumer who pays the access fee is then able to purchase all he or she wants at $3/unit. Note, however, that the consumer will only purchase four units. His or her willingness to pay for additional units beyond four is less than the $3 price. In the end, the firm receives $16 from each customer (the $4 access fee and the $12 in product sales). Again the access-fee scheme results in profits of $4 from each consumer, which is double the profits of pricing as a monopolist. Some examples of access fees include all-you-can-eat buffets, cover charges at a bar or night club, and membership fees at a club store. In each of these situations the consumer pays up-front for access to a facility. Once in the facility, he or she can consume/purchase items at a fixed price (which could be zero in the case of an all you can eat buffet) and stops consuming once the willingness to pay for an additional consumption item exceeds the set price.

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9.9: Second-Degree Price Discrimination

Second-degree price discrimination can occur when there are different segments of consumers, for example, high demand customers and low demand customers. However, the firm is unable to accurately assign a customer to a segment prior to the sale. In this case, the seller provides volume discounts, essentially bundle pricing, but offers different amounts in the bundles at different prices. The separate bundles are carefully calibrated to extract the most surplus possible from each market segment. Schemes aimed at second-degree price discrimination are encountered every day (e.g., family-sized packaging).

The problem facing the seller is that he or she cannot assign consumers to one segment or another. Thus, the seller needs to set the bundles so that members of each segment self select into a particular bundle. To successfully implement second-degree price discrimination, the bundles must be designed so that the small bundle is most attractive to the low-demand customers and the large bundle is most attractive to the high-demand customers.

The firm must be careful when setting the volume discount. In fact, for second-degree price discrimination to work, the volume discount must satisfy the following conditions:

1. The small bundle must be attractive to the low-demand segment (non-negative surplus).
2. The large bundle must be attractive to the high-demand segment (non-negative surplus).
3. The small bundle must provide a value to the low-demand segment that is at least as good as the large bundle.
4. The large bundle must provide a value to the high-demand segment that is at least as good as the small bundle.

The first two conditions are called participation constraints. They will be satisfied provided the prices charged for the small and large bundles do not exceed the total willingness to pay of low-demand and high-demand customers, respectively. The last two conditions are called self-selection constraints and must be satisfied in order for the low-demand customers to voluntarily choose the small bundle and the high-demand customers to voluntarily choose the large bundle.

To meet these constraints, the firm should choose the size of the small bundle and set its price in order to extract the entire willingness to pay from the low-demand segment. By doing so, the firm gets as much as it can while still satisfying the participation constraint (specifically, the condition 1 above). Consumer surplus for low-demand customers will be zero.

The firm will then choose the size of the large bundle and set its price in order to capture as much of the high-demand customers' willingness to pay as possible. However, unlike the low-demand segment, the firm will be unable to extract the entire magnitude of willingness to pay from the high-demand customers. Consequently, high-demand customers will have positive consumer surplus. To see why, note that the high-demand segment will derive a strictly positive net benefit from purchasing the small bundle. Consequently, if the firm were to set the large bundle and its price in a fashion that took all of the consumer surplus from high-demand customers, the high-demand customers would simply choose small bundles instead. In other words, the self-selection constraint (condition 4) would not hold. Thus, the firm must design and price the large bundle so that it provides at least as much surplus to high-demand customers as does the small bundle.

An example of a pricing scheme that meets all four conditions is presented in Figure $9.9.1$. Panel A shows demand for a low-demand consumer. Panel B shows the demand for a high-demand consumer. The small bundle offered to the low-demand consumer consists of a two units. The low-demand consumer is charged his or her full willingness to pay (the area under the demand curve from 0 to 2 units) of $12. The size and price of the small bundle are determined in exactly the same way as described above under the bundle-pricing scheme.

The important thing is that a high-demand consumer gets positive surplus if they buy this small bundle. In this case, the high-demand consumer gets surplus of $4 from the small bundle. For this reason, the firm cannot charge the high-demand consumer his or her full willingness to pay for the large bundle. If it did, the high-demand consumer would simply buy small bundles in order to get positive surplus. Thus, the firm must set the price of the large bundle so that it provides at least $4 in surplus. The large bundle is set at three units. The large bundle price is set at no more than $17, which induces the high-demand consumer to purchase the large bundle. The per-unit price of the large bundle is $0.33 lower than the per unit price of the small bundle. Thus, the firm is giving the high-demand consumer a volume discount.

This volume discount is not offered because the firm is trying to be nice to its high-demand consumers. The volume discount allows it to make more money. It makes $4 by selling the small bundle. It makes $5 when it sells the large bundle. Thus, the ability to sell extra to the high-demand customers via the large bundle allows the firm to be more profitable. The volume discount

described above is discriminatory because it allows the firm to price in a way that exploits differences in demand between the high- and low-demand segments. That said, not all volume discounts are discriminatory. For example, if it is less costly to package an deliver larger lots, volume discounts could represent differences in cost of providing the good in larger lots, not differences in willingness to pay.

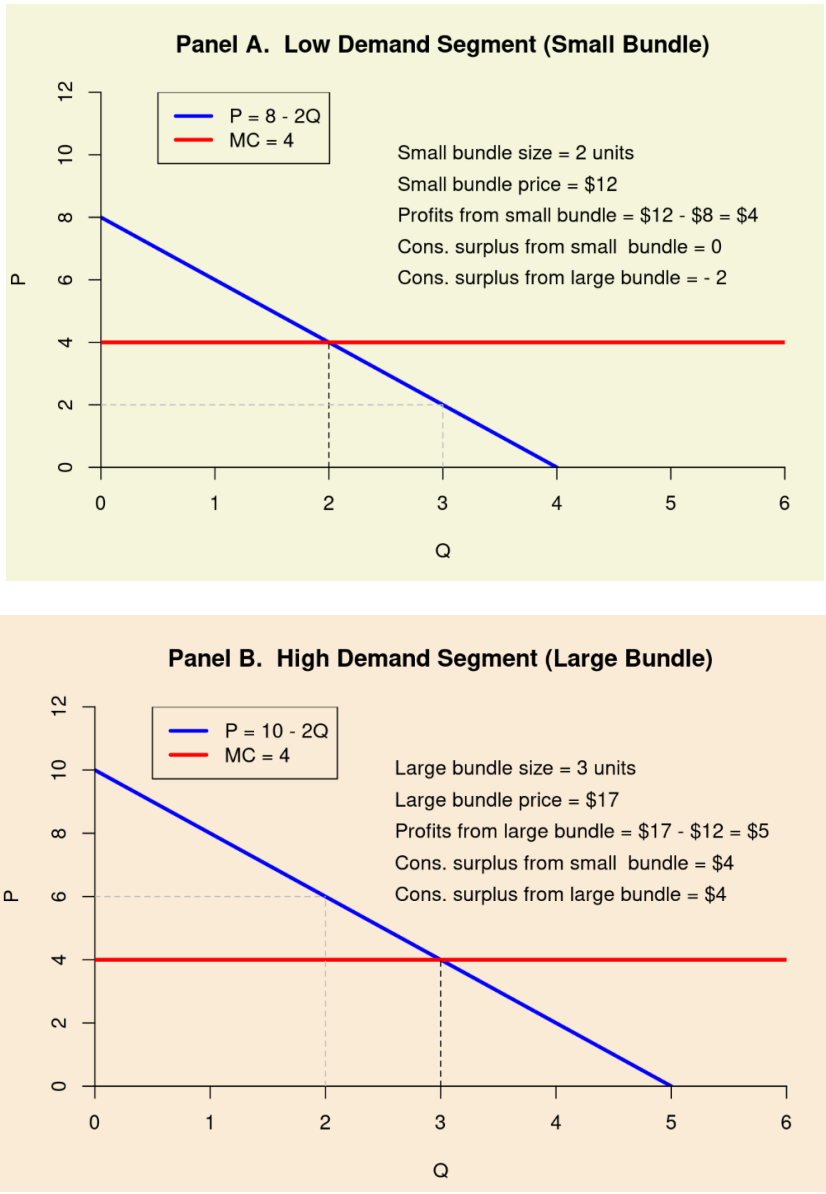


Figure 9.9.1: **An example of second-degree price discrimination meeting all four constraints.**

Let us take a moment to verify that the example in Figure 9.9.1 meets the participation and self selection constraints.

1. **The small bundle must be attractive to the low-demand segment (non-negative surplus).** This constraint is met in the example. The price of the small bundle just equals the willingness to pay of the low-demand segment. This is the highest the price can be and still have a bundle that is attractive enough for low-demand segment to participate. Surplus is zero but not negative.
2. **The large bundle must be attractive to the high-demand segment (non-negative surplus).** This constraint is met in the above example. High-demand consumers get $4 of surplus from the large bundle.
3. **The small bundle must provide a value to the low-demand segment that is at least as good as the large bundle.** In this example, the small bundle provides no consumer surplus to the low-demand consumer, but the large bundle provides -$4 of surplus.
4. **The large bundle must provide a value to the high-demand segment that is at least as good as the small bundle.** In this example, it does; the large bundle provides surplus of $4 to the high-demand consumer. This is exactly what could have

been obtained from the small bundle.

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9.10: Third-Degree Price Discrimination

If the seller can easily identify customers with different demand elasticities, then the seller may be able to employ **third-degree price discrimination**. There are many examples of third-degree price discrimination. These include senior citizen or student discounts, weekend (weekday) rates, and variable utility rates. Historically, federal marketing orders for agricultural products have been offered as examples of third-degree price discrimination. For example, the federal milk marketing orders reflect differences in demand for milk sold for use as a beverage, soft dairy products (e.g., yogurts and soft cheeses), hard dairy products (e.g., butter and hard cheeses), dry milk (Chouinard et al. 2010). For third-degree price discrimination to work, the following conditions must hold:

1. The firm can assign customers into distinct groups and enforce differential pricing by group or there is a relatively straightforward mechanism of self selection.
2. Reselling between consumer groups is not feasible. Otherwise, arbitrage will occur between segments with different demands.
3. The different groups have different elasticities of demand. Otherwise, there is no point in offering different prices to different segments even if differential pricing by segment is possible.
4. The deals being offered must be socially benign.

With third-degree price discrimination, bundling or charging access fees are not possible. If it were, the firm would simply offer different bundles or different access fees to each segment and would approximate first-degree price discrimination in each segment. In third-degree price discrimination, the best the firm can do is charge the monopoly price to each segment. As you might recall from Chapter 7, each segment will be charged the price that satisfies $MC = P_i(1 + \frac{1}{\varepsilon_i})$, where ε_i is the elasticity of demand from the ith segment. Table $9.10.1$ provides an example of three segments, each with a different elasticity of demand. Verify that $MC = P_i(1 + \frac{1}{\varepsilon_i})$ for each segment in the table.

Table $9.10.1$: Prices charged to different segments under third-degree price discrimination

Value	Segment A	Segment B	Segment C
Marginal Cost	4.00	4.00	4.00
ε_i	-2.81	-2.55	-1.87
P_i	6.21	6.58	8.60

Note that in Table $9.10.1$, the firm does not face any difference in cost across the different segments. In each case, the marginal cost is $4. However, each segment is charged a different price. The price is based solely on the differences in the elasticity of demand. Note that Segment C pays the highest price. Members of this segment have the least elastic demand. Members of segment A pay the lowest price; they have the most elastic demand.

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9.11: Some Other Pricing Schemes

There are several other pricing schemes that are commonly encountered. Some of these have elements of discrimination. **Package pricing**, or bundling across products or services, can benefit the seller in some circumstances. Often, goods or services are priced and sold as a take-it-or-leave-it package. Some examples include vacation packages, combo meals, cable TV packages. Table 9.11.1 helps to illustrate why package pricing could makes sense.

Table 9.11.1. Valuations for different food items across three customers

Customers	Fries	Sandwich	Drink	Total Bundle
Customer A	2.00	5.00	0.75	7.75
Customer B	2.50	3.50	1.50	7.50
Customer C	1.75	4.25	1.00	7.00

Let us consider the case where the firm's costs are such that it is most profitable to have each customer in the market for each item. In this case, the highest price the firm can charge without bundling is the lowest willingness to pay for each item. Without package pricing, the firm can charge $1.75 for the fries, $3.50 for the sandwich, and $0.75 for the drink. It gets $6.00 in revenue from each customer. By offering take-it-or-leave-it combo packages, the firm can charge $7.00 per package. This represents a nice 16.7 percent increase in revenue per customer.

Contractual tie-in sales are another way to extract additional revenues from high-demand customers when the firm is unable to distinguish between high- and low-demand a priori but plans to enter into a long-term contractual relationship. The logic is that all customers are charged the same entry fee. Once on board, the high-demand customer generates more revenue from tie-in sales. The best example is a franchise. After entering into franchise agreement, the franchisee will normally need to buy inputs from the franchisor. High-demand franchisees, those with good locations and brisk businesses, will therefore generate more revenue for the franchisor than the low-demand franchisees.

Captive product pricing is a similar, related pricing strategy but without contractual obligations (e.g., vacuum cleaner bags, replacement blades for hand razors, printer cartridges). In these cases, the product itself, e.g., the shaving handle or inkjet printer, is priced low and may even be given away. The revenue is made on high-priced sales of replacement components, e.g., razor blades or ink cartridges, which the consumer purchases once he/she becomes captive.

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9.12: Concluding Comments

Through this chapter you have learned about several pricing schemes that are commonly used to convert would-be consumer surplus into higher profits. The content of this chapter is a natural extension to the material presented in Chapter 7 and represents extensions wherein discriminatory pricing strategies may bring about outcomes that are superior, from the firms perspective, to monopoly pricing. Importantly, some of these schemes could result in outcomes that are socially superior as well. In particular, if a firm is able to perfectly price discriminate, all consumer surplus is converted to profit, but the allocation of resources is efficient and the economy avoids the dead-weight loss to occurs under monopoly pricing. The issue is the distribution of value from a transaction between buyer and seller. As you complete problems sets 1 and 2 below, note that consumer surplus that would have accrued to buyers under the competitive outcome simply gets transformed into profits when the seller is able to perfectly price discriminate.

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9.13: References

Lieberman, J. K. and G. J. Siedel. 1989. *The Legal Environment of Business*. Harcourt Brace Jovanovich.

Chouinard, H. H., D. E. Davis, J. T. LaFrance, and J. M. Perloff. 2010. Milk marketing order winners and losers. *Applied Economic Perspectives and Policy* 32 (1): 59-76.

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9.14: Problem Sets

Problem Set 1. Bundle pricing (approximates first-degree price discrimination).

Exercise 9.1

Given the following:

The individual inverse demand is P = 10-2Q.

Marginal cost is 4.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.2

Given the following:

The individual inverse demand is P = 9-3Q.

Marginal cost is 3.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.3

Given the following:

The individual inverse demand is P = 6-1.5Q.

Marginal cost is 3.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.4

Given the following:

The individual inverse demand is P = 12-2Q.

Marginal cost is 6.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.5

Given the following:

The individual inverse demand is P = 24-3Q.

Marginal cost is 6.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.6

Given the following:

The individual inverse demand is P = 32-4Q.

Marginal cost is 16.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.7

Given the following:

The individual inverse demand is P = 20-2Q.

Marginal cost is 10.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.8

Given the following:

The individual inverse demand is P = 12-3Q.

Marginal cost is 6.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.9

Given the following:

The individual inverse demand is P = 15-3Q.

Marginal cost is 3.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Exercise 9.10

Given the following:

The individual inverse demand is P = 8-2Q.

Marginal cost is 4.

Assume all individuals in the market have this inverse demand.

What is the bundle size, bundle price, and profits per bundle?

What is consumer surplus after purchasing the bundle?

Answer available at the end of this section.

Problem Set 2. Access fee (approximates first-degree price discrimination).

Exercise 9.11

Given the following:

The individual inverse demand is P = 10-2Q.

Marginal cost is 4.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.12

Given the following:

The individual inverse demand is P = 9-3Q.

Marginal cost is 3.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.13

Given the following:

The individual inverse demand is P = 6-1.5Q.

Marginal cost is 3.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.14

Given the following:

The individual inverse demand is P = 12-2Q.

Marginal cost is 6.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.15

Given the following:

The individual inverse demand is P = 24-3Q.

Marginal cost is 6.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.16

Given the following:

The individual inverse demand is P = 32-4Q.

Marginal cost is 16.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.17

Given the following:

The individual inverse demand is P = 20-2Q.

Marginal cost is 10.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.18

Given the following:

The individual inverse demand is P = 12-3Q.

Marginal cost is 6.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.19

Given the following:

The individual inverse demand is P = 15-3Q.

Marginal cost is 3.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Exercise 9.20

Given the following:

The individual inverse demand is P = 8-2Q.

Marginal cost is 4.

Assume all individuals in the market have this inverse demand.

What is the access fee and per-unit price?

How many units will each customer purchase after paying the access fee?

What are the firm's profits per customer?

How much consumer surplus does each customer get?

Answer available at the end of this section.

Problem Set 3. Prices charged to each segment (third-degree price discrimination).

Exercise 9.21

Given the following:

Sement 1's elasticity is -2.

Sement 2's elasticity is -3.

Marginal cost is 2.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.22

Given the following:

Sement 1's elasticity is -4.

Sement 2's elasticity is -1.5.

Marginal cost is 3.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.23

Given the following:

Sement 1's elasticity is -3.

Sement 2's elasticity is -2.

Marginal cost is 4.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.24

Given the following:

Sement 1's elasticity is -2.

Sement 2's elasticity is -1.5.

Marginal cost is 5.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.25

Given the following:

Sement 1's elasticity is -2.

Sement 2's elasticity is -3.

Marginal cost is 4.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.26

Given the following:

Sement 1's elasticity is -4.

Sement 2's elasticity is -2.

Marginal cost is 3.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.27

Given the following:

Sement 1's elasticity is -2.

Sement 2's elasticity is -3.

Marginal cost is 2.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.28

Given the following:

Sement 1's elasticity is -4.

Sement 2's elasticity is -2.

Marginal cost is 3.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.29

Given the following:

Sement 1's elasticity is -4.

Sement 2's elasticity is -2.

Marginal cost is 6.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Exercise 9.30

Given the following:

Sement 1's elasticity is -6.

Sement 2's elasticity is -2.

Marginal cost is 5.

Assume third-degree price discrimination is feasible.

What price is charged to Segment 1?

What price is charged to Segment 2?

Answer available at the end of this section.

Problem Set 4. Multiple Choice

Exercise 9.31

1. **Which best explains price discrimination?**

a) Charging different prices based on quality differences

b) Charging higher prices to reflect higher costs of service

c) Charging different prices for the same product based on willingness to pay

d) All of the above

Answer available at the end of this section.

Exercise 9.32

2. **Which practice is most consistent with second-degree price discrimination?**

a) Charging access fees that are equal to consumer surplus

b) Volume discounts

c) Special offers for groups of consumers (e.g., student discounts)

d) All of the above

Answer available at the end of this section.

Exercise 9.33

3. **Which practice could approximate first-degree price discrimination?**

a) Charging access fees that are equal to consumer surplus

b) Volume discounts

c) Special offers for groups of consumers (e.g., student discounts)

d) All of the above

Answer available at the end of this section.

Exercise 9.34

4. **Under third-degree price discrimination**

a) The firm takes the consumer's entire surplus

b) The firm sets the monopoly or monopolistically competitive price (MR = MC) in each of the market segments it faces

c) The firm must worry about self-selection constraints and so must leave some surplus for high demand customers

d) The firm charges the competitive price (P = MC)

Answer available at the end of this section.

Exercise 9.35

5. **If individual demands are homogeneous, bundle pricing can approximate**

a) First-degree price discrimination

b) Second-degree price discrimination

c) Third-degree price discrimination

d) Fourth-degree price discrimination

Answer available at the end of this section.

Exercise 9.36

6. **If individual demands are homogeneous, an access fee plus fixed price per unit can approximate**

a) First-degree price discrimination

b) Second-degree price discrimination

c) Third-degree price discrimination

d) Fourth-degree price discrimination

Answer available at the end of this section.

Exercise 9.37

7. **In which case does the seller set price to take the consumer's entire surplus?**

a) First-degree price discrimination

b) Second-degree price discrimination

c) Third-degree price discrimination

d) Fourth-degree price discrimination

Answer available at the end of this section.

Exercise 9.38

8. **When would third-degree price discrimination *not* work?**

a) When the market can be divided into segments with very different elasticities of demand

b) When all market segments have very similar elasticities of demand

c) When resale between segments is easy

d) Both (b) and (c)

Answer available at the end of this section.

Answers

Exercise 9.1

The bundle size is 3 units.
The bundle price is 21 dollars.
Profits per bundle are 9 dollars.
Consumer surplus is 0 dollars.

Exercise 9.2

The bundle size is 2 units.
The bundle price is 12 dollars.
Profits per bundle are 6 dollars.
Consumer surplus is 0 dollars.

Exercise 9.3

The bundle size is 2 units.
The bundle price is 9 dollars.
Profits per bundle are 3 dollars.
Consumer surplus is 0 dollars.

Exercise 9.4

The bundle size is 3 units.
The bundle price is 27 dollars.
Profits per bundle are 9 dollars.
Consumer surplus is 0 dollars.

Exercise 9.5

The bundle size is 6 units.
The bundle price is 90 dollars.
Profits per bundle are 54 dollars.
Consumer surplus is 0 dollars.

Exercise 9.6

Add texts here. Do not delete this text first.

Exercise 9.7

The bundle size is 5 units.
The bundle price is 75 dollars.
Profits per bundle are 25 dollars.
Consumer surplus is 0 dollars.

Exercise 9.8

The bundle size is 2 units.
The bundle price is 18 dollars.
Profits per bundle are 6 dollars.
Consumer surplus is 0 dollars.

Exercise 9.9

The bundle size is 4 units.
The bundle price is 36 dollars.
Profits per bundle are 24 dollars.
Consumer surplus is 0 dollars.

Exercise 9.10

The bundle size is 2 units.
The bundle price is 12 dollars.
Profits per bundle are 4 dollars.
Consumer surplus is 0 dollars.

Exercise 9.11

The access fee is 9 dollars.
The per-unit price is 4 dollars.
Each customer buys 3 units.
Profits per customer are 9 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.12

The access fee is 6 dollars.
The per-unit price is 3 dollars.
Each customer buys 2 units.

Profits per customer are 6 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.13

The access fee is 3 dollars.
The per-unit price is 3 dollars.
Each customer buys 2 units.
Profits per customer are 3 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.14

The access fee is 9 dollars.
The per-unit price is 6 dollars.
Each customer buys 3 units.
Profits per customer are 9 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.15

The access fee is 54 dollars.
The per-unit price is 6 dollars.
Each customer buys 6 units.
Profits per customer are 54 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.16

The access fee is 32 dollars.
The per-unit price is 16 dollars.
Each customer buys 4 units.
Profits per customer are 32 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.17

The access fee is 25 dollars.
The per-unit price is 10 dollars.
Each customer buys 5 units.
Profits per customer are 25 dollars.
Each customer's surplus is 0 dollars

Exercise 9.18

The access fee is 6 dollars.
The per-unit price is 6 dollars.
Each customer buys 2 units.
Profits per customer are 6 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.19

The access fee is 24 dollars.
The per-unit price is 3 dollars.
Each customer buys 4 units.
Profits per customer are 24 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.20

The access fee is 4 dollars.
The per-unit price is 4 dollars.
Each customer buys 2 units.
Profits per customer are 4 dollars.
Each customer's surplus is 0 dollars.

Exercise 9.21

Segment 1 is charged 4 dollars.
Segment 2 is charged 3 dollars.

Exercise 9.22

Segment 1 is charged 4 dollars.
Segment 2 is charged 9 dollars.

Exercise 9.23

Segment 1 is charged 6 dollars.
Segment 2 is charged 8 dollars.

Exercise 9.24

Segment 1 is charged 10 dollars.
Segment 2 is charged 15 dollars.

Exercise 9.25

Segment 1 is charged 8 dollars.
Segment 2 is charged 6 dollars.

Exercise 9.26

Segment 1 is charged 4 dollars.
Segment 2 is charged 6 dollars.

Exercise 9.27

Segment 1 is charged 4 dollars.
Segment 2 is charged 3 dollars.

Exercise 9.28

Segment 1 is charged 4 dollars.
Segment 2 is charged 6 dollars.

Exercise 9.29

Segment 1 is charged 8 dollars.
Segment 2 is charged 12 dollars.

Exercise 9.30

Segment 1 is charged 6 dollars.
Segment 2 is charged 10 dollars.

Exercise 9.31

c

Exercise 9.32

b

Exercise 9.33

a

Exercise 9.34

b

Exercise 9.35

a

Exercise 9.36

a

Exercise 9.37

a

Exercise 9.38

d

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10: STRATEGIC INTERACTIVE AND GAME THEORY IN MARKETS

10.1: Game Theory Introduction
10.2: Cooperative Strategy (Collusion)
10.3: Repeated and Sequential Games
10.4: First Mover Advantage
10.5: Problem Sets

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10.1: Game Theory Introduction

Learning Objectives

- **Define** and apply core concepts from game theory (players, payoffs, strategies, equilibrium).
- **Distinguish** between cooperative and non-cooperative strategies.
- **Explain** dominant strategies, Nash equilibrium, and maximin reasoning.
- **Analyze** repeated and sequential games in agricultural markets.
- **Explain** first-mover advantage and credible commitments in real markets.
- **Apply** these concepts to pricing, advertising, and production decisions in agribusiness.

In competitive markets—especially agricultural and food markets—businesses constantly make decisions while anticipating how rivals will respond. Should a firm set high or low prices? Advertise or stay quiet? Enter a new market now, or wait? These strategic choices are the foundation of **game theory**.

Game theory helps us understand situations where each decision-maker's outcome depends on the choices of others. From farmers deciding when to harvest to firms setting beef prices, these concepts explain real-world market behavior and strategic thinking in agribusiness.

Game theory was introduced in the previous chapter to better understand oligopoly. Recall the definition of game theory.

Game Theory = A framework to study strategic interactions between players, firms, or nations.

Game theory is the study of strategic interactions between players. The key to understanding strategic decision making is to understand your opponent's point of view, and to deduce his or her likely responses to your actions.

A game is defined as:

Game = A situation in which firms make strategic decisions that take into account each other's' actions and responses.

A payoff is the outcome of a game that depends of the selected strategies of the players.

Payoff = The value associated with a possible outcome of a game.

Strategy = A rule or plan of action for playing a game.

An optimal strategy is one that provides the best payoff for a player in a game.

Optimal Strategy = A strategy that maximizes a player's expected payoff.

Games are of two types: cooperative and noncooperative games.

Cooperative Game = A game in which participants can negotiate binding contracts that allow them to plan joint strategies.

Noncooperative Game = A game in which negotiation and enforcement of binding contracts are not possible.

In noncooperative games, individual players take actions, and the outcome of the game is described by the action taken by each player, along with the payoff that each player achieves. Cooperative games are different. The outcome of a cooperative game will be specified by which group of players become a cooperative group, and the joint action that the group takes. The groups of players are called, "coalitions." Examples of noncooperative games include checkers, the prisoner's dilemma, and most business situations where there is competition for a payoff. An example of a cooperative game is a joint venture of several companies who band together to form a group (collusioin).

The discussion of the prisoner's dilemma led to one solution to games: the equilibrium in dominant strategies. There are several different strategies and solutions for games, including:

1. Dominant strategy
2. Nash equilibrium
3. Maximin strategy (safety first, or secure strategy)
4. Cooperative strategy (collusion).

Equilibrium in Dominant Strategies

The dominant strategy was introduced in the previous chapter.

Dominant Strategy = A strategy that results in the highest payoff to a player regardless of the opponent's action.

Equilibrium in Dominant Strategies = An outcome of a game in which each firm is doing the best that it can regardless of what its competitor is doing

Recall the prisoner's dilemma from Chapter Five.

		PRISONER B	
		CONFESS	NOT CONFESS
PRISONER A	CONFESS	(8,8)	(1, 15)
	NOT CONFESS	(15,1)	(3,3)

Figure 10.1.1: Prisoner's Dilemma

Prisoner's Dilemma: Dominant Strategy

(1) If B CONF, A should CONF $(8 < 15)$

(2) If B NOT, A should CONF $(1 < 3)$

...A has the same strategy (CONF) no matter what B does.

(3) If A CONF, B should CONF $(8 < 15)$

(4) If A NOT, B should CONF $(1 < 3)$

...B has the same strategy (CONF) no matter what A does.

Thus, the equilibrium in dominant strategies for this game is $(\text{CONF}, \text{CONF}) = (8, 8)$.

Nash Equilibrium

A second solution to games is a Nash Equilibrium.

Nash Equilibrium = A set of strategies in which each player has chosen its best strategy given the strategy of its rivals.

To solve for a Nash Equilibrium:

(1) Check each outcome of a game to see if any player wants to change strategies, given the strategy of its rival.

(a) If no player wants to change, the outcome is a Nash Equilibrium.

(b) If one or more player wants to change, the outcome is not a Nash Equilibrium.

A game may have zero, one, or more than one Nash Equilibria. The Prisoner's Dilemma is shown in Figure $10.1.1$. We will determine if this game has any Nash Equilibria.

Prisoner's Dilemma - Nash Equilibrium

(1) Outcome $=$ $(\mathrm{CONF},\ \mathrm{CONF})$

(a) Is CONF best for A given B CONF? Yes.

(b) Is CONF best for B given A CONF? Yes.

...$(\mathrm{CONF},\ \mathrm{CONF})$ is a Nash Equilibrium.

(2) Outcome $=$ $(\mathrm{CONF},\ \mathrm{NOT})$

(a) Is CONF best for A given B NOT? Yes.

(b) Is NOT best for B given A CONF? No.

...$(\mathrm{CONF},\ \mathrm{NOT})$ is not a Nash Equilibrium.

(3) Outcome $=$ $(\mathrm{NOT},\ \mathrm{CONF})$

(a) Is NOT best for A given B CONF? No.

(b) Is CONF best for B given A NOT? Yes.

...$(\mathrm{NOT},\ \mathrm{CONF})$ is not a Nash Equilibrium.

(4) Outcome $=$ $(\mathrm{NOT},\ \mathrm{NOT})$

(a) Is NOT best for A given B NOT? No.

(b) Is NOT best for B given A NOT? No.

...$(\mathrm{NOT},\ \mathrm{NOT})$ is not a Nash Equilibrium.

Therefore, $(\mathrm{CONF},\ \mathrm{CONF})$ is a Nash Equilibrium, and the only one Nash Equilibrium in the Prisoner's Dilemma game. Note that in the Prisoner's Dilemma game, the Equilibrium in Dominant Strategies is also a Nash Equilibrium.

Advertising Game

In this advertising game, two computer software firms (Microsoft and Apple) decide whether to advertise or not. The outcomes depend on their own selected strategy and the strategy of the rival firm, as shown in Figure $10.1.2$.

		APPLE	
		ADVERTISE	NOT ADVERTISE
MICROSOFT	ADVERTISE	(20, 20)	(10, 5)
	NOT ADVERTISE	(5, 10)	(14, 14)

Figure 10.1.2: Advertising: Two Software Firms. Outcomes in million USD.

Advertising: Dominant Strategy

(1) If $\mathrm{APP\ AD}$, MIC should AD $(20 > 5)$

(2) If $\mathrm{APP\ NOT}$, MIC should NOT $(14 > 10)$

...different strategies, so no dominant strategy for Microsoft.

(3) If $\mathrm{MIC\ AD}$, APP should AD $(20 > 5)$

(4) If $\mathrm{MIC\ NOT}$, APP should NOT $(14 > 10)$

...different strategies, so no dominant strategy for Apple.

Thus, there are no dominant strategies, and no equilibrium in dominant strategies for this game.

Advertising: Nash Equilibria

(1) Outcome $= (\mathrm{AD}, \mathrm{AD})$

(a) Is AD best for MIC given $\mathrm{APP\ AD}$? Yes.

(b) Is AD best for \(\text{APP\) given $\mathrm{MIC\ AD}$? Yes.

...$(\mathrm{AD}, \mathrm{AD})$ is a Nash Equilibrium.

(2) Outcome $= (\mathrm{AD}, \mathrm{NOT})$

(a) Is AD best for MIC given $\mathrm{APP\ NOT}$? No.

(b) Is NOT best for APP given $\mathrm{MIC\ AD}$? No.

...$(\mathrm{AD}, \mathrm{NOT})$ is not a Nash Equilibrium.

(3) Outcome $= (\mathrm{NOT}, \mathrm{AD})$

(a) Is NOT best for MIC given $\mathrm{APP\ AD}$? No.

(b) Is AD best for APP given $\mathrm{MIC\ NOT}$? No.

...$(\mathrm{NOT}, \mathrm{AD})$ is not a Nash Equilibrium.

(4) Outcome $= (\mathrm{NOT}, \mathrm{NOT})$

(a) Is NOT best for MIC given $\mathrm{APP\ NOT}$? Yes.

(b) Is NOT best for APP given $\mathrm{MIC\ NOT}$? Yes.

...$(\mathrm{NOT},\ \mathrm{NOT})$ is a Nash Equilibrium.

There are two Nash Equilibria in the Advertising game: $(\mathrm{AD},\ \mathrm{AD})$ and $(\mathrm{NOT},\ \mathrm{NOT})$. Therefore, in the Advertising game, there are two Nash Equilibria, and no Equilibrium in Dominant Strategies.

It can be proven that in game theory, every Equilibrium in Dominant Strategies is a Nash Equilibrium. However, a Nash Equilibrium may or may not be an Equilibrium in Dominant Strategies.

Maximin Strategy (Safety First; Secure Strategy)

A strategy that allows players to avoid the largest losses is the Maximin Strategy.

Maximin Strategy = A strategy that maximizes the minimum payoff for one player.

The maximin, or safety first, strategy can be found by identifying the worst possible outcome for each strategy. Then, choose the strategy where the lowest payoff is the highest.

6.1.9 Prisoner's Dilemma: Maximin Strategy (Safety First)

We use Figure $10.1.2$ to find the Maximin Strategy for the Prisoner's Dilemma.

(1) Player A

(a) If CONF, worst payoff $= 8$ years.

(b) If NOT, worst payoff $= 15$ years.

...A's Maximin Strategy is $\mathrm{CONF}\ (8 < 15)$.

(2) Player B

(a) If CONF, worst payoff $= 8$ years.

(b) If NOT, worst payoff $= 15$ years.

...B's Maximin Strategy is $\mathrm{CONF}\ (8 < 15)$.

Therefore, the Maximin Equilibrium for the Prisoner's Dilemma is $(\mathrm{CONF},\ \mathrm{CONF})$. This outcome is also an Equilibrium in Dominant Strategies, and a Nash Equilibrium.

Advertising Game: Maximin Strategy (Safety First)

(1) $\mathrm{MICROSOFT}$

(a) If AD, worst payoff $= 10$.

(b) If NOT, worst payoff $= 5$.

...MICROSOFT's Maximin Strategy is $\mathrm{AD}\ (5 < 10)$.

(2) APPLE

(a) If AD, worst payoff $= 10$.

(b) If NOT, worst payoff $= 5$.

...APPLE's Maximin Strategy is $\mathrm{AD}\ (5 < 10)$.

Therefore, the Maximin Equilibrium in the Advertising game is $(\mathrm{AD},\ \mathrm{AD})$. Recall that this outcome is one of two Nash Equilibria in the advertising game: $(\mathrm{AD},\ \mathrm{AD})$ and $(\mathrm{NOT},\ \mathrm{NOT})$. If both players choose Maximin, there is only one equilibrium: $(\mathrm{AD},\ \mathrm{AD})$.

1. The relationships between the game theory strategies can be summarized:
2. An Equilibrium in Dominant Strategies is always a Maximin Equilibrium.
3. A Maximin Equilibrium is NOT always an Equilibrium in Dominant Strategies.
4. An Equilibrium in Dominant Strategies is always a Nash Equilibrium. A Nash Equilibrium is NOT always an Equilibrium in Dominant Strategies.

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10.2: Cooperative Strategy (Collusion)

The cooperative strategy is defined as the best joint outcome for both players together.

Cooperative Strategy = A strategy that leads to the highest joint payoff for all players.

Thus, the cooperative strategy is identical to collusion, where players work together to achieve the best joint outcome. In the Prisoner's Dilemma (Figure 6.1), the cooperative outcome is found by summing the two players' outcomes together, and finding the outcome that has the smallest jail sentence for the prisoners together: $(\text{NOT}, \text{NOT}) = (3, 3)$.

This outcome is the collusive solution, which provides the best outcome if the prisoners could make a joint decision and stick with it. Of course, there is always the temptation to cheat on the agreement, where each player does better for themselves, at the expense of the other prisoner.

Similarly, the cooperative outcome in the advertising game (Figure 6.2) is $(\text{AD}, \text{AD}) = (20, 20)$. This outcome provides the highest profits ($= 40$ million USD) to both firms. Note that the advertising game is not a prisoner's dilemma, since there is no incentive to cheat once the cooperative solution has been achieved.

Game Theory Example: Steak Pricing Game

A pricing game for steaks if shown in Figure $10.2.1$. In this game, two beef processors, Tyson and JBS, are determining what price to charge for steaks. Suppose that these two firms are the major players in this steak market, and the outcomes depend on the strategies of both firms, since players choose which company to purchase from based on price. If both firms choose low prices, the outcome is low profits. Additional profits are earned by choosing high prices. However, when both firms have high prices, there is an incentive to undercut the other firm with a low price, to increase profits at the expense of the other firm.

		TYSON	
		LOW	HIGH
JBS	LOW	(2, 2)	(12, 0)
	HIGH	(0, 12)	(10, 10)

Figure $10.2.1$: Steak Pricing Game: Two Beef Firms. Outcomes in million USD.

Steak Pricing Game: Dominant Strategy

(1) If TYSON LOW, JBS should LOW $(2 > 0)$

(2) If TYSON HIGH, JBS should LOW $(12 > 10)$

...the dominant strategy for TYSON is LOW.

(3) If JBS LOW, TYSON should LOW $(2 > 0)$

(4) If JBS HIGH, TYSON should LOW $(12 > 10)$

... the dominant strategy for JBS is LOW.

The Equilibrium in Dominant Strategies for the Steak Pricing game is $(\mathrm{LOW},\ \mathrm{LOW})$. This is an unexpected result, since it is a less desirable scenario than $(\mathrm{HIGH},\ \mathrm{HIGH})$ for both firms. We have seen that an Equilibrium in Dominant Strategies is also a Nash Equilibrium and a Minimax Equilibrium. These results will be checked in what follows.

Steak Pricing Game: Nash Equilibrium

(1) Outcome $= (\mathrm{LOW},\ \mathrm{LOW})$

(a) Is LOW best for JBS given $\mathrm{TYSON\ LOW}$? Yes.

(b) Is LOW best for TYSON given $\mathrm{JBS\ LOW}$? Yes.

...$(\mathrm{LOW},\ \mathrm{LOW})$ is a Nash Equilibrium.

(2) Outcome $= (\mathrm{LOW},\ \mathrm{HIGH})$

(a) Is LOW best for JBS given $\mathrm{TYSON\ HIGH}$? Yes.

(b) Is HIGH best for TYSON given $\mathrm{JBS\ LOW}$? No.

...$(\mathrm{LOW},\ \mathrm{HIGH})$ is not a Nash Equilibrium.

(3) Outcome $= (\mathrm{HIGH},\ \mathrm{LOW})$

(a) Is HIGH best for JBS given $\mathrm{TYSON\ LOW}$? No.

(b) Is LOW best for TYSON given $\mathrm{JBS\ HIGH}$? Yes.

...$(\mathrm{HIGH},\ \mathrm{LOW})$ is not a Nash Equilibrium.

(4) Outcome $= (\mathrm{HIGH},\ \mathrm{HIGH})$

(a) Is HIGH best for JBS given $\mathrm{TYSON\ HIGH}$? No.

(b) Is HIGH best for TYSON given $\mathrm{JBS\ HIGH}$? No.

...$(\mathrm{HIGH},\ \mathrm{HIGH})$ is not a Nash Equilibrium.

Therefore, there is only one Nash Equilibrium in the Steak Pricing game: $(\mathrm{LOW},\ \mathrm{LOW})$.

Steak Pricing Game: Maximin Equilibrium (Safety First)

(1) JBS

(a) If LOW, worst payoff $= 2$.

(b) If HIGH, worst payoff $= 0$.

...JBS' Maximin Strategy is LOW $(0 < 2)$.

(2) TYSON

(a) If LOW, worst payoff $= 2$.

(b) If HIGH, worst payoff $= 0$.

...TYSON's Maximin Strategy is LOW $(0 < 2)$.

The Maximin Equilibrium in the Steak Pricing game is $(\mathrm{LOW},\ \mathrm{LOW})$. Interestingly, if both firms cooperated, they could achieve

much higher profits.

Steak Pricing Game: Cooperative Equilibrium (Collusion)

Both JBS and Tyson can see that if they were to cooperate, either explicitly or implicitly, profits would increase significantly. The cooperative outcome is $(\text{HIGH}, \text{HIGH}) = (10, 10)$. This is the outcome with the highest combined profits. Both firms are better off in this outcome, but each firm has an incentive to cheat on the agreement to increase profits from 10 m USD to 12 m USD.

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10.3: Repeated and Sequential Games

Repeated Games

A game that is played only once is called a “one-shot” game. Repeated games are games that are played over and over again.

Repeated Game = A game in which actions are taken and payoffs received over and over again.

Many oligopolists and real-life relationships can be characterized as a repeated game. Strategies in a repeated game are often more complex than strategies in a one-shot game, as the players need to be concerned about the reactions and potential retaliations of other players. As such, the players in repeated games are likely to choose cooperative or “win-win” strategies more often than in one shot games. Examples include concealed carry gun permits: are you more likely to start a fight in a no-gun establishment, or one that allows concealed carry guns? Franchises such as McDonalds were established to allow consumers to get a common product and consistent quality at locations new to them. This allows consumers to choose a product that they know will be the same, given the repeated game nature of the decision to purchase meals at McDonalds.

Sequential Games

A sequential game is played in “turns,” or “rounds” like chess or checkers, where each player takes a turn.

Sequential Game = A game in which players move in turns, responding to each others’ actions and reactions.

Product Choice Game One

An example of a sequential game is the product choice game shown in Figure 10.3.1.

		GENERAL MILLS	
		WHEAT	OAT
KELLOGGS	WHEAT	(-5, -5)	(10, 10)
	OAT	(10, 10)	(-5, -5)

Figure 10.3.1: Product Choice Game One: Cereal. Outcomes are in million USD.

In this game, two cereal producers (Kelloggs and General Mills) decide whether to produce and sell cereal made from wheat or oats. If both firms select the same category, both firms lose five million USD, since they have flooded the market with too much cereal. However, the two firms split the two markets, with one firm producing wheat cereal and the other firm producing oat cereal, both firms earn ten million USD. In this situation, it helps both firms if they can decide which firm goes first, to signal to the other firm. It does not matter which firm produces wheat or oat cereal, as long as the two firms divide the two markets. This type of repeated game can be solved by one firm going first, or signaling to the other firm which product it will produce, and letting the other firm take the other market.

Product Choice Game Two

It might be that one of the two markets is more valuable than the other. This situation is shown in Figure 10.3.2.

		GENERAL MILLS	
		WHEAT	OAT
KELLOGGS	WHEAT	(-5, -5)	(10, 20)
	OAT	(20, 10)	(-5, -5)

Figure 10.3.2: Product Choice Game Two: Cereal. Outcomes are in million USD.

This cereal market game is very similar to the previous game, but in this case the oat cereal market is worth much more than the wheat cereal market. As in the Product Choice One game, if both firms select the same market, both lose five million USD. Similarly, if each firm chooses a different market, then both firms make positive economic profits. The difference between the two product choice games is that the earnings are asymmetrical in the Product Choice Two game (Figure 10.3.2): the firm that is in the oat cereal market earns 20 million USD, and the firm in the wheat cereal market earns 10 million USD. In this situation, both firms will want to choose OAT first. If Kelloggs is able to choose OAT first, then it is in General Mill's best interest to select WHEAT. The player in this sequential game who goes first has a first player advantage, worth ten million USD. Each firm would be willing to pay up to ten million USD for the right to select first. In a repeated game, the market stabilizes with one firm producing oat cereal, and the other firm producing wheat cereal. There is no advantage for either firm to switch strategies, unless the firm can play OAT first, causing the other firm to move into wheat cereal.

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10.4: First Mover Advantage

The first mover advantage is similar to the Stackelberg model of oligopoly, where the leader firm had an advantage over the follower firm. In many oligopoly situations, it pays to go first by entering a market before other firms. In many situations, it pays to determine the firm's level of output first, before other firms in the industry can decide how much to produce. Game theory demonstrates how many real-world firms determine their output levels in an oligopoly.

First Mover Advantage Example: Ethanol

Ethanol provides a good example of the first-mover advantage. Consider an ethanol market that is a Stackelberg duopoly. To review the Stackelberg model, assume that there are two ethanol firms in the same market, and the inverse demand for ethanol is given by

$$P = 120–2Q, \tag{10.4.1}$$

where P is the price of ethanol in USD/gallon, and Q is the quantity of ethanol in million gallons. The cost of producing ethanol is given by $C(Q) = 12Q$, and total output is the sum of the two individual firm outputs:

$$Q = Q_1 + Q_2. \tag{10.4.2}$$

First, suppose that the two firms are identical, and they are Cournot duopolists. To solve this model, Firm One maximizes profits:

$$\begin{aligned}
\max \pi_1 &= TR_1–TC_1 \\
\max \pi_1 &= P(Q)Q_1–C(Q_1) && \text{[price depends on total output } Q = Q_1 + Q_2\text{]} \\
\max \pi_1 &= [120–2Q]Q_1–12Q_1 \\
\max \pi_1 &= [120–2Q_1–2Q_2]Q_1–12Q_1 \\
\max \pi_1 &= 120Q_1–2Q_1^2–2Q_2Q_1–12Q_1 \\
\frac{\partial \pi_1}{\partial Q_1} &= 120–4Q_1–2Q_2–12 = 0 \\
4Q_1 &= 108–2Q_2 \\
Q_1^* &= 27–0.5Q_2 \text{ million gallons of ethanol}
\end{aligned}$$

This is Firm One's reaction function. Assuming identical firms, by symmetry:

$$Q_2^* = 27–0.5Q_1 \tag{10.4.3}$$

The solution is found through substitution of one equation into the other.

$$\begin{aligned}
Q_1^* &= 27–0.5(27–0.5Q_1) \\
Q_1^* &= 27–13.5 + 0.25Q_1^* \\
Q_1^* &= 13.5 + 0.25Q_1^* \\
0.75Q_1^* &= 13.5 \\
Q_1^* &= 18 \text{ million gallons of ethanol}
\end{aligned}$$

Due to symmetry from the assumption of identical firms:

$$\begin{aligned}
Q_i &= 18 \text{ million gallons of ethanol, } i = 1, 2 \\
Q &= 36 \text{ million gallons of ethanol} \\
P &= 48 \text{ USD/gallon ethanol}
\end{aligned}$$

Profits for each firm are:

$$\pi_i = P(Q)Q_i–C(Q_i) = 48(18)–12(18) = (48–12)18 = 36(18) = 648 \text{ million USD} \tag{10.4.4}$$

This result shows that if each firm produces 18 million gallons of ethanol, each firm will earn 648 million USD in profits. This is shown in Figure 10.4.1, where several different possible output levels are shown as strategies for Firm A and Firm B, together with payoffs.

Next, suppose that the two firms are not identical, and that one firm is a leader and the other is the follower. By calculating the Stackelberg model solution, the possible outcomes of the game can be derived, as shown in Figure 10.4.1.

In the Stackelberg model, assume that Firm One is the leader and Firm Two is the follower. In this case, Firm One solves for Firm Two's reaction function:

$$\begin{aligned}
\max \pi_2 &= TR_2\text{–}TC_2 \\
\max \pi_2 &= P(Q)Q_2\text{–}C(Q_2) && \text{[price depends on total output } Q = Q_1 + Q_2\text{]} \\
\max \pi_2 &= [120\text{–}2Q]Q_2\text{–}12Q_2 \\
\max \pi_2 &= [120\text{–}2Q_1\text{–}2Q_2]Q_2\text{–}12Q_2 \\
\max \pi_2 &= 120Q_2\text{–}2Q_1Q_2\text{–}2Q_2^2\text{–}12Q_2 \\
\frac{\partial \pi_2}{\partial Q_2} &= 120\text{–}2Q_1\text{–}4Q_2\text{–}12 = 0 \\
4Q_2 &= 108\text{–}2Q_1 \\
Q_2^* &= 27\text{–}0.5Q_1
\end{aligned}$$

Next, Firm One, the leader, maximizes profits holding the follower's output constant using the reaction function:

$$\begin{aligned}
\max \pi_1 &= TR_1\text{–}TC_1 \\
\max \pi_1 &= P(Q)Q_1\text{–}C(Q_1) && \text{[price depends on total output } Q = Q1 + Q2\text{]} \\
\max \pi_1 &= [120\text{–}2Q]Q_1\text{–}12Q_1 \\
\max \pi_1 &= [120\text{–}2Q_1\text{–}2Q_2]Q_1\text{–}12Q_1 \\
\max \pi_1 &= [120\text{–}2Q_1\text{–}2(27\text{–}0.5Q_1)]Q_1\text{–}12Q_1 && \text{[substitution of One's reaction function]} \\
\max \pi_1 &= [120\text{–}2Q_1\text{–}54 + Q_1]Q_1\text{–}12Q_1 \\
\max \pi_1 &= [66\text{–}Q_1]Q_1\text{–}12Q_1 \\
\max \pi_1 &= 66Q_1\text{–}Q_1^2\text{–}12Q_1 \\
\frac{\partial \pi_1}{\partial Q_1} &= 66\text{–}2Q_1\text{–}12 = 0 \\
2Q_1^* &= 54 \\
Q_1^* &= 27 \text{ million gallons of ethanol}
\end{aligned}$$

This can be substituted back into Firm Two's reaction function to solve for Q_2^*.

$$\begin{aligned}
Q_2^* &= 27\text{–}0.5Q_1 = 27\text{–}0.5(27) = 27\text{–}13.5 = 13.5 \text{ million gallons of ethanol} \\
Q &= Q_1 + Q_2 = 27 + 13.5 = 40.5 \text{ million gallons of ethanol} \\
P &= 120\text{–}2Q = 120\text{–}2(40.5) = 120\text{–}81 = 39 \text{ USD/gallon ethanol} \\
\pi_1 &= (39\text{–}12)27 = 27(27) = 729 \text{ million USD} \\
\pi_2 &= (39\text{–}12)13.5 = 27(13.5) = 364.5 \text{ million USD}
\end{aligned}$$

These results are displayed in Figure 10.4.1. In a one-shot game, the Nash Equilibrium is (18, 18), yielding payoffs of 648 million USD for each ethanol plant in the market. Each firm desires to select 18 million gallons, and have the other firm select 13.5 million gallons, in which case profits would increase to 810 million USD. However, the rival firm will not unilaterally cut production to 13.5, since it would lose profits at the expense of the other firm.

		FIRM B (m GAL)		
		13.5	18	27
FIRM A (m GAL)	13.5	(729, 729)	(607.5, 810)	(364.5, 729)
	18	(810, 607.5)	(648, 648)	(324, 486)
	27	(729, 364.5)	(486, 324)	(0, 0)

Figure 10.4.1: First-Mover Advantage: Ethanol. Outcomes are in million USD.

In a sequential game, if Firm A goes first, it will select 27 million gallons of ethanol. In this case, Firm B will choose to produce 13.5 million gallons of ethanol, which is the Stackelberg solution. Firm A, as the first mover, has increased profits from 648 to 729 million USD by being able to go first. This is the first mover advantage.

Empty Threat

Figure 10.4.2 shows a sequential game between two grain seed dealers: Monsanto, a large international agribusiness, and a Local Grower. Monsanto is the dominant firm, and chooses a pricing strategy first. If Monsanto selects a HIGH price strategy, the Local Grower will select a LOW price, and both firms are profitable. In this case, the Local Grower has the low price, so makes more money than Monsanto.

		LOCAL GROWER	
		HIGH PRICE	LOW PRICE
MONSANTO	HIGH PRICE	(100, 80)	(80, 100)
	LOW PRICE	(20, 0)	(10, 20)

Figure 10.4.2: Empty Threat: Grain Seed Dealers. Outcomes are in million USD.

Could Monsanto threaten the Local Grower that it would set a LOW price, to try to cause the Local Grower to set a HIGH price, and increasing Monsanto profits from 80 million USD to 100 million USD? Monsanto could threaten to set a LOW price, but it is not believable, since Monsanto would have very low payoffs in both outcomes. In this case, Monsanto's threat is an empty threat, since it is neither credible nor believable.

Pre-Emptive Strike

Suppose two big box stores are considering entering a small town market. If both Walmart and Target enter this market, both firms lose ten million USD, since the town is not large enough to support both firms. However, if one firm can enter the market first (a "pre-emptive strike"), it can gain the entire market and earn 20 million USD. The firm that goes first wins this game in a significant way. This explains why Walmart has opened so many stores in a large number of small cities.

		TARGET	
		ENTER	DON'T ENTER
WALMART	ENTER	(–10, –10)	(20, 0)
	DON'T ENTER	(0, 20)	(0, 0)

Figure 10.4.3: Pre-Emptive Strike: Big Box Stores. Outcomes are in million USD.

Commitment and Credibility

Figure 10.4.3 shows a sequential game between beef producers and beef packers. In this game, the packer is the leader, and decides to produce and sell LOW or HIGH quality beef.

		PACKERS	
		LOW QUALITY	HIGH QUALITY
PRODUCERS	LOW QUALITY	(20, 50)	(20, 5)
	HIGH QUALITY	(10, 10)	(40, 20)

Figure 10.4.3: Commitment and Credibility One: Beef Industry. Outcomes are in m USD.

If the packers go first, they will select LOW, since they know that by doing so, the producers would also select LOW. This results in 50 million USD for the packers and 20 million USD for the producers. The producers would prefer the outcome (HIGH, HIGH), as their profits would increase from 20 to 40 million USD. In this situation, the beef producers can threaten the packers by committing to producing HIGH quality beef only. The packers will select LOW if they do not believe the threat, in the attempt to achieve the outcome (LOW, LOW). However, if the producers can commit to the HIGH quality strategy, and prove to the packers that they will definitely choose HIGH quality, the packers would choose HIGH also, and the producers would achieve 40 million USD.

The producers could come up with a strategy of visibly and irreversibly reducing their own payoffs to prove to the packers that they are serious about HIGH quality, and cause the packers to choose HIGH also. This commitment, if credible, could change the outcome of the game, resulting in higher profits for the producers, at the expense of the packers. Such a credible commitment is shown in Figure 10.4.4, which replicates Figure 10.4.3 with the exception of the LOW outcomes for the producers. If the beef producers sell off their low quality herd, and have no low quality cattle, they change the sequential game from the one shown in Figure 6.9 to the one in Figure 6.10.

		PACKERS	
		LOW QUALITY	HIGH QUALITY
PRODUCERS	LOW QUALITY	(0, 50)	(0, 0)
	HIGH QUALITY	(10, 10)	(40, 20)

Figure 10.4.4: Commitment and Credibility Two: Beef Industry. Outcomes are in m USD.

If the packers are the leaders in Figure 10.4.7, they select the HIGH quality strategy. If they select LOW, the producers would choose HIGH, yielding 10 million USD for the packers. When the packers select HIGH, the packers earn 20 million USD. Therefore, a producer strategy of shutting down or destroying the low quality productive capacity results in the desired outcome for the producers: (HIGH, HIGH). The strategy of taking an action that appears to put a firm at a disadvantage can provide the incentives to increase the payoffs of a sequential game. This strategy can be effective, but is risky. The producers need accurate knowledge of the payoffs of each strategy.

The commitment and credibility game is related to barriers to entry in monopoly. A monopolist often has a strong incentive to keep other firms out of the market. The monopolist will engage in entry deterrence by making a credible threat of price warfare to deter entry of other firms. In many situations, a player who behaves irrationally and belligerently can keep rivals off balance, and change the outcome of a game. Political leaders who appear irrational may be using their unpredictability to achieve long run goals.

A policy example of this type of strategy occurs during bargaining between politicians. If one issue is not going in a desired direction, a political group can bring in another issue to attempt to persuade the other party to compromise.

The “holdup game” is another example of commitment and credibility. Often, once significant resources are committed to a project, the investor will ask for more resources. If the project is incomplete, the funder will often agree to pay more money to have the project completed. Large building projects are often subject to the holdup game.

For example, if a contractor has been paid 20 million USD to build a campus building, and the project is only 50 percent complete, the contractor could halt construction, letting the half-way completed building sit unfinished, and ask for 10 million USD more, due to “cost overruns.” This strategy is often effective, even if a contract is carefully and legally drawn up ahead of time. The contractor has the University right where they want it: stuck with an unfinished building unless they increase the dollars to the project. The contractor is effectively saying, “do it my way, or I quit.”

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10.5: Problem Sets

Exercise 10.1

What is game theory and why is it useful in markets?

Answer available at the end of this section.

Exercise 10.2

What is a payoff in game theory?

Solution

A payoff is the outcome or reward a player receives from a specific combination of strategies. It can represent profit, cost, or another measurable result.

Exercise 10.3

What is a dominant strategy?

Answer available at the end of this section.

Exercise 10.4

How does a Nash equilibrium differ from a dominant strategy equilibrium?

Answer available at the end of this section.

Exercise 10.5

What is the maximin (safety-first) strategy?

Answer available at the end of this section.

Exercise 10.6

What is a cooperative strategy (collusion)?

Answer available at the end of this section.

Exercise 10.7

Why is collusion unstable in many markets?

Answer available at the end of this section.

Exercise 10.8

What is a repeated game and why does it encourage cooperation?

Answer available at the end of this section.

Exercise 10.9

What is first-mover advantage?

Answer available at the end of this section.

Exercise 10.10

What is a credible commitment in strategic markets?

Answer available at the end of this section.

Answers

Exercise 10.1

Game theory is a framework for studying strategic interactions where the outcome depends on the choices of multiple players. It helps firms anticipate competitor actions and make better pricing, advertising, and production decisions.

Exercise 10.3

A dominant strategy is the best strategy for a player regardless of what the opponent does. If a player has a dominant strategy, they will always prefer it.

Exercise 10.4

A Nash equilibrium occurs when no player wants to change their strategy given the other player's choice.
A dominant strategy equilibrium occurs when all players have dominant strategies.
Every dominant strategy equilibrium is a Nash equilibrium, but not vice versa.

Exercise 10.5

The maximin strategy maximizes the minimum possible payoff. It is used when players are risk-averse and want to avoid the worst-case scenario.

Exercise 10.6

A cooperative strategy is when players work together to maximize joint payoffs. In markets, this often means collusion—firms coordinating decisions like raising prices. However, collusion is often illegal.

Exercise 10.7

Collusion is unstable because each firm has an incentive to cheat—lowering prices to steal market share while benefiting from others keeping prices high.

Exercise 10.8

A repeated game is played multiple times. Because players interact repeatedly, they tend to cooperate more to avoid retaliation and maintain long-term gains.

Exercise 10.9

First-mover advantage occurs when a firm gains a strategic benefit by making a decision before rivals, such as entering a market first or committing to a production level early.

Exercise 10.10

A credible commitment is a strategic move that shows a firm will stick to a strategy. It must be believable and often involves taking actions that are costly to reverse, such as removing production capacity to signal high-quality output.

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11: SIGNALS, ADVERTISING, AND MARKET COMPETITION

Learning Objectives

The specific objectives of this chapter are as follows:

- **Explain** the problems of adverse selection and moral hazard that result from information asymmetries.
- **Explain** the role of advertising to facilitate transactions that involve costly information, asymmetric information, or some combination of the two.
- **Distinguish** between default-independent and default-contingent signals, provide examples of each, and describe situations where each may be effective.
- **Explain** the concept of a separating equilibrium and why it is important to the functioning of economic signals.

In many economic models, it is assumed that information is freely available. For example, in the neoclassical model of the consumer covered in Chapter 5, the consumer knew prices and the amount of satisfaction that would derived from purchased goods. In Lancaster's model or Becker's model, the consumer knew even more and could ascertain the amounts of characteristics that were inherent in purchased goods or the time commitments required for household production. Moreover, both the buyer and seller were equally informed about characteristics of the product. In many real world cases, information is not freely available. Information is costly to obtain and a buyer must search for availability of goods and the prices at which they are being offered. Moreover, it is often difficult to judge, pre-purchase, how much of a given characteristic a product will contain.

If information is necessary for economic decision making and is costly, then it might be interesting to subject it to more formal analysis. In fact, economic analysis of information has been one of the most productive areas in the past few decades. The focus in this chapter will be necessarily brief with the overall aims being (1) to shed light on some primary information problems in the functioning of markets and (2) to emphasize the roles that advertising and other activities can play in solving these problems.

11.1: Overview and Objectives

11.2: Asymmetric Information

11.3: Advertising

11.4: Advertising as Information

11.5: Market Signals to Counteract Asymmetric Information Problems

11.6: A Formal Model of Signals

11.7: Concluding Comments

11.8: References

11.9: Problem Sets

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11.1: Overview and Objectives

In many economic models, it is assumed that information is freely available. For example, in the neoclassical model of the consumer covered in Chapter 5, the consumer knew prices and the amount of satisfaction that would derived from purchased goods. In Lancaster's model or Becker's model, the consumer knew even more and could ascertain the amounts of characteristics that were inherent in purchased goods or the time commitments required for household production. Moreover, both the buyer and seller were equally informed about characteristics of the product. In many real world cases, information is not freely available. Information is costly to obtain and a buyer must search for availability of goods and the prices at which they are being offered. Moreover, it is often difficult to judge, pre-purchase, how much of a given characteristic a product will contain.

If information is necessary for economic decision making and is costly, then it might be interesting to subject it to more formal analysis. In fact, economic analysis of information has been one of the most productive areas in the past few decades. The focus in this chapter will be necessarily brief with the overall aims being (1) to shed light on some primary information problems in the functioning of markets and (2) to emphasize the roles that advertising and other activities can play in solving these problems. The specific objectives of this chapter are as follows:

- Explain the problems of adverse selection and moral hazard that result from information asymmetries.
- Explain the role of advertising to facilitate transactions that involve costly information, asymmetric information, or some combination of the two.
- Distinguish between default-independent and default-contingent signals, provide examples of each, and describe situations where each may be effective.
- Explain the concept of a separating equilibrium and why it is important to the functioning of economic signals.

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11.2: Asymmetric Information

Asymmetric information describes situations wherein one party to the transaction (e.g., the seller) has more information about the product or service in question than another party (e.g., the buyer). For example, in many cases, the producer will possess better information about the quality of raw materials used in the manufacture of a product than the buyer. The producer may present the product to the buyer as representing the finest quality. The buyer could inspect the product prior to purchase, but there may be ways that the producer could mask shoddy workmanship. In many cases, the buyer will be unable to distinguish between good and poor quality before the sale. The consumer may only learn whether the producer used substandard inputs after consumption of the product or through its extended use. In short, the producer could use better information (and the buyer's lack of information) to his or her advantage.

If only as a savvy consumer, you can relate to the scenario just described. In a famous paper, Akerlof (1970) noted that asymmetric information could, in severe cases, cause markets for high quality products to fail. He described a "lemons market," where only low-quality products are provided. In this context, the term "lemons" refers to used automobiles of poor quality, the example used in Akerlof's (1970) paper. The lemons market occurs because no buyer would be willing to pay a premium for high quality because everyone understands that sellers have an incentive to pass off low-quality products at a high-quality price.

To consider further how asymmetric information could cause market failures, let us explore two problems that relate to asymmetric information. One is called adverse selection. The other is called moral hazard. Adverse selection refers to cases where asymmetric information makes it difficult for parties to enter into a mutually beneficial transaction because of concerns that one party could use its informational advantage to the detriment of the other. The lemons market is an example of adverse selection. Adverse selection problems are the primary focus of this chapter. Moral hazard, on the other hand, refers to cases where asymmetric information can create problems after two parties have entered into a business arrangement because of one party's inability to accurately monitor the behavior or effort of the other. According to Milgrom and Roberts (1992), adverse selection and moral hazard arose out of insurance market terminology but have since taken on broader meanings. Given the origins in insurance markets, let us use insurance as an example to illustrate each of these two problems.

Adverse Selection

Adverse selection results when asymmetric information creates pre-contractual problems. For example, customers who buy dental insurance likely know more about their risks of needing costly dental procedures than do insurance providers. Let us take the hypothetical case of John Doe. John is a recent graduate and knows that he has a high likelihood of being predisposed to dental problems because they run in his family. Moreover, he has had many cavities up to this point in his life. John is fairly certain that there will be expensive dental procedures in his near future. When there is an opportunity to sign up for dental insurance through his employer, John Doe jumps at the chance. To him it seems like a great deal. Jane Doe (no relation to John), on the other hand, has the same opportunity to sign up for dental insurance. Jane has never had a cavity before and feels fortunate to have a good set of teeth. To Jane, the premiums for dental insurance seem high. She would like to have some insurance against the costs of expensive dental care should she need it, but she knows that the most she will pay her dentist in a normal year will be the cost of routine cleanings and checkups. She can pay those out-of-pocket for much less than what she would pay in dental insurance premiums. Because of this, Jane decides not to enroll in the dental insurance program.

In the end, one would expect customers with bad teeth to enroll in dental insurance and customers with good teeth not to enroll. This is adverse selection. Many people with good teeth would like to insure against the cost of dental care should it be needed. but a problem arises because the insurance company is unable to distinguish between high-risk and low-risk customers *a priori*. It is possible that dental insurance is lemons market in that only high-premium insurance catering to high-risk customers is available. Asymmetric information, in this example, could prevent the emergence of a market for lower-cost dental insurance tailored to lower-risk customers.

Moral Hazard

Moral hazard results when asymmetric information creates post-contractual problems that result from one party being unable to fully monitor the effort or actions of the other. Once a people buy insurance, they may be less careful because they are at least partially insured against a loss. Insurance companies cannot monitor customers all the time, so an asymmetric information problem emerges after an insurance policy has been sold. Moral hazard is partially mitigated by providing incentives in the form

of deductibles, co-payments, and partial coverage. For example, a person who has dental insurance, will likely still practice good oral hygiene. Aside from large deductibles and copayments, corrective dental procedures such as fillings, root canals, and crowns can be painful and inconvenient. Such losses in utility are not covered by the insurance.

Market Solutions to Adverse Selection and Moral Hazard

In the case of moral hazard, a common market solution is to develop contracts that provide incentives. For example, your automobile insurance company probably gives you a discount on your premiums if you have not filed a claim in the past few years, have a good driving record (few or no arrests for traffic violations), and/or have good grades. Basically, the company that insures you would like you to drive carefully. Since you are often in a hurry and have coverage that at least partially offsets the costs you would incur in the event of an accident, it knows that you may, on occasion, not be as careful as it would like you to be. It is prohibitively costly for the company to have a representative follow you around and file detailed reports on the carefulness of your driving habits. Instead, the insurance company offers you a set of incentives, based on things that it can observe (like the number of traffic violations) and that it knows are correlated with the degree of risk it takes in insuring you.

Livestock production contracts in agriculture are good examples of incentive-based contracts designed to address moral hazard problems. In broiler chicken production, an integrator provides contract growers with chicks, feed, and other inputs. The integrator would like its contract growers to work hard to minimize mortality and increase feed conversion. The integrator could offer a fixed payment for each flock of birds grown. However, this would result in a moral hazard problem because contract growers would get the same payment regardless of whether they put lots of effort or minimal effort into growing the birds. To address moral hazard, broiler contracts are designed so that growers who do well relative to others in their settlement pool receive premiums while those who do less well receive penalties. Again, it is costly for the integrator to monitor the effort expended by each of its contract growers, but it can easily measure mortality and feed conversion rates. If these are correlated with grower effort, it can design contract provisions to provide incentives for growers to put the desired levels of effort into raising the birds.

A common market solution to adverse selection problems is to rely on an economic signal. A signal is a way for one party to send a believable message to another about the characteristics contained in the products. Advertising is an example of an economic signal. As you will see, advertising clearly has a multifaceted role and can address problems of costly information as well as problems of asymmetric information. The remainder of the chapter is comprised primarily of a discussion of advertising and other economic signals to overcome adverse selection problems resulting from asymmetric information.

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11.3: Advertising

Advertising is a huge industry, with billions spent every year on marketing products. Are these enormous expenditures worth it? The benefits of increased sales and revenues must be at least as large as the increased costs to make it a good investment. In this section, the profit-maximizing level of advertising will be identified and evaluated.

One important point about advertising is the costs associated with advertising expenditures. If advertising works, it increases sales of the product. There are two major costs, the direct costs of advertising and the additional costs associated with increasing production if the advertising is effective. A typical analysis sets the marginal revenues of advertising equal to the marginal costs of advertising

$$MR_A = MC_A. \tag{11.3.1}$$

This would be correct if the level of output remained constant. However, the output level will increase if advertising works, and the additional costs of increased output must be taken into account for a comprehensive and correct analysis, as will be shown below.

Graphical Analysis of Advertising

The graph for advertising is shown in Figure 11.3.1. Notice the two major effects of advertising and marketing efforts:

1. an increase in demand, in this case from D_0 to D_A, and
2. an increase in costs, shown here as the movement from ATC_0 to ATC_A.

In the analysis shown here, advertising costs are considered to be fixed costs that do not vary with the level of output. This is true for a billboard, or television commercial. Note that the marginal costs do not change, since marginal costs are variable costs. The analysis could be easily extended to include variable advertising costs.

Economic analysis of advertising and marketing is straightforward: continue to advertise as long as the benefits outweigh the costs. In Figure 11.3.1, the optimal level of advertising occurs at quantity Q_A and price P_A. Profits with advertising are shown by the rectangle π_A. If profits with advertising are larger than profits without advertising $(\pi_A > \pi_0)$, then advertising should be undertaken.

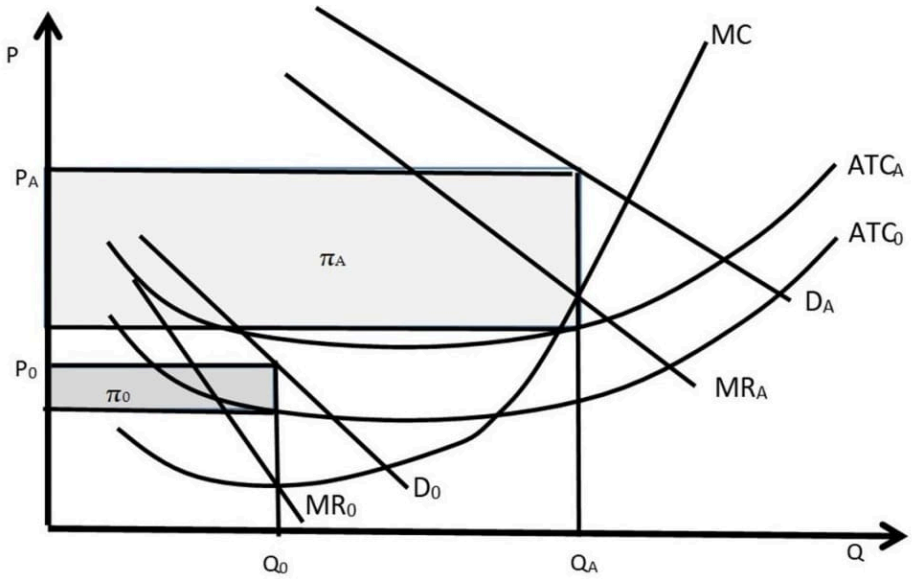


Figure 11.3.1: Economic analysis of advertising and marketing.

In general, if the increase in sales $(D_A–D_0)$ is larger than the increase in costs, advertising should be undertaken. The optimal level of advertising can be found using marginal economic analysis, as described in the next section.

General Rule for Advertising

The profit-maximizing level of advertising can be derived, and the outcome is interesting and important, since it diverges from setting the marginal costs of advertising equal to the marginal revenues of advertising. Note that the graphical and mathematical analyses of advertising presented here could be used for any marketing program, not only advertising campaigns.

Assume that the demand for a product is given in Equation 11.3.2, where quantity demanded (Q^d) is a function of price (P) and the level of advertising (A).

$$Q^d = Q(P, A) \tag{11.3.2}$$

This demand equation differs from the usual approach of using an inverse demand equation. For this model, it is more useful to use the actual demand equation instead of an inverse demand equation $[P = P(Q^d)]$. The profit equation is shown in Equation 11.3.3, where the cost function is given by $C(Q)$.

$$\max \pi = TR–TC \tag{11.3.3}$$

$$\max \pi = PQ(P, A)–C(Q)–A \tag{11.3.4}$$

The profit-maximizing level of advertising (A^*) is found by taking the first derivative of the profit function, and setting it equal to zero. This derivative is slightly more complex than usual, since the quantity that appears in the cost function depends on advertising, as shown in Equation 11.3.2. Therefore, to find the first derivative, we will need to use the chain rule from calculus, which is used to differentiate a composition of functions, such as the derivative of the function $f(g(x))$ shown in Equation 11.3.5.

$$\text{If } f(g(x)) \text{ then} \frac{\partial f}{\partial x} = f'(g(x)) \cdot g'(x) \tag{11.3.5}$$

The chain rule simply says that to differentiate a composition of functions, first differentiate the outer layer, leaving the inner layer unchanged [the term $f'(g(x))$], then differentiate the inner layer [the term $g'(x)$].

In Equation 11.3.3, the cost function is a composition of the cost function and the demand function: $C(Q(P, A))$. So the derivative

$$\frac{\partial C}{\partial A} = C'(Q(A)) \cdot Q'(A) = \left(\frac{\partial C}{\partial Q}\right) \cdot \left(\frac{\partial Q}{\partial A}\right). \tag{11.3.6}$$

Thus, the first derivative of the profit equation with respect to advertising is given by:

$$\frac{\partial \pi}{\partial A} = P\left(\frac{\partial Q}{\partial A}\right) - \left(\frac{\partial C}{\partial Q}\right) \cdot \left(\frac{\partial Q}{\partial A}\right) - 1 = 0 \tag{11.3.7}$$

Rearranging, the first derivative can be written as in Equation 11.3.8:

$$P\left(\frac{\partial Q}{\partial A}\right) = MC \cdot \left(\frac{\partial Q}{\partial A}\right) + 1. \tag{11.3.8}$$

The term on the left hand side is marginal revenues of advertising (MR_A), and the term on the right hand side is the marginal cost of advertising $(MC_A = 1)$, plus the additional costs associated with producing a larger output to meet the increased demand resulting from advertising $[MC \cdot \left(\frac{\partial Q}{\partial A}\right)]$.

This result can be used to find an optimal "rule of thumb" for advertising, or a "General Rule for Advertising." There are three preliminary definitions that will be useful in deriving this important result. First, the advertising to sales ratio is given by $\frac{A}{PQ}$, and reflects the percentage of advertising in total revenues (price multiplied by quantity, PQ). Second, the advertising elasticity of demand is defined.

Advertising Elasticity of Demand (E^A) = The percentage change in quantity demanded resulting from a one percent change in advertising expenditure.

$$E^A = \frac{\%\Delta Q^d}{\%\Delta A} = \left(\frac{\partial Q}{\partial A}\right)\left(\frac{A}{Q}\right). \tag{11.3.9}$$

Third, recall the Lerner Index (L), a measure of monopoly power. We derived the relationship between the Lerner Index and the price elasticity of demand, shown in Equation 11.3.10:

$$L = \frac{P–MC}{P} = -\frac{1}{E^d}. \tag{11.3.10}$$

With these three preliminary equations, we can derive a relatively simple and very useful general rule of advertising from the profit-maximizing condition for advertising, given in Equation 11.3.8.

$$\begin{aligned} P\left(\frac{\partial Q}{\partial A}\right) &= MC \cdot \left(\frac{\partial Q}{\partial A}\right) + 1 \\ (P–MC)\left(\frac{\partial Q}{\partial A}\right) &= 1 \\ \frac{P–MC}{P} \cdot \left(\frac{\partial Q}{\partial A}\right)\left(\frac{A}{Q}\right) &= \left(\frac{A}{PQ}\right) \\ \frac{A}{PQ} &= -\frac{E^A}{E^d} \end{aligned}$$

This simple rule states that the profit-maximizing advertising to sales ratio (A/PQ) is equal to minus the elasticity of advertising (E^A) divided by the price elasticity of demand $(-E^d)$. The result is simple and powerful: (1) if the elasticity of advertising is large, increase the advertising to sales ratio, and (2) if the price elasticity of demand is large, decrease the advertising to sale ratio. A firm with monopoly power, or a higher Lerner Index, will want to advertise more (E^d small), since the marginal profit from each additional dollar of advertising or marketing expenditure is greater.

Most business firms have at least crude approximations of the two elasticities needed to use this simple rule. Many firms advertise less than the optimal rate, since marketing can appear to be expensive if it is a large percentage of sales. However, simple economic principles can be used to determine the optimal, profit-maximizing level of advertising and/or marketing expenditures using this simple rule.

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11.4: Advertising as Information

Advertising, until recent decades, has been fairly neglected in economic analysis. It is probably safe to say that economists saw advertising as an obvious way for sellers to influence consumer tastes and preferences. It was taken for granted that the purpose of advertising was to make the demand curve less elastic and provide sellers with more discretion in setting prices. There is probably truth in this. However, recent work has shown that advertising can do much to overcome informational problems in markets and, hence, can be valuable in helping markets function and in improving the efficiency of the economic allocation problem. In a classic article, Nelson (1974) noted that the messages conveyed in advertising activities depend on whether the good being advertised has **search characteristics** or **experience characteristics**.

Search characteristics refer to aspects of a product that can readily be assessed by inspection prior to sale. There is no asymmetric information problem with search characteristics. Customers have access to the same information as the seller. However, knowledge about search characteristics could be costly information because finding out about search characteristics might require effort on part of the consumer. Thus, advertising could play a role in reducing search costs to consumers. Unlike search characteristics, **experience characteristics are known to customers only through use of the product and cannot be determined by inspection prior to sale**. Asymmetric information can be a major problem when it comes to experience characteristics.

To better develop the distinction between search and experience characteristics, consider corn flakes. A box of corn flakes at the supermarket contains both search characteristics and experience characteristics. Assuming that labeling regulations are effective and adequately enforced, the consumer can look at the box to determine how many ounces it contains, the ingredients that were used in the manufacture of the product, a date that provides information about the product's freshness, and the nutrients that the product will provide. Each of these is a search characteristic. The customer does not need to buy the product to be fully informed about characteristics such as these. A consumer might have other questions about the corn flakes such as: Will they have a rich toasted corn flavor? Are they crunchy, and will they stay crunchy after milk is added? Will the corn flakes pair well with a handful of fresh blueberries? These are all questions about experience characteristics. There is no way for the consumer to be sure about the taste and texture attributes of the cornflakes until after the cornflakes leave the store and he or she consumes them.

Advertising Can Address Both Search and Experience Characteristics

Advertising can clearly play a role when it comes to helping consumers become informed about search characteristics. Advertising can inform consumers that a product exists and provide information about its price and search attribute. This can lower the cost that consumers would otherwise face in their search for information and can help the economy work smoothly. However, many advertising messages do not seem to be doing anything that would aid in information search.

For example, anyone in the United States, and most of the world for that matter, knows that Coca-Cola is a soft drink available for purchase almost anywhere at any time. Most people do not need an advertising message to let them know Coca-Cola exists, tastes sweet, is carbonated, and provides caffeine. Occasionally Coca-Cola may come out with a new flavor variation, e.g., vanilla-flavored Coke. In such instances, it might facilitate consumer search to have an advertising campaign informing consumers that a new vanilla-flavored variation of Coca-Cola is available. Similarly, a retail establishment might offer a temporary price reduction on Coca-Cola products. Consumer search would be aided if an advertising message provided information about this change in price.

These exceptions aside, most advertisements for soft drinks like Coca-Cola do not convey material information about product availability, search attributes or price. Most consumers would find it hard to believe that Coca-Cola plays a central role in the recreational excursions of polar bear families as depicted in a recent Super Bowl advertisement. Why would Coca-Cola spend the enormous sum of money that it takes to develop and run an add on the Superbowl that ultimately does little to reduce search costs? Nelson (1974) provides a compelling explanation.

Nelson's (1974) main argument is that when it comes to experience characteristics, advertising is informative. The mere fact that a seller advertises provides information about experience characteristics, even if the content of the advertisement does not explicitly mention the characteristic. As shown below, Nelson's (1974) basic idea can be formalized using an economic model that shows an equilibrium wherein high-quality producers choose to advertise and low-quality producers choose to not advertise. In this model, "high quality" will refer to products containing experience characteristics for which consumers are willing to pay a premium.

The Logic of Advertising as a Signal

Let us consider a market with the following features:

1. There is asymmetric information wherein sellers have more information about the quality of their products than do buyers.
2. Buyers are aware that they have less information and are naturally wary of adverse selection problems. As a result, buyers discount quality claims made by sellers.

The high-quality seller needs some way to convince the skeptical buyer that the product she is selling indeed does provide high quality. If she cannot convince buyers of her high quality, she cannot sell at the high-quality price and will not be willing to incur extra costs required to produce high-quality products. The high-quality seller must convince the buyer that it would be against her interest to use asymmetric information to her advantage. That is, the seller needs to convince buyers that it would not make sense for her to charge a high-quality price for a low-quality product.

An extravagant advertising campaign is something that is visible to the buyer and something that the buyer will presumably understand to be costly. The buyer might reason that if the seller is spending a great deal of money on an advertisement, the seller must have good quality because the only way to recoup the advertising outlay would be to generate repeat purchases. If quality is bad, repeat purchases would not materialize, and the seller would not recover advertising costs. Hence, firms that advertise must be those who are providing high quality. As explained in more detail below, under certain conditions expenditures on things like advertising can serve as an irredeemable bond that commits the seller to high quality. Advertising is one example of a signaling mechanism that could potentially overcome adverse selection problems that result from asymmetric information.

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11.5: Market Signals to Counteract Asymmetric Information Problems

Advertising is a good example of an economic signal, but there are many others. For example, a firm that develops a new product that is of high quality could face reluctance from consumers who, never having encountered the product before, are skeptical of the quality claims. A low introductory price could send a signal to consumers in much the same way as a costly advertising campaign. In fact, low introductory prices are often used in conjunction with advertising campaigns for new products. By offering a low introductory price, the message the firm is trying to send is: "We are selling this product for less than it is worth because we know that once you try it, you will like it so much we will make up our initial losses in repeat purchases." Both advertising and low introductory prices depend on repeat purchases in order to be effective signals.

Some signals do not depend on repeat purchases. For example, a company that offers a warranty is signaling customers that their product is of high quality. Customers understand that the firm will incur costs if it has to fulfill warranty obligations, so it would be unprofitable to offer a generous warranty on low-quality products. Hence, customers and firms might use the presence, absence, or terms of warranties to overcome asymmetric information problems.

Types of Market Signals

Kirmani and Rao (2000) reviewed both theoretical and empirical literature on economic signals and the ways they overcome asymmetric information problems in different contexts. They grouped signals broadly into two groups. The first group is what they termed to be **default-independent signals**. These signals represent up-front costs that firms incur to show customers that providing low quality would not be in the firm's economic interest. Advertising and low introductory prices, two examples already mentioned, are classified as default-independent signals. Other default independent signals include investments in brand equity defined broadly, coupons, and slotting allowances that manufacturers pay to retailers. With a default-independent signal, the firm incurs the signaling cost regardless of whether it ultimately provides high quality or low quality. The main feature is that buyers understand the signal to mean that it is in the firm's interest to provide high quality. Investments in advertising, profits lost through low introductory prices, or large cash outlays for slotting allowances, can only be recovered if quality turns out to be high and repeat sales are good. Repeat sales are very important to default-independent signals. For non-durable and frequently purchased items (like food products) default-independent signals are common.

The second group of signals consists of what Kirmani and Rao (2000) classify to be **default-contingent signals**. These include warranties, money-back guarantees, and the like. For these types of signals, the firm makes no significant initial investment in the signal. If quality turns out to be bad, however, the firm stands to face costs associated with the signal. For example, if a warranty is used to signal quality and the firm defaults by providing low quality contrary to claim, it would face losses that come from settlement of customer warranty claims. In this case, repeat sales are irrelevant to whether the warranty is an effective signal. Hence, default-contingent signals are commonly associated with durable and infrequently purchased items. However, default-contingent signals can be important for frequently purchased products as well. One example is the use of a high selling price to signal high quality. This involves no up-front cost to the firm, but if the firm defaults and provides low quality at a high price, its ability to charge the high price in the future is jeopardized. By charging the high price, the firm is putting its future revenues at risk if it provides low quality.

An Effective Signal Requires a Seperating Equilibrium

This is a good place to introduce the notion of a separating equilibrium. A separating equilibrium is an outcome where the high-quality firms send signals and the low-quality firms do not. For a signal of any sort to work, it must be that high-quality firms find it advantageous to signal and low-quality firms find signals to be against their economic interest. When there is a separating equilibrium, the only thing customers need to do is to identify which firms are sending signals and which firms are not. Customers are informed of quality differences merely by observing which firms signal. In short, the signal becomes information about quality.

Unfortunately, there is nothing that says separating equilibriums will always result or will even be the norm. For example, most, if not all, producers of consumer products go to some extra expense in making their packaging look attractive. If both poor-quality and high-quality products come in attractive packaging, then attractive packaging cannot be an effective signal and cannot be used by customers to make quality judgments. In this case, there is not a separating equilibrium because both poor-quality and

high-quality producers find it advantageous to signal.

Potential for Customer Abuse and Other Limitations of Signals

For some types of default-contingent signals, particularly warranties and money back guarantees, there is potential for customer abuse that results in both high-quality and low-quality firms being unwilling to signal. For example, if attention to maintenance is bothersome and costly, then customers with warranty protection may give less attention to such matters than customers without warranty protection. (Note that this is an example of moral hazard on part of the customer.) Also, the degree of subjectivity that constitutes acceptable quality will be important for default-contingent signals, such as warranties, to be effective. Warranties might work well with automobiles. It is likely that both the buyer and seller can reach an agreement as to whether a problem exists and would be covered under the warranty. For example, the transmission either works or it does not. For vacation packages, another infrequently purchased item, it would be much harder to determine whether the customer who wanted his money back after reporting a bad vacation experience has a legitimate complaint or is simply trying to abuse a money back guarantee.

Similarly, some default independent signals such as low introductory prices could, in some situations, be ineffective for lack of a separating equilibrium. If a high-quality firm uses a low introductory price, it is likely to attract quality-insensitive customers as well as quality-sensitive customers. When the high-quality firm stops its low price campaign and raises its price to the high-quality level, it loses its quality-insensitive customers. These customers do not much care about quality anyway and opt for lower-priced and lower-quality products once the campaign ends. The low introductory price signal depends on repeat purchases and a large proportion of quality-insensitive customers who do not provide repeat purchases raises the cost of using a low introductory price as a signal. In this case, customer heterogeneity raises the cost of a signal perhaps to the point where both high-quality and low-quality firms find it in their advantage to not signal.

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11.6: A Formal Model of Signals

Consider a market with two kinds of firms. The first type is a high-quality firm. This firm is capable of producing high-quality products but must incur extra production costs if it decides to produce high quality. Because of asymmetric information, the high-quality firm might cheat customers by charging a high-quality price for low-quality products. The other type of firm is a low-quality firm. This firm is only capable of producing low quality. Because of asymmetric information, the low-quality firm might deceive customers by offering its low-quality products at a high-quality price. Finally, assume that there is a demand for both high-quality and low-quality products. The high-quality demand is comprised of quality-sensitive customers who are willing to pay a premium for quality. The low-quality market is comprised of quality-insensitive customers who are unwilling to pay a premium for quality.

Let us define the following profit outcomes in terms of the firm's choice of price and/or quality level.

1. $\pi(P_H, H)$ is the profit level of a high-quality firm that sells at the high-quality price and truthfully provides high quality (and incurs extra production costs).
2. $\pi(P_H, L)$ is the profit level of a high- or low-quality firm that is untruthful. It sells at the high-quality price but actually provides customers with a low-quality product.
3. $\pi(P_L, L)$ is the profit level of a high- or low-quality firm that truthfully provides low quality.
4. $\pi(P_L, H)$ is the profit of a high-quality firm who provides high quality (and incurs extra production costs) but sells at the low-quality price.

Let us rule out the the fourth case by assuming $\pi(P_L, H) < 0$. That is, it is never profitable for a high-quality firm to produce a high-quality product but sell at the low-quality price. Thus, cases 1 to 3 are the only ones of interest in our model.

Conditions for a Lemons Market

Given asymmetric information, a lemons market could occur if

1. There is an incentive for high-quality firms to cheat by providing low quality at the high-quality price. In other words, $\pi(P_H, L) > \pi(P_H, H)$. In this case, the incentive to cheat is the difference $\pi(P_H, L) - \pi(P_H, H) > 0$,

and/or

2. There is an incentive for low-quality firms to deceive by pretending to be high-quality firms because $\pi(P_H, L) > \pi(P_L, L)$. In this case, the incentive to deceive is $\pi(P_H, L) - \pi(P_L, L) > 0$.

With either or both of these incentives in place, customers would be wary of any firm that charges the high-quality price. Even if the customer cares a great deal about quality, he/she would naturally be suspicious of cheating or deception by sellers and would want to avoid paying a premium for quality that is not provided. If customers were very suspicious of cheating or deception, none may be willing to pay the high-quality price. The result is a market outcome where only low quality is provided and all firms get $\pi(P_L, L)$. It may be true that $\pi(P_H, H) > \pi(P_L, L)$ and high-quality firms would be better off economically by truthfully providing high quality. However, customer suspicions prevent high-quality firms from accessing the high-quality market. This is the lemons problem mentioned earlier in the chapter.

A Signal to Correct the Lemons Problem

An economic signal could correct the lemons problem if the cost of the signal was lower when a firm provided high quality and higher when the firm provided low quality. Let us consider the case of a warranty. Define C as the warranty cost of a firm that provides high quality and define C' to be the warranty cost of a firm that provides low quality. High-quality products should have fewer warranty claims, so it is reasonable to assert that $C' > C$.

Could offering a warranty serve as the entry ticket for a high-quality firm that wants to truthfully sell on the high-quality market? The answer is yes, provided that customers understand the signal and each of the following conditions hold.

Condition 1. Access to the high-quality market is economically attractive in the presence of a truthful signal. If warranties are to be a successful signal, then high-quality firms must be willing to truthfully provide high quality in the presence of warranty

costs. It must be that

1A. $\pi(P_H, H) - C > \pi(P_L, L)$,

which implies

1B. $\pi(P_H, H) - \pi(P_L, L) > C$

The left side of 1B represents the benefits of truthfully accessing the high-quality market and selling at a high-quality price. The right side is the cost of offering warranties on high-quality products.

Condition 2: The signal removes the incentive for high-quality firms to cheat. If warranties are to be a successful signal, then the warranty must remove the incentive for high-quality firms to cheat. It must be that

2A. $\pi(P_H, H) - C > \pi(P_H, L) - C'$,

which implies

2B. $C' - C > \pi(P_H, L) - \pi(P_H, H)$.

The left side of inequality 2B represents the additional signal cost the firm would face if it cheated. The right side represents the incentive to cheat. Thus, if 2B holds, the cost of cheating is larger than the benefits of cheating.

Condition 3: The signal removes the incentive for low-quality firms to deceive. Finally, if warranties are to be a successful signal then they must make it unattractive for low-quality firms to deceive customers by pretending to be high-quality firms. It must be that

3A. $\pi(P_L, L) > \pi(P_H, L) - C'$,

which implies

3B. $C' > \pi(P_H, L) - \pi(P_L, L)$.

The left side of inequality 3B is the cost of offering a warranty on low-quality products, and the right hand side represents the incentive to deceive. Thus if 3B holds, the costs of deception exceed the benefits.

If all three of these conditions hold, there will be a separating equilibrium in the model where high-quality firms will signal and truthfully provide high-quality and low-quality firms will not signal and will provide low quality. Consumers who are willing to pay a premium for quality can safely purchase from firms with the signal. Those consumers who are not quality conscious will buy from firms that do not signal. In short, the signal corrects the lemons market problem and allows for the high-quality market to exist. If any one of these three conditions do not hold, however, there is no separating equilibrium and the signal is ineffective.

Advertising Cost as Quality-Dependent

The example of a warranty was chosen to explain the separating equilibrium because it is simple to see why warranty costs in the presence of false quality claims would be higher than warranty costs in the presence of true quality claims. Let us now consider why and how advertising might also be an effective signal. Given the model presented above, advertising could be an effective signal if advertising had a lower cost when quality claims were true than when quality claims were false.

To see why this might be the case, let A represent brand equity and suppose that access to the high-quality market in any given time period, t requires that $A_t > \overline{A}$. Firms with brand equity greater than or equal to $\overline{A}$ are able to charge the high-quality price. Firms with brand equity below $\overline{A}$ cannot and must charge the low-quality price. Suppose further that brand equity depreciates with time and needs to be replenished with advertising. The dynamics of brand equity when high quality is truthfully provided are

$A_t = \delta A_{t-1} + a_t$,

where $0 < \delta < 1$ is the rate of depreciation in brand equity and a_t is advertising expenditure in the current period.

The dynamics of brand equity when a firm provides low quality are

$$A_t = \delta' A_{t-1} + a_t,$$

where $0 \leq \delta' < \delta$. If a firm puts low-quality products on the market, a smaller portion, $\delta' < \delta$, of its brand equity carries over from the prior period. This means that brand equity depreciates at a faster rate when low quality is provided. This is a reasonable assertion.

Given these dynamics, the minimal steady-state expenditure required to maintain continuous access to the high-quality market for a firm that truthfully provides high quality would be $a_t = (1 - \delta)\overline{A}$. If a firm falsely claimed high quality, its cost of accessing the high-quality market would be higher at $a_t = (1 - \delta')\overline{A}$. Thus, advertising has the feature that it is less expensive when high-quality is provided than when not. In the parlance of the signalling model above, we have a truthful signal cost, C, and a false signal cost, C', that satisfy

$$C = (1 - \delta)\overline{A} < C' = (1 - \delta')\overline{A}.$$

This quality-dependent difference in advertising cost could bring about a separating equilibrium provided that C and C' are of appropriate magnitudes to satisfy conditions 1 through 3 above.

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11.7: Concluding Comments

Economists have long held that advertising has been a means of influencing consumer preferences in a manner that makes demand less elastic and gives further discretion in price setting. The argument here is that advertising is way for sellers to increase their market power in an imperfectly competitive market. This argument is not without merit but does not explain the breadth and differences in advertising messages observed in real world commerce. Furthermore, if this were the only purpose of advertising, it would be difficult to defend it as a valuable use of economic resources. Advertising would be doing nothing to make the economy more productive. Its sole purpose would be to transfer wealth from buyers to sellers and would probably worsen welfare losses that result from resource misallocation problems observed in models of imperfectly competitive behavior. As such, advertising would be a prime candidate for regulation or even prohibition under laws similar to those that prohibit collusion, price fixing, or other anti-competitive behavior.

Recent work in information economics has noted that advertising can facilitate consumer search and can provide believable signals about experience attributes that cannot be verified pre-sale. Economists are developing a deeper understanding of advertising and its role in a market economy. If advertising does aid search and mitigate problems of asymmetric information, then it plays a valuable role that can facilitate the functioning of markets.

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11.8: References

Akerlof, G. “The Market for Lemons: Qualitative Uncertainty and the Market Mechanism” Quarterly Journal of Economics 84(1970):488-500.

Kirmani, A. and A. R. Rao. “No Pain, No Gain: A Critical Review of the Literature on Signaling Unobservable Product Quality.” Journal of Marketing 64(2000):66-79.

Milgrom, P. and J. Roberts. Economics, Organization, and Management. Englewood Cliffs, NJ: Prentice Hall, 1992.

Nelson, P. “Advertising as Information.” Journal of Political Economy 82(1974):729-754.

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11.9: Problem Sets

Exercise 11.9.1

Given the following:

Profits of falsely claiming high quality with no signal are 120.

Profits of truthfully claiming high quality with no signal are 100.

Profits of truthfully claiming low quality are 80.

The cost of a true signal of high quality is 16.

The cost of a false signal of high quality is 38.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.2

Given the following:

Profits of falsely claiming high quality with no signal are 130.

Profits of truthfully claiming high quality with no signal are 100.

Profits of truthfully claiming low quality are 60.

The cost of a true signal of high quality is 32.

The cost of a false signal of high quality is 71.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.3

Given the following:

Profits of falsely claiming high quality with no signal are 140.

Profits of truthfully claiming high quality with no signal are 120.

Profits of truthfully claiming low quality are 70.

The cost of a true signal of high quality is 24.

The cost of a false signal of high quality is 75.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.4

Given the following:

Profits of falsely claiming high quality with no signal are 150.

Profits of truthfully claiming high quality with no signal are 120.

Profits of truthfully claiming low quality are 50.

The cost of a true signal of high quality is 31.

The cost of a false signal of high quality is 99.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.5

Given the following:

Profits of falsely claiming high quality with no signal are 160.

Profits of truthfully claiming high quality with no signal are 120.

Profits of truthfully claiming low quality are 80.

The cost of a true signal of high quality is 41.

The cost of a false signal of high quality is 80.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.6

Given the following:

Profits of falsely claiming high quality with no signal are 150.

Profits of truthfully claiming high quality with no signal are 110.

Profits of truthfully claiming low quality are 60.

The cost of a true signal of high quality is 38.

The cost of a false signal of high quality is 93.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.7

Given the following:

Profits of falsely claiming high quality with no signal are 140.

Profits of truthfully claiming high quality with no signal are 110.

Profits of truthfully claiming low quality are 70.

The cost of a true signal of high quality is 34.

The cost of a false signal of high quality is 66.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.8

Given the following:

Profits of falsely claiming high quality with no signal are 130.

Profits of truthfully claiming high quality with no signal are 110.

Profits of truthfully claiming low quality are 50.

The cost of a true signal of high quality is 20.

The cost of a false signal of high quality is 82.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.9

Given the following:

Profits of falsely claiming high quality with no signal are 120.

Profits of truthfully claiming high quality with no signal are 90.

Profits of truthfully claiming low quality are 80.

The cost of a true signal of high quality is 29.

The cost of a false signal of high quality is 44.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Exercise 11.9.10

Given the following:

Profits of falsely claiming high quality with no signal are 130.

Profits of truthfully claiming high quality with no signal are 90.

Profits of truthfully claiming low quality are 60.

The cost of a true signal of high quality is 42.

The cost of a false signal of high quality is 66.

(1) Is truthful access to the high-quality market profitable given the signal?

(2) Does the signal remove the incentive of high-quality firms to cheat?

(3) Does the signal remove the incentive of low-quality firms to deceive?

(4) Is there a separating equilibrium that corrects the lemons market?

Answer available at the end of this section.

Problem Set 2. Multiple Choice

Exercise 11.9.1

1. **Which was not one of the examples of an economic signal?**

a) Low introductory prices

b) A warranty

c) Advertising

d) Production management contracts

Answer available at the end of this section.

Exercise 11.9.2

2. **Which of the following is a market solution to the adverse selection problem?**

a) Incentive-based contracts

b) First degree price discrimination

c) Equilibrium pricing mechanisms

d) Behavioral economics models

e) Economic signals

Answer available at the end of this section.

Exercise 11.9.3

3. **Which of the following is a market solution to the moral hazard problem?**

a) Incentive-based contracts

b) First degree price discrimination

c) Equilibrium pricing mechanisms

d) Behavioral economics models

e) Economic signals

Answer available at the end of this section.

Exercise 11.9.4

4. **Which of the following would be the best example of a default-contingent signal?**

a) Advertising

b) Low-introductory prices

c) Warranties

d) Job-market signaling with a college education

Answer available at the end of this section.

Exercise 11.9.5

5. **Which of the following would be the best example of a default-independent signal?**

a) Advertising

b) Low-introductory prices

c) Job-market signaling with a college education

d) All of the above

Answer available at the end of this section.

Exercise 11.9.6

6. **Asymmetric information means**

a) One party to a transaction is better informed than another

b) That information is freely available to both parties but neither party has correct information

c) Both parties are about equally informed but each places a different value on the information

d) Choices (b) and (c) only

Answer available at the end of this section.

Exercise 11.9.7

7. **Provided there is a separating equilibrium, this mechanism can mitigate the adverse selection (lemons market) problem**

1. An incentive based contract
2. An economic signal
3. A tit-for-tat responses
4. A 2nd degree price discrimination strategy

Answer available at the end of this section.

Exercise 11.9.8

8. **Which best describes a separating equilibrium**

a) A partial equilibrium model

b) A situation where all firms signal regardless of quality

c) A situation where only firms providing high quality find it in their interest to signal

d) A situation where no firms signal

Answer available at the end of this section.

Answers

Exercise 11.9.1
Answer for (1): Yes
Answer for (2): Yes
Answer for (3): No
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.2
Answer for (1): Yes
Answer for (2): Yes
Answer for (3): Yes
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.3
Answer for (1): Yes
Answer for (2): Yes
Answer for (3): Yes
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.4
Answer for (1): Yes
Answer for (2): Yes
Answer for (3): No
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.5
Answer for (1): No
Answer for (2): No
Answer for (3): No
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.6
Answer for (1): Yes
Answer for (2): Yes
Answer for (3): Yes

There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.7

Answer for (1): Yes
Answer for (2): Yes
Answer for (3): No
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.8

Answer for (1): Yes
Answer for (2): Yes
Answer for (3): Yes
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.9

Answer for (1): No
Answer for (2): No
Answer for (3): Yes
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.10

Answer for (1): No
Answer for (2): No
Answer for (3): No
There is a separating equilibrium if all answers are 'Yes'

Exercise 11.9.1

d

Exercise 11.9.2

e

Exercise 11.9.3

a

Exercise 11.9.4

c

Exercise 11.9.5

d

Exercise 11.9.6

Exercise 11.9.7

b

Exercise 11.9.8

c

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12: POLICY, SUBSIDIES, AND WELFARE ANALYSIS IN AGRICULTURE

12.1: Price Ceiling

12.2: Price Support

12.3: Quantitative Restriction

12.4: Import Quota

12.5: Taxes

12.6: Subsidies

12.7: Immigration

12.8: Welfare Impacts of International Trade

12.9: Problem Sets

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12.1: Price Ceiling

Learning Objectives

- **Explain** why governments intervene in agricultural markets and identify major policy tools.
- **Evaluate** price and quantity controls including price ceilings, price supports, subsidies, quantitative restrictions, and import quotas.
- **Analyze** the effects of policies on consumer surplus, producer surplus, government costs, and deadweight loss.
- **Apply** welfare analysis to trade, immigration, and government market interventions.
- **Understand** the trade-offs between equity, efficiency, and political goals in agricultural policy decision-making.

Agricultural markets do not always operate freely — governments often intervene to stabilize prices, support farmers, or protect consumers. These policies include price ceilings, price supports, subsidies, quotas, and taxes. Each policy changes market outcomes, shifts surplus between consumers and producers, and creates trade-offs.

Understanding these interventions is essential for analyzing modern food systems, agricultural markets, and global trade. You will learn how government policies alter market efficiency, who gains and loses, and how welfare analysis helps evaluate policy outcomes.

In some circumstances, the government believes that the free market equilibrium price is too high. If there is political pressure to act, a government can impose a maximum price, or price ceiling, on a market.

Price Ceiling = A maximum price policy to help consumers.

A price ceiling is imposed to provide relief to consumers from high prices. In food and agriculture, these policies are most often used in low-income nations, where political power is concentrated in urban consumers. If food prices increase, there can be demonstrations and riots to put pressure on the government to impose price ceilings. In the United States, price ceilings were imposed on meat products in the 1970s under President Richard M. Nixon. Price ceilings were also used for natural gas during this period of high inflation. It was believed that the cost of living had increased beyond the ability of family earnings to pay for necessities, and the market interventions were used to make beef, other meat, and natural gas more affordable.

Price ceilings are often imposed on housing prices in US urban areas. Rent control has been a longtime feature in New York City, where rent-controlled apartments continue to have low rental rates relative to the free market rate. The boom in the software industry has increased housing prices and rental rates enormously in the San Francisco Bay Area, Seattle, and the Puget Sound region. Rent control is being considered in both places to make San Francisco and Seattle more affordable for middle-class workers.

Welfare Analysis

Welfare analysis can be used to evaluate the impacts of a price ceiling. In what follows, we will compare a baseline free market scenario to a policy scenario, and compare the benefits and costs of the policy relative to the baseline of free markets and competition. Consider the price ceilings imposed on the natural gas markets. The purpose, or objective, of this policy was to help consumers. We will see that the policy does help ***some*** consumers, but makes other consumers worse off. The policy also hurts producers.

This unanticipated outcome is worth restating: price ceilings help some consumers, but hurt other consumers. All producers are made worse off. This outcome is not the intent of policy makers. Economists play an important role in the analysis and communication of policy outcomes to policy makers.

The baseline scenario for all policy analysis is free markets. Figure $12.1.1$ shows the free market equilibrium for the natural gas market. The quantity of natural gas is in trillion cubic feet (tcf) and the price of natural gas in in dollars per million cubic feet (USD/mcf).

Social welfare is maximized by free markets, because the size of the welfare area $CS + PS$ is largest under the free market

scenario. As we will see, any government intervention into a market will necessarily reduce the total level of surplus available to consumers and producers. All price and quantity policies will help some individuals and groups, hurt others, and have a net loss to society. Policy makers typically ignore or downplay individuals and groups who are negatively affected by a proposed policy. The two triangles CS and PS are as large as possible in Figure 12.1.1.

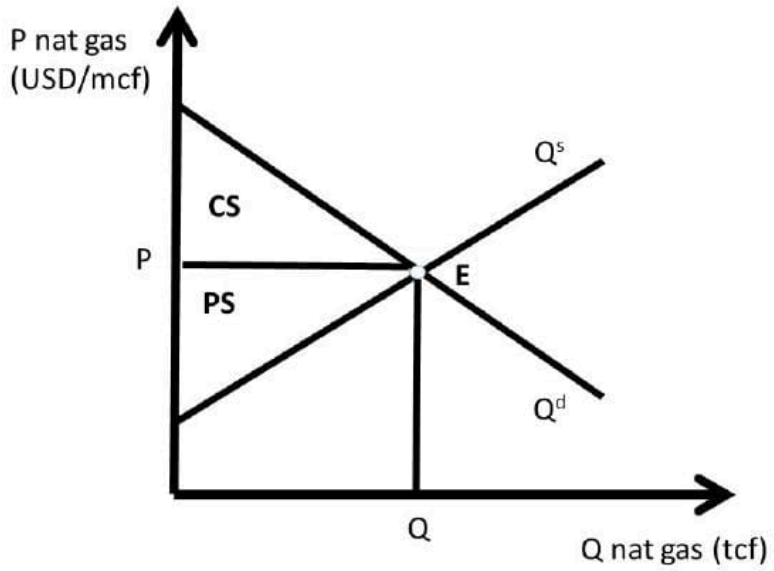


Figure 12.1.1: Natural Gas Market Baseline Scenario: Free Markets

The price ceiling policy is evaluated in Figure 12.1.2, where P' is the price ceiling. Here, the government has passed a law that does not allow natural gas to be bought or sold at any price higher than $P'(P' < P)$. For a price ceiling to have an impact, it must be "binding." This occurs only when the price ceiling is set below the market price $(P' < P)$. If the price ceiling were set above $P(P' > P)$, it would have no effect, since the good is bought and sold at the market price, which is below the price ceiling, and legally permissible. Such a law would not be binding on market transactions.

If the price ceiling is set at P', then the new equilibrium quantity under the price ceiling (Q') is found at the minimum of quantity demanded (Q^d) and quantity supplied (Q^s), as in Equation 12.1.1.

$$Q' = min(Q^s, Q^d) \tag{12.1.1}$$

This condition states that the quantity at any nonequilibrium price (P) will be the smallest of production or consumption. At the low price P', producers decrease quantity supplied, and consumers increase quantity demanded, resulting in $Q' = Q^s$ (Figure 12.1.2). This is the maximum amount of natural gas placed on the market, although consumers desire a much larger amount.

The first step in the welfare analysis is to assign letters to each area in the price ceiling graph. Next, the letters corresponding to the baseline free market scenario are recorded (initial, or baseline, values have a subscript 0), followed by the surpluses under the price ceiling (ending values have a subscript 1). Finally, the change from free markets to the price policy are calculated to conclude the qualitative analysis of a price ceiling. If the supply and demand curves have numbers (actual data) associated with them, a numerical analysis can be conducted.

The initial, baseline, free market values in the natural gas market at market equilibrium price P are:

$$CS_0 = A + B$$

and

$$PS_0 = C + D + E.$$

Social welfare is defined as the total amount of surplus available in the market, $CS + PS$:

$$SW_0 = A + B + C + D + E.$$

After the price ceiling is put in place, the price is P', and the quantity is Q'. New surplus values are found in the same way as under

free markets. Consumer surplus is the willingness to pay minus price actually paid, or the area beneath the demand curve and above the price line at the new price P': $(A + C)$. Producer surplus is the price received minus the cost of production, or the area above the supply curve and below the price line (E):

$$CS_1 = A + C,$$

$$PS_1 = E,$$

and

$$SW_1 = A + C + E.$$

Recall that social welfare (SW) is equal to the sum of all surpluses available in the market: $SW = CS + PS$. The welfare analysis outcomes are found by calculating the changes in surplus:

$$\Delta CS = CS_1 – CS_0 = +C – B$$
$$\Delta PS = PS_1 – PS_0 = –C – D$$
$$\Delta SW = SW_1 – SW_0 = –B – D$$

The results are fascinating, since the sign of the change in consumer surplus is ambiguous: the sign of ΔCS depends on the relative magnitude of areas $C and B$. If demand is elastic, and supply is inelastic, the price ceiling is more likely to yield a positive change in consumer surplus $(C > B)$. The policy makes some consumers better off, and some consumers worse off. The consumers located on the demand curve between the origin (0, 0) and Q' are made better off by area C, as they purchase natural gas at a lower price $(P' < P)$. Consumers located on the demand curve between Q' and Q have a lower willingness to pay than consumers located between the origin and Q', and are made worse off by the price ceiling $(-B)$ since they are unable to purchase natural gas at the lower price ceiling \((P'

Natural gas producers are made unambiguously worse off by the price ceiling: both the price (P) and the quantity (Q) are decreased $(P' < P; Q' < Q)$, and the change in producer surplus due to the policy is unambiguously negative $(–C – D)$

The term deadweight loss (DWL) is used to designate the loss in surplus to the market from government intervention, in this case a price ceiling. Deadweight loss is found by reversing the negative sign on the change in social welfare $(–\Delta SW)$:

$$DWL = –\Delta SW = B + D.$$

The deadweight loss area BD is called the welfare triangle, and is typical for market interventions. Interestingly, and perhaps unexpectedly, all government interventions have deadweight loss to society. Free markets are voluntary, with no coercion. Any price or quantity restriction will necessarily reduce the surplus available to producers and/or consumers in a market.

In current debates over rent control in congested urban areas, economists continue to point out the potential impact of rent control policies: a reduction in affordable housing. These policies are often put in place in spite of economic views, with mixed results. Renters who can find a rent-controlled property win, but many renters are unable to find housing, and must relocated outside the urban center and commute to work from a distant home.

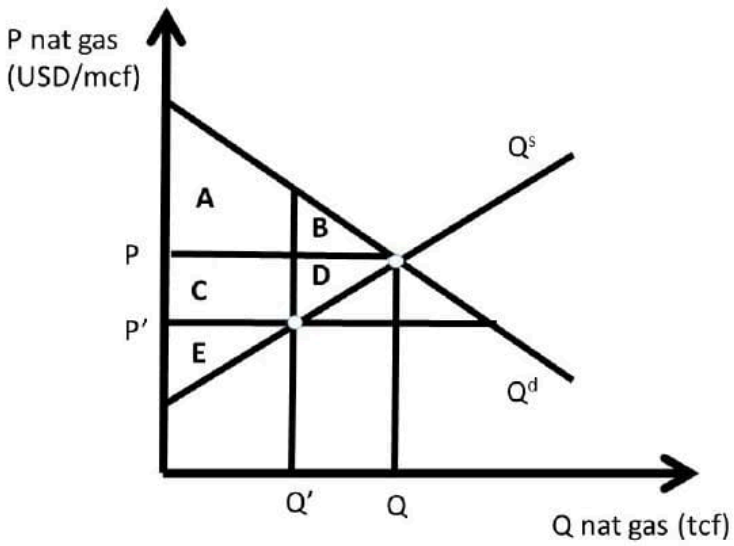


Figure 12.1.2: A Price Ceiling in the Natural Gas Market

As indicated above, price ceilings on food and agricultural products are most often used in low-income nations, such as in Asia and Sub-Saharan Africa. Price supports for food and agricultural products are most often used in high-income nations such as the US, European Union (EU), Japan, Australia, and Canada.

Quantitative Analysis

In this example, that beef consumers lobby the government to pass a price ceiling on beef products. This happened in the USA in the 1970s, during a period of high inflation. Beef consumers believe that prices are too high and democratically elected officials give their constituents what they want. Suppose that the inverse supply and demand for beef are given by:

$$P = 20–2Q^d, \tag{12.1.2}$$

and

$$P = 4 + 2Q^s. \tag{12.1.3}$$

Where P is the price of beef in USD/lb, and Q is the quantity of beef in million lbs. The equilibrium price and quantity of beef can be calculated by setting the inverse supply and demand equations equal to each other to achieve:

$$P^e = \text{ USD } 12/\text{lb beef},$$

and

$$Q^e = 4 \text{ million lbs beef}.$$

These values, together with the supply and demand functions, allow us to measure the well-being of both consumers and producers before and after the price ceiling policy is implemented (Figure 12.1.3).

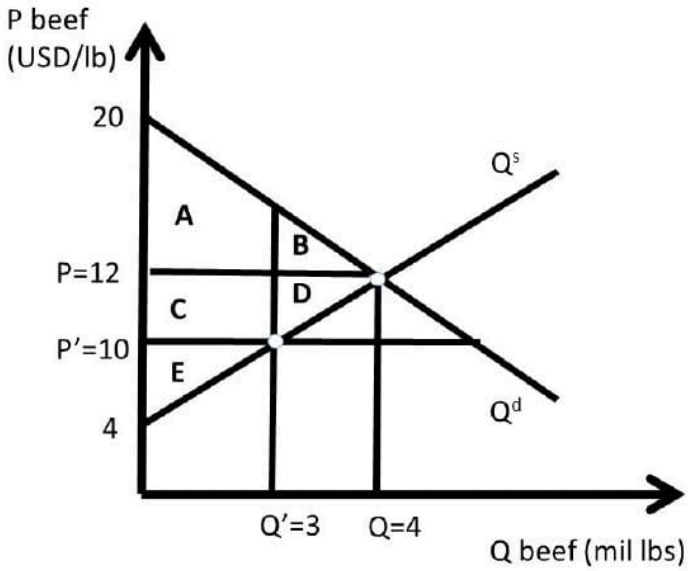


Figure 12.1.3: A Quantitative Price Ceiling in the Beef Market

The free-market equilibrium levels of CS and PS are designated with the subscript 0, calculated in equations 12.1.4 and 12.1.5.

$$CS_0 = A + B = 0.5(20–12)(4) = 0.5(8)(4) = \text{ USD } 16 \text{ million} \tag{12.1.4}$$

$$PS_0 = C + D + E = 0.5(12–4)(4) = 0.5(8)(4) = \text{ USD } 16 \text{ million} \tag{12.1.5}$$

The level of social welfare is the sum of all surplus in the market, as in Equation 12.1.6.

$$SW_0 = A + B + C + D + E = 0.5(20–4)(4) = 0.5(16)(4) = \text{ USD } 32 \text{ million} \tag{12.1.6}$$

Assume that the price ceiling is set by the Government at $P' = 10$ USD/lb beef. The quantity is found by finding the minimum of quantity supplied and quantity demanded. In the case of a binding price ceiling $(P' < P)$, the quantity supplied will be the relevant quantity, since producers will produce only Q' lbs of beef. Consumers will desire to purchase a much larger amount at $P' < P$, but are unable to at the lower price P', since production falls from Q to Q'. The quantity of Q' is found by substituting the new price into the inverse supply equation.

$$P = 4 + 2Q^s = 10 = 4 + 2Q^s,$$

therefore,

$$Q' = 3$$

The price ceiling (P') and reduced quantity (Q') can be seen in Figure 12.1.3. Next, the levels of CS, PS, and $SW$are calculated at the price ceiling level. To find the surplus level of area A, split the shape into one triangle and one rectangle by substitution of $Q' = 3$ into the inverse demand curve to get $P = 14$. Area A is equal to:$0.5(20–14)3 + (14–12)3 = 9 + 6 = 15$ million USD. We are now ready to calculate the level of surplus for the price ceiling.

$$CS_1 = A + C = 15 + (12–10)(3) = 15 + 6 = \text{ USD } 21 \text{ million} \tag{12.1.7}$$

$$PS_1 = E = 0.5(10–4)(3) = 0.5(6)(3) = \text{ USD } 9 \text{ million} \tag{12.1.8}$$

$$SW_1 = A + C + E = 21 + 9 = \text{ USD } 30 \text{ million} \tag{12.1.9}$$

The changes in welfare due to the price ceiling are:

$$\Delta CS = CS_1–CS_0 = +C–B = 21–16 = \text{ USD } +5 \text{ million} \tag{12.1.10}$$

$$\Delta PS = PS_1–PS_0 = –C–D = 9–16 = \text{ USD } –7 \text{ million} \tag{12.1.11}$$

$$\Delta SW = SW_1–SW_0 = –B–D = 30–32 = \text{ USD } –2 \text{ million} \tag{12.1.12}$$

The Dead Weight Loss (DWL) of the price ceiling is the loss to social welfare, of the negative of the change in social welfare:

$$DWL = –\Delta SW = 2 \text{ USD million.} \tag{12.1.13}$$

The quantitative analysis of a price ceiling provides timely, important, and interesting results. First, only a subset of consumers are made better off due to a price ceiling. These consumers win because they pay a lower price for the good under the price ceiling than in the free market $(P' < P)$. Second, some consumers are made worse off due to the price ceiling, since the quantity of the good available is reduced $(Q' < Q)$. This is because producers reduce the quantity supplied if the price is lowered (the Law of Supply). Third, all producers of the good are made unambiguously worse off due to the price ceiling, since both price and quantity are reduced $(P' < P; Q' < Q)$.

The magnitude of the consumer gains and losses are determined by the elasticities of supply and demand. Elastic demand and inelastic supply provide larger consumer benefits, since area B in Figure $12.1.3$ is relatively small under these conditions. If demand is inelastic and supply is elastic, consumers are less likely to gain from the price ceiling, as area C in Figure $12.1.3$ is relatively small in this case.

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12.2: Price Support

This section continues the welfare analysis of price policies by investigating the welfare analysis of a **price support**, also called a minimum price. Price supports are intended to help producers. The outcome of the welfare analysis demonstrates that price supports can increase producer surplus, but in many cases at a large cost to the rest of society. Figure $12.2.1$ shows the impact of a price support in the wheat market. This policy is more likely to be enacted in a high-income nation where agricultural producers are a small group that can be more easily subsidized by a large economy.

Price Support = A minimum price policy enacted to help producers.

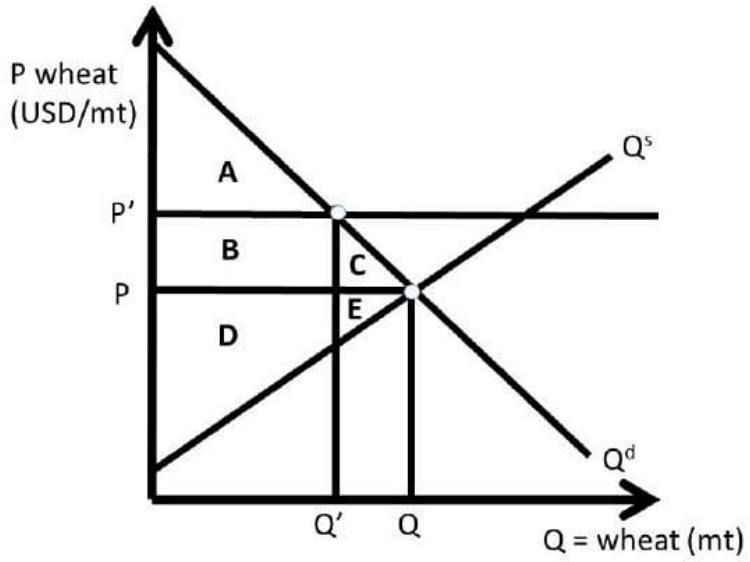


Figure $12.2.1$: Case One: Price Support in Wheat Market, No Surplus

The price support mandates that all wheat be bought or sold at a minimum price of \(P^{\prime}\). If the price support were set at a level lower than the market equilibrium price \((P^{\prime} < P)\), it would have no effect (it would not be “binding”). The quantity of wheat on the market depends on how the policy works. There are three possibilities for how the price support is implemented: (1) no surplus exists, (2) the surplus exists, and (3) the government purchases the surplus. Each case will be described in detail in what follows.

Case One: Price Support with No Surplus

The first case is the simplest, but least realistic. In Case One, we assume that producers correctly forecast the quantity demanded, and produce only enough to meet demand. No surplus exists. In Figure $12.2.1$, the price support is set by the government at P'. It is assumed in this case that producers forego increasing quantity supplied along the supply curve to price P', and instead produce only enough wheat to meet consumer needs, Q':

$$Q' = \min(Q^s, Q^d).$$

In Case One, no surplus exists. The producers produce and sell only enough wheat to meet the low level of quantity demanded, Q'. The initial, free market surplus levels are:

$$\begin{aligned} CS_0 &= A + B + C \\ PS_0 &= D + E \\ SW_0 &= A + B + C + D + E \end{aligned}$$

After the price support is put in place, the new levels of surplus are;

$$CS_1 = A,$$

$$PS_1 = B + D,$$

and

$$SW_1 = A + B + D.$$

Changes in surplus from free markets to the price support with no surplus are:

$$\Delta CS = -B - C,$$

$$\Delta PS = +B - E,$$

$$\Delta SW = -C - E$$

and

$$DWL = -\Delta SW = C + E$$

Consumers are unambiguously worse off: price is higher $(P' > P)$ and quantity is lower $(Q' < Q)$, relative to the free market case. Producers may or may not be better off, depending on the relative size of areas B and E. If demand is inelastic and supply is elastic, it is more likely that producer surplus is higher with the price support $(B > E)$. This reflects the analysis of price support in the previous chapter. The producers with low production costs, located on the supply curve between the origin (0, 0) and Q', are made better off since they receive a higher price for the wheat that they produce $(P' > P)$. The high-cost producers, located on the supply curve between Q' and Q, are made worse off, since they no longer produce wheat.

The deadweight loss (DWL) equals welfare triangle CE. The price support helps producers, if demand is sufficiently inelastic, but at the expense of the rest of society. In high-income nations such as the US, this policy transfers surplus from the average consumer to producers. Wheat producers have higher levels of income and wealth than the average consumers, so the policy represents a transfer of income to individuals who are better off than the consumers.

Case Two: Price Support When Surplus Exists

Case Two is more realistic than Case One. In Case Two, wheat producers increase quantity supplied to Q'', found at the intersection of P' and the supply curve. This is shown in Figure 12.2.2. At the price support level P', consumers purchase only Q', so a **surplus** exists equal to Q''–Q'.

Surplus = Quantity supplied minus quantity demanded = Q^s–Q^d.

Note that this surplus of quantity shared the same world as consumer surplus and producer surplus, but refers to an excess quantity instead of an excess value. The initial values of surplus at free market levels are:

$$CS_0 = A + B + C,$$

$$PS_0 = D + E,$$

and

$$SW_0 = A + B + C + D + E.$$

After the price support is put in place, the new levels of surplus reflect the large costs of producing the surplus, with no buyers at the high price $(P' > P)$. The cost of producing the surplus is the area under the supply curve, between Q' and Q'': GHI. The area GHI is the cost of producing the surplus, Q''–Q', because it is the area under the supply curve. The surplus levels with the price support, assuming that the surplus exists are:

$$CS_1 = A,$$

$$PS_1 = B + D–G–H–I,$$

and

$$SW_1 = A + B + D–G–H–I.$$

Changes in surplus from free markets to the price support with the surplus are:

$$\Delta CS = -B - C,$$

$$\Delta PS = +B - E - G - H - I,$$

$$\Delta SW = -C - E - G - H - I,$$

and

$$DWL = -\Delta SW = C + E + G + H + I.$$

The impact on consumers remains the same as in Case One, but the impact on producers is much costlier. The surplus is costly to produce, and does not have a buyer. If this policy were to be implemented, the government would have to do something with the surplus of wheat created by the policy, or market forces would put pressure on the wheat market to return to equilibrium.

If the surplus remained, market forces would put downward pressure on the price of what making the price support more difficult and more expensive to maintain. This leads to Case Three, where the government purchases the surplus grain and removes it from the market, described in the next section.

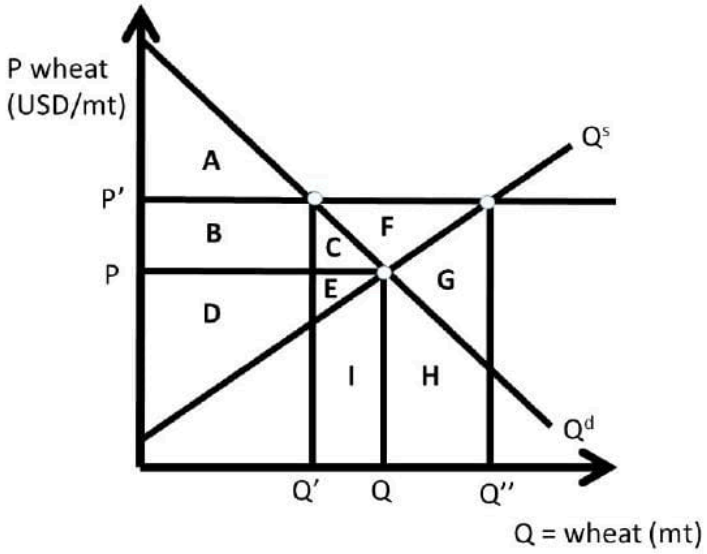


Figure 12.2.2: Case Two: Price Support in Wheat Market, Surplus Exists

Case Three: Price Support When Government Purchases Surplus

The surplus created by a price support is costly to producers, and if nothing is done to eliminate the surplus, the policy does not achieve the objective of helping producers. There are three methods for the government to eliminate the surplus:

1. Destroy the surplus,
2. Give the surplus away domestically, or
3. Give the surplus away internationally.

In all three cases, the government purchases the surplus at the price support level. This is the only way to maintain the price support. Without government purchases, the surplus would result in market forces that put downward pressure on the price of wheat. Destroying the surplus is not politically popular, since it involves eliminating food when there are hungry people in the

world. The US did this in earlier decades by dumping surplus grain in the ocean, killing baby pigs, and dumping milk on the ground. This was not popular with consumers, producers, or politicians. The practice of destroying food to maintain higher food prices is not used today.

Domestic food programs make more sense as a method for eliminating the surplus. School breakfast and school lunch programs make use of the food surpluses by assisting those in need. Food aid is using the surplus food from the USA to alleviate hunger in other nations. Food aid and other forms of international assistance are popular programs that help the US producers and the recipient nation's consumers. Food aid can be controversial, since it lowers food prices in receiving nations, and can cause "dependency" of the recipient on the donor nation.

Food aid results in lower prices, which cause a decrease in the quantity of food supplied in the recipient nation. Although food aid may alleviate hunger and/or starvation, it decreases the incentives for a nation to produce food. This is a true paradox, making food and agricultural policy a challenge for policy makers: there are winner and losers that result from all public policies.

Case Three is shown in Figure $12.2.3$, where the government purchases the surplus $(Q''–Q')$.

As in the two previous cases, the initial values of surplus at free market levels are:

$$CS_0 = A + B + C,$$

$$PS_0 = D + E,$$

$$G_0 = 0,$$

and

$$SW_0 = A + B + C + D + E.$$

Note that the government (G) is included in this case of the price support. After the price support is put in place, the new levels of surplus reflect the large costs of the government buying the surplus. The cost of producing the surplus $(Q''–Q')$ at the price support level equals P' multiplied by $(Q''–Q')$, which is equal to area $CEFGHI$ (Figure $12.2.3$), the cost of producing the surplus. The surplus levels with the price support, assuming that the surplus exists are:

$$CS_1 = A,$$

$$PS_1 = B + C + D + E + F,$$

$$G_1 = –C–E–F–G–H–I,$$

and

$$SW_1 = A + B + D–G–H–I.$$

Changes in surplus from free markets to the price support with the surplus are:

$$\Delta CS = -B - C,$$

$$\Delta PS = +B + C + F,$$

$$\Delta G = -C - E - F - G - H - I,$$

$$\Delta SW = -C - E - G - H - I,$$

and

$$DWL = -\Delta SW = C + E + G + H + I.$$

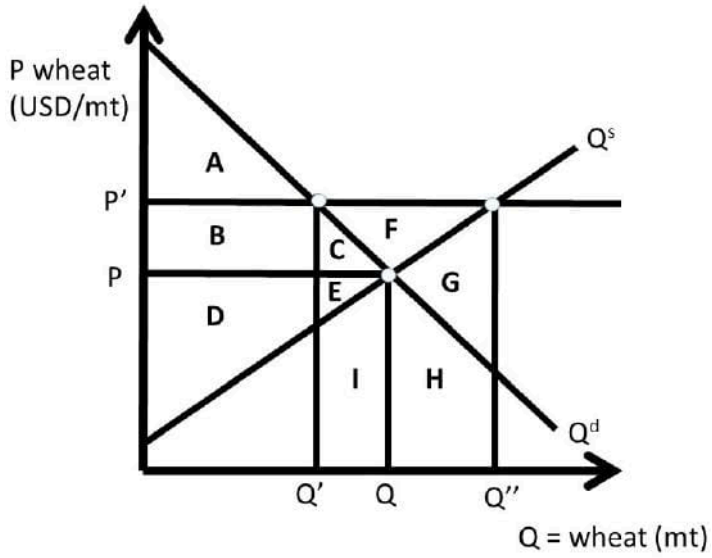


Figure 12.2.3: Case Three: Price Support in Wheat Market, Government Purchases Surplus

The total societal surplus changes are identical in Cases Two and Three: $DWL = CEGHI$ in both cases. The distribution of benefits is quite different, however. In Case Two, the producers bear the large costs of overproduction: $-GHI$. In Case Two, the government has attempted to help producers, but has decreased producer surplus due to the unintended consequence of wheat growers producing too much food at the high level of the price support. If the government does purchase the surplus as in Case 3, these high costs are shifted to taxpayers, and producers are helped by the price support program.

The price support does meet the objective of helping producers in Case 3, but at a high cost to society. As in the case of the price ceiling, the price support results in losses to society $(DWL > 0)$. This is true of all government interventions into the market. The maximum level of surplus occurs with free markets and free trade. In food and agriculture, there are numerous cases of government intervention into markets, reflecting objectives other than maximizing social welfare.

In some circumstances, policy makers determine that the distributional consequences of a policy are more important than maximizing social welfare. In these cases, who gets what determines policy outcomes, rather than the overall efficiency of the market.

Quantitative Analysis of a Price Support

In this example, wheat producers are successful in their efforts to convince Congress to pass a law that authorizes a price support for wheat. Suppose that the inverse supply and demand for wheat are given by:

$$P = 10 – Q^d, \tag{12.2.1}$$

and

$$P = 2 + Q^s. \tag{12.2.2}$$

Where P is the price of wheat in USD/MT, and Q is the quantity of wheat in million metric tons (MMT). The equilibrium price (P^e) and quantity of wheat $(Q^e)$are calculated by setting the inverse supply and demand equations equal to each other to achieve:

$$P^e = \text{USD } 6/\text{MT wheat},$$

and

$$Q^e = 4 \text{ MMT wheat}.$$

These values, together with the supply and demand functions, allow us to measure the changes in surpluses for both consumers and producers due to the price support (Figure 12.2.4).

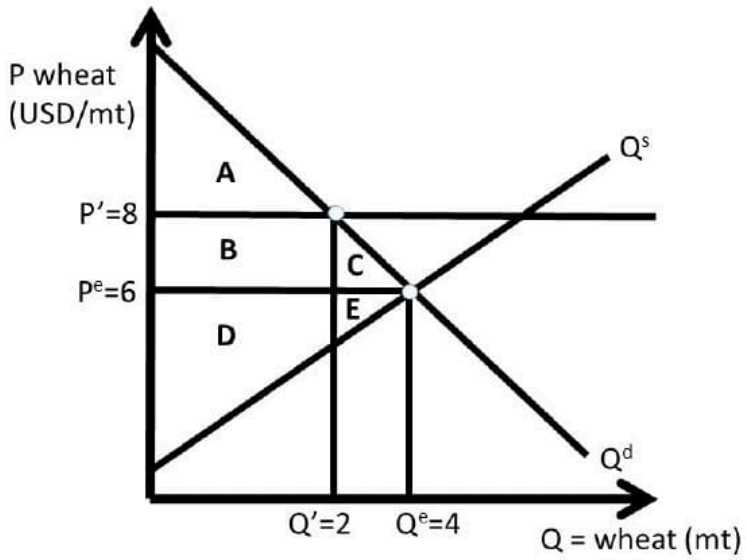


Figure 12.2.4: Case One: Quantitative Price Support in Wheat Market, No Surplus

The calculations will proceed by directly determining the changes in surplus, rather than calculating the initial and ending values of surplus, as we did above for the price ceiling. To find the dollar values of the areas in Figure 12.2.4, recall that you can always find a price or quantity by substitution of a P or Q into the inverse supply or inverse demand curve. There is always enough information provided to find prices, quantities, and the areas that represent surplus values.

Assume that the price support is set at $P' = 8$ USD/MT wheat. The quantity is found by the minimum of quantity demanded (Q^d) and quantity supplied (Q^s): $\min(Q^s, Q^d)$. Therefore, the quantity is $Q' = Q^d$, the quantity demanded. Surplus changes are:

$$\begin{aligned}
\Delta CS &= -B - C = -4 - 2 = -6 \text{ USD million} \\
\Delta PS &= +B - E = +4 - 2 = +2 \text{ USD million} \\
\Delta G &= 0 \\
\Delta SW &= -C - E = -2 - 2 = -4 \text{ USD million} \\
DWL &= -\Delta SW = C + E = +4 \text{ USD million}
\end{aligned}$$

The government does nothing in Case One, and wheat producers supply only enough wheat to the market to meet consumer demand. Case Two is shown in Figure 12.2.5. In Case Two, producers produce a large amount of wheat (Q'') due to the high price P'. There is a large surplus created, but in this case there is no intervention by the government. Wheat producers have very large costs, since they produce 6 million metric tons (Q''), and consumers only purchase 2 million metric tons (Q', Figure 12.2.5).

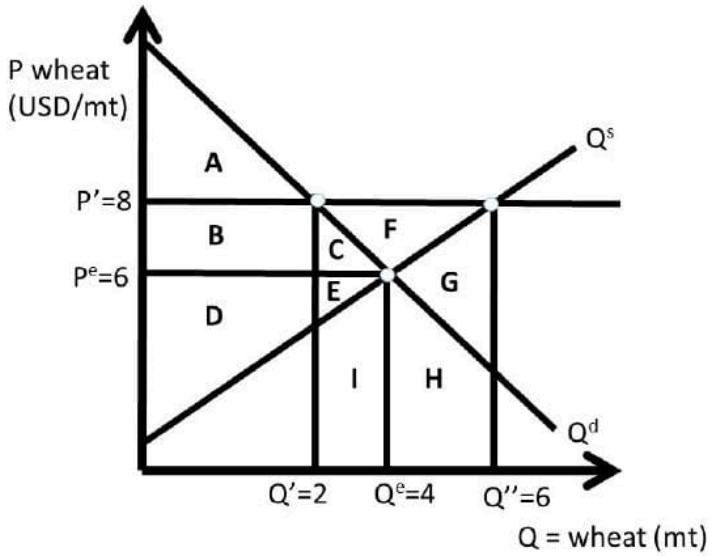


Figure 12.2.5: Case Two: Quantitative Price Support in Wheat Market, Surplus Exists

$$\Delta CS = -B-C = -4-2 = -6 \text{ USD million}$$
$$\Delta PS = +B-E-G-H-I = +4-26 = -22 \text{ USD million}$$
$$\Delta G = 0$$
$$\Delta SW = -C-E-G-H-I = -28 \text{ USD million}$$
$$DWL = -\Delta SW = C + E + G + H + I = +28 \text{ USD million}$$

In Case Three, the government intervenes and buys the surplus. This allows the price to stay at the price support level, P'. Quantity supplied and quantity demanded are at the same levels as in Case Two, but the government's expenses are large, and wheat producers benefit from the high price $(P' > P^e)$ and larger quantity sold $(Q'' > Q^e$, Figure 12.2.6).

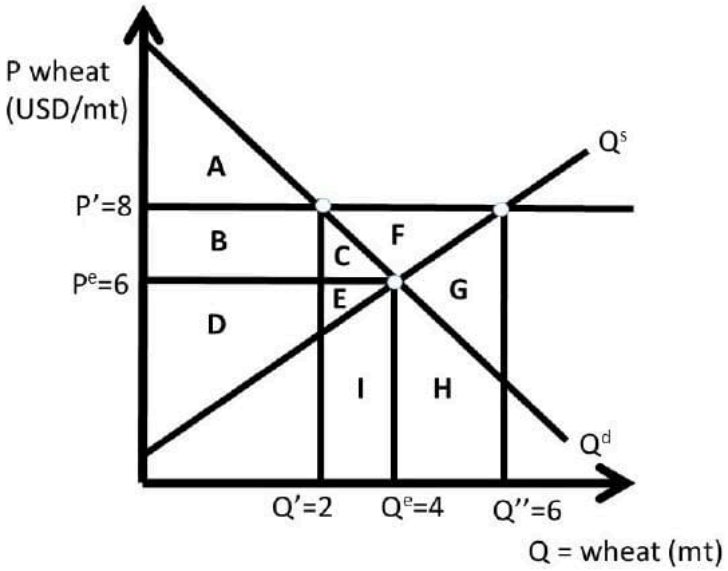


Figure 12.2.6: Case Three: Quantitative Wheat Price Support, Government Buys Surplus

$$\Delta CS = -B-C = -4-2 = -6 \text{ USD million}$$
$$\Delta PS = +B + C + F = 4 + 2 + 4 = +10 \text{ USD million}$$
$$\Delta G = -C-E-F-G-H-I = -32 \text{ USD million}$$
$$\Delta SW = -C-E-G-H-I = -28 \text{ USD million}$$
$$DWL = -\Delta SW = C + E + G + H + I = +28 \text{ USD million}$$

In Case Three, the price support has large costs, paid for by the government. One benefit that is not explicitly included is the food

aid that could be provided to domestic and foreign consumers. These benefits would provide noneconomic gains, but no added surplus value to the program. Price supports can increase producer surplus, but at a cost. Government interventions often have unintended consequences, such as the surplus of grain in this case.

After World War II, European nations subsidized food and agriculture heavily. Since they had experienced massive food shortages during the War, Europeans did not want to rely on other nations for food. The large subsidies resulted in large surpluses of food that had to be exported at below-market prices to maintain the high food prices within Europe. In the next section, we will discuss quantitative restrictions as another means of increasing prices in food and agriculture.

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12.3: Quantitative Restriction

Governments in high income nations often subsidize agricultural producers. A price support is one public policy intended to increase producer surplus. The unintended consequence of the price support is a large surplus that is costly to either producers, the government, or both. Another policy intended to help producers is a quantitative restriction, also called output control or supply control. The idea of supply control is to decrease output in order to increase the price. The analysis of elasticity in Chapter One demonstrated that this policy would work only if the demand for the good is inelastic.

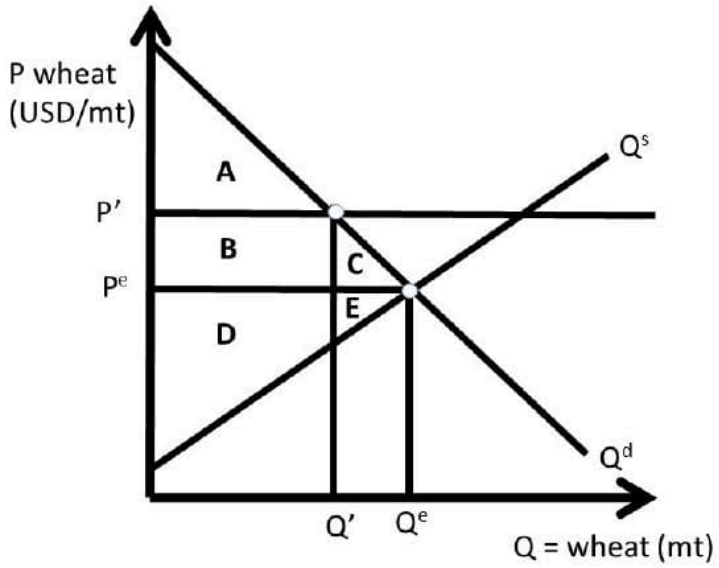


Figure 12.3.1: Quantitative Restriction in Wheat Market

A quantitative restriction in the wheat market is shown in Figure 12.3.1. Wheat output is restricted to $Q' < Q^e$, resulting in a higher price $P' > P^e$. The welfare analysis of this policy is identical to that of a price support: if wheat output is reduced by an amount that raises the price to P', the policy is equivalent to Case One of the Price Support analyzed in the previous section. Therefore, the welfare analysis of the quantitative restriction in Figure 12.3.1 is:

$$\Delta CS = -B-C,$$

$$\Delta PS = +B-E,$$

$$\Delta SW = -C-E,$$

and

$$DWL = -\Delta SW = C + E.$$

The magnitudes of these welfare changes depend on the elasticities of supply and demand. Note that producers only gain if the demand curve is sufficiently inelastic. If wheat demand is sufficiently inelastic relative to the elasticity of supply, then $B > E$, and the change in producer surplus is positive. However, if the demand is sufficiently elastic relative to the elasticity of supply, then $B < E$, and producers lose. This result emphasizes one of the important agricultural policy conclusions of this course: in a global economy, the demand for agricultural goods is elastic due to global competition, and price supports and supply control will hurt producers more than they will help them. This was the result found in Section 1.4.9 above. The welfare analysis of the quantitative restriction highlights this important policy contribution.

The benefit of the quantitative restriction is the lack of a surplus, which is a costly weakness of price supports. One difficulty with supply control is administration and enforcement. Wheat producers will not be free to choose how much wheat that they produce. Instead, the government will allow only a certain amount of wheat produced by each farmer, called a quota. This quantitative restriction can be accomplished through acreage controls also, where wheat producers can only plant a percentage of their total acreage to wheat. This is an imperfect policy, since producers could increase yield per acre on the acres that they are allowed

to plant. If the output is restricted, it is difficult to enforce the policy, and if overproduction occurs, it is difficult to remove the surplus.

Although government programs and policies are well intended, they often cause unintended consequences. Price supports and quantitative restrictions can help producers, but at the expense of consumers.

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12.4: Import Quota

The large benefits of free trade have been emphasized in this book. Free markets and free trade are based on voluntary, mutually-beneficial transactions that make both trading partners better off. The global economic gains from free trade have been enormous, as they enhance efficiency of resource use. Comparative advantage and gains from trade allow each individual, firm, or nation to "do what they do best, and trade for the rest."

Not everyone wins from trade, however. As was emphasized in Section 1.6.3 above, the overall net benefits are positive, but there are winners and losers from trade. Specifically, producers in importing nations and consumers in exporting nations lose due to price changes that negatively affect them. Like all public policies, free trade has winners and losers. The overall size of the economy is maximized under free markets and free trade, but there are distributional consequences that result in winners and losers.

Trade barriers are most often erected to protect domestic producers from imports. Sugar is produced in the United States, but at higher production costs than sugar production in tropical climates found in Cuba, the Dominican Republic, and Haiti. If free trade prevailed, all sugar consumed in the USA would be imported, since it is cheaper to buy sugar than to produce it domestically. Sugar producers are interested in maintaining sugar production in the USA, as this is how they make their living. Agricultural trade policy has limited sugar imports to a much smaller amount than the free trade level, through a sugar quota, demonstrated in Figure 12.4.1. The import reduction makes sugar in the USA more scarce, and therefore more valuable.

In a closed economy, market forces ensure that supply and demand are equal $(Q^s = Q^d)$. If the USA were a closed economy, the price of sugar would be very high, well above the world market price of sugar P_w. Suppose that the USA is a "small nation" purchaser of sugar: this means that the USA is a "price taker," facing a constant world price of sugar for all quantities purchased. The assumption of an importing nation being a small nation, or price taker, simplifies our analysis. In the real world, the importer may be large enough to influence the world price of sugar through large purchases of sugar on the global market.

This is represented as a horizontal line at Pw in Figure 12.4.1. At the world price of P_w, the USA would produce Q^s domestically and consume Q^d. The difference between quantity demanded and quantity supplied is imports $(Q^d–Q^s)$. The equality of domestic supply and demand has been broken by the ability to import less expensive sugar from other nations. Note that in a situation with no imports, the domestic price in the USA would be at the intersection of Q^s and Q^d.

Domestic sugar producers lobby the government for protection, and receive it in the form of a sugar quota, meaning a maximum amount of sugar imports. The right to import sugar is auctioned off to the highest bidders, who pay for the right to import sugar. Suppose that the quota is set at $Q^{d'}–Q^{s'}$. This level of quota is binding, since $(Q^{d'}–Q^{s'}) < (Q^d–Q^s)$.

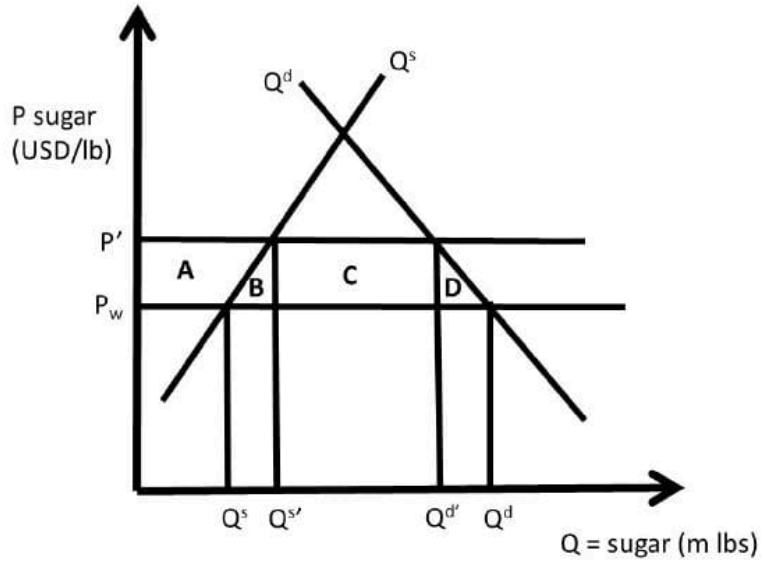


Figure 12.4.1: Sugar Import Quota

This level of imports is the horizontal distance between $Q^{d'}$ and $Q^{s'}$ in Figure 12.4.1. At this quota level, the price of sugar increases to P', since the quantity of sugar in the market is reduced from free market levels. At this high price $(P' > P_w)$, quantity supplied increases from Q^s to $Q^{s'}$, and quantity demanded decreases from Q^d to $Q^{d'}$. These changes are due to the quota, which decreases the amount of sugar allowed into the country. Sugar producers are pleased with this policy, since the price is higher and domestic quantity supplied $(Q^{s'} > Q^s)$ larger.

Welfare Analysis of an Import Quota

The welfare analysis of the import quota identifies the changes in economic surplus of producers, consumers, and the government. The government gains from selling the import quota permits to the sugar importers. These firms will compete with each other to win the right to import sugar. The firms will bid up the price in an auction until the price is equal to the market value of the quota. In this case, the market value is equal to $(P'–P_w)$, since this is the gain from importing one pound of sugar into the USA. The complete welfare analysis is:

$$\Delta CS = -A–B–C–D,$$

$$\Delta PS = +A,$$

$$\Delta G = +C,$$

$$\Delta SW = -B–D,$$

and

$$DWL = B + D.$$

Producers gain, but with large costs to consumers. The government gains from the sale of the quota permits (or licenses) to sugar importers. Sugar consumers are made much worse off from this policy. The area B is called the “production loss” of the policy. This area is equal to the losses of using scarce resources to produce sugar in the USA instead of buying it at the world price. Area B represents the production costs, since it is the area under the supply curve, and above the world price (P_w). These resources could be more efficiently used producing something other than sugar. Area D is called the “consumption loss” of the import quota. This is the area under the demand curve and above the world price (P_w), which represents the extra dollars spent by US consumers buying domestic sugar instead of low-cost imported sugar. Areas B and D represent the loss in social welfare, or the deadweight loss, of the government intervention. Free markets and free trade would provide efficiency of resource use and lower costs to consumers.

In the USA, sugar prices are typically one to two times higher than the world price, resulting in billions of dollar losses to sugar consumers. This policy also has an interesting unintended consequence. High fructose corn syrup (HFCS) is a perfect substitute in consumption for sucrose (sugar made from sugar cane or sugar beets). Corn producers lobby the government to maintain the sugar import quota, to keep the price of sugar high. When the sugar price is high, buyers of sugar (Coca Cola, Pepsi, Mars, etc.) switch out of sucrose and into fructose. Corn farmers are among the largest supporters of the sugar import quota! The positive impact on corn producers is a truly unique and unanticipated cause and effect of protection of domestic sweetener producers from foreign competition.

Quantitative Welfare Analysis of an Import Quota

Suppose that the inverse demand and supply of sugar are given by:

$$P = 100–Q^d,$$

and

$$P = 10 + Q^s,$$

Where P is the price of sugar in USD/lb, and Q is the quantity of sugar in million pounds. Suppose also that the world price of sugar is given by $P_w = 20$ USD/lb, as shown in Figure 12.4.2. In a closed economy, there would be no imports or exports, so $Q^s = Q^d$ at this market equilibrium, where supply is equal to demand:

$$Q^e = 45 \text{ million pounds of sugar}$$

and

$$P^e = 55 \text{ USD/lb}.$$

This is a high price of sugar relative to the world price, occurring at the intersection of Q^s and Q^d in Figure 12.4.2. If imports are allowed, the USA can break the equality of production and consumption $(Q^s \neq Q^d)$ through imports of less expensive sugar $(Q^s < Q^d)$. If we assume that the USA is a "small nation" in sugar trade, then the USA is a price taker, and can import as much or as little sugar as it desires at the world price. Note that a "large nation" means that a country is a price maker, and has enough market power to influence the price of the imported good.

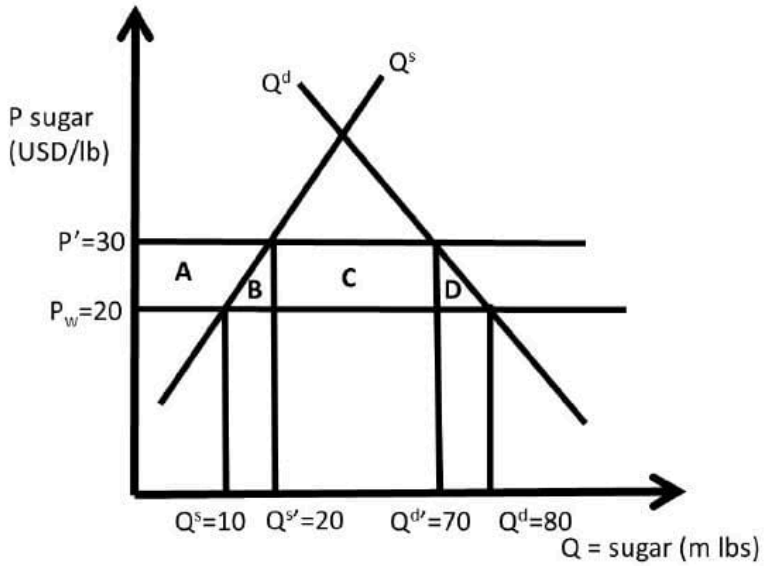


Figure 12.4.2: Quantitative Sugar Import Quota

The free market equilibrium in an open economy can be calculated by substitution of the world price into the inverse supply and demand functions. At the world price, $Q^s = 10$ m lbs sugar and $Q^d = 80$ m lbs sugar. Imports are equal to Q^s–$Q^d = 70$ m lbs sugar. Social welfare is maximized at this free trade equilibrium, since sugar is produced by the lowest cost producers. Ten million pounds of sugar are produced by domestic producers along the supply curve below the world price, and 70 m lbs are produced by foreign sugar producers at the world price of 20 USD/lb.

Now assume that a sugar import quota is implemented, equal to 50 m lbs of sugar. To be binding, the import quota must be less than the free-market level of imports. Since this is less than the free trade import level, it will decrease the amount of sugar available in the USA, and cause price to increase. The sugar price that results from the quota (P') can be calculated using the inverse supply and demand curves and the import quota:

$$Q^{d'}\text{–}Q^{s'} = 50,$$

$$P' = 100\text{–}Q^{d'},$$

and

$$P' = 10 + Q^{s'}.$$

Rearranging the first equation: $Q^d = 50 + Q^s$. Substitution of the first equation into the inverse demand equation yields:

$$P' = 100\text{–}(50 + Q^{s'}) = 50\text{–}Q^{s'}.$$

This equation can be set equal to the inverse supply equation:

$$P' = 50\text{–}Q^{s'} = 10 + Q^{s'}.$$

Solving for $Q^{s'}$:

$$2Q^{s'} = 50–10,$$

or

$$Q^{s'} = 40/2 = 20 \text{ m lbs sugar.}$$

Substituting this into the import equation and the inverse supply function yield:

$$P' = 30 \text{ USD/ lb,}$$

and

$$Q^{d'} = 70 \text{ m lbs sugar.}$$

These values are all shown in Figure 12.4.2. Notice that quantity supplied has increased $(Q^{s'} > Q^{s})$ and quantity demanded has decreased $(Q^{d'} < Q^{d})$ due to the import quota and the resulting higher price $(P' > P_{w})$. The welfare analysis can now be conducted by calculation of the areas in the graph.

$$\begin{aligned} \Delta CS &= -A–B–C–D = –750 \text{ USD million} \\ \Delta PS &= +A = +150 \text{ USD million} \\ \Delta G &= +C = +500 \text{ million} \\ \Delta SW &= -B–D = –100 \text{ USD million} \\ DWL &= B + D = +100 \text{ million} \end{aligned}$$

The government gains area C by auctioning off the permits that allow firms to import sugar. The quantitative results confirm that import restrictions help domestic producers, but at thigh costs to domestic consumers. The high price for sugar also provides support to corn producers, since High Fructose Corn Syrup (HFCS) is a close substitute to sucrose. Taxes are analyzed in the next section.

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12.5: Taxes

Taxes are often imposed to provide government revenue. The government also uses taxes to decrease the consumption of a good such as alcohol or tobacco. These taxes are called “sin taxes,” on goods that are not favored by society. These goods often have inelastic demands, which allows the government to apply a tax and earn revenues. Taxes can also be used to meet environmental objectives, or other societal goals: goods such as gasoline and coal emissions are taxed.

There are two types of tax: (1) specific tax, and (2) ad valorem tax.

Specific Tax = A tax imposed per-unit of the good to be taxed.

Ad Valorem Tax = A tax imposed as a percentage of the good to be taxed.

Both types of tax have the same qualitative effects, so we will study a specific, or per-unit tax (t = USD/unit). Taxes result in price changes for both buyers and sellers of the taxed good. The welfare analysis of a tax provides important results on who pays for the tax: the buyers or sellers? The term, “tax incidence,” refers to how a tax is divided between buyers and sellers. Let P_b be the buyer’s price, and P_s be the seller’s price. In markets without a tax, buyers and sellers both pay the same equilibrium market price ($P_b = P_s = P^e$). In a market for a taxed good, however, this equality is broken. With a tax, the buyer’s price is higher than the seller’s price by the amount of the tax:

$$P_b = P_s + t$$

Economists say that the tax drives a wedge between the buyer’s price and the seller’s price, as shown in Figure 12.5.1. The specific tax (t) is equal to the vertical distance between P_b and P_s. The tax incidence, or who pays for the tax, depends of the elasticities of supply and demand.

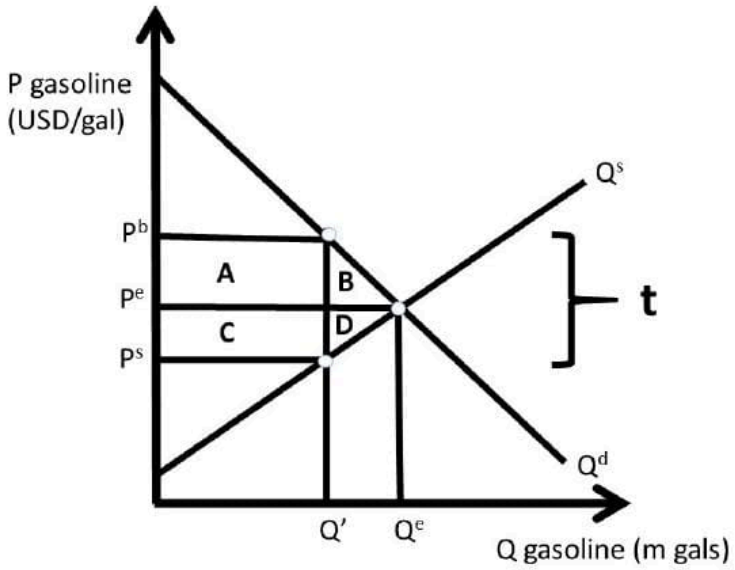


Figure 12.5.1: Tax on Gasoline

Welfare Analysis of a Tax

The welfare analysis of the tax compares the initial market equilibrium with the post-tax equilibrium.

$$\Delta CS = -A-B,$$

$$\Delta PS = -C-D,$$

$$\Delta G = +A + C,$$

$$\Delta SW = -B - D,$$

and

$$DWL = B + D.$$

In Figure 12.5.1, the incidence of the tax is equal between buyers and sellers of gasoline $(P^b - P^e = P^e - P^s)$. This is because the supply and demand curves are drawn symmetrically. In the real world, the tax incidence will depend on the supply and demand elasticities. The **pass through fraction** is the percentage of the tax "passed through" from producers to consumers.

$$\text{Pass Through Fraction } = \frac{E^s}{E^s - E^d}$$

We will calculate this for the gasoline market in the next section.

Quantitative Welfare Analysis of a Tax

Suppose that the inverse demand and supply of gasoline are given by:

$$P_b = 8 - Q^d,$$

and

$$P_s = 2 + Q^s,$$

Where P is the price of gasoline in USD/gal, and Q is the quantity of gasoline in million gallons. Market equilibrium is found where supply equals demand: $Q^e = 3$ million gallons of gasoline and $P^e = P_b = P_s = 5$ USD/gal of gasoline (Figure 12.5.2).

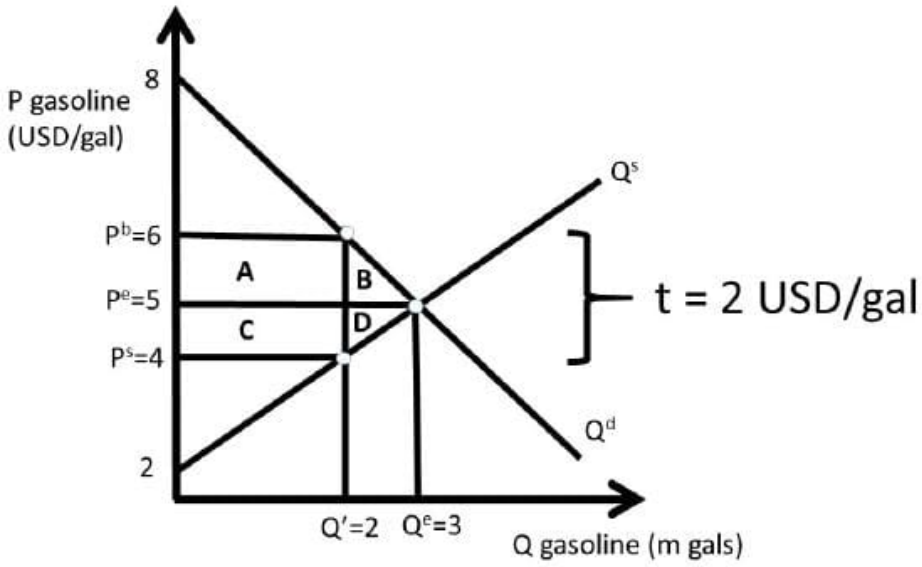


Figure 12.5.2: Tax on Gasoline

With the tax, the price relationship is given by:

$$P_b = P_s + t.$$

Assume that the government sets the tax equal to 2 USD/gal $(t = 2)$. Substitution of the inverse supply and demand equations into the price equation yields:

$$8 - Q^d = 2 + Q^s + 2$$

Since $Q^d = Q^s = Q'$ after the tax:

$$4 = 2Q'$$
$$Q' = 2 \text{ million gallons of gasoline.}$$

The quantity can be substituted into the inverse supply and demand equations to find the buyer's and seller's prices.

$$P_b = 6 \text{ USD/gal},$$

and

$$P_s = 4 \text{ USD/gal}.$$

These prices are shown in Figure 12.5.2. The welfare analysis is:

$$\Delta CS = -A - B = -2.5 \text{ USD million}$$
$$\Delta PS = -C - D = -2.5 \text{ USD million}$$
$$\Delta G = +A + C = +4 \text{ USD million}$$
$$\Delta SW = -B - D = -1 \text{ USD million}$$
$$DWL = B + D = +1USD \text{ million}$$

Note that the change in social welfare equals the sum of the welfare changes due to the tax: $\Delta SW = \Delta CS + \Delta PS + \Delta G$.

The pass through fraction can now be calculated to find the tax incidence.

$$PTF = \frac{E_s}{E_s - E_d}$$

The elasticity of demand at the market equilibrium is equal to $-\frac{5}{3}$, and the supply elasticity is $+\frac{5}{3}$. See Section 1.4.10 above for a review of how to calculate elasticities.

This yields:

$$PTF = \frac{E_s}{E_s - E_d} = \frac{(5/3)}{(5/3 - (-5/3))} = \left(\frac{5}{3}\right)\left(\frac{10}{3}\right) = 0.5.$$

This result shows that consumers pay for exactly one half of the tax, and producers pay for one half of the tax. The tax achieved the objective of increasing government revenues, but it did lower the quantity of the good produced and consumed, with lower social welfare. In free markets, consumers re able to pay the lower market price and consume more of the good. Producers receive a higher price, and produce and sell a larger quantity of the good than in the no-tax case. Therefore, taxes imposed by the government decrease social welfare, but allow the government to provide goods and services such as national defense at the federal level; highways, schools, and jails at the State level; and roads and parks at the local level. The next section will discuss subsidies.

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12.6: Subsidies

The policy objective of a subsidy is to help producers, or encourage the use of a good. The seller's price is higher than the buyer's price by the amount of the subsidy (s).

$$P_s = P_b + s$$

The subsidy is the vertical distance between the seller's price and the buyer's price, as shown in Figure $12.6.1$.

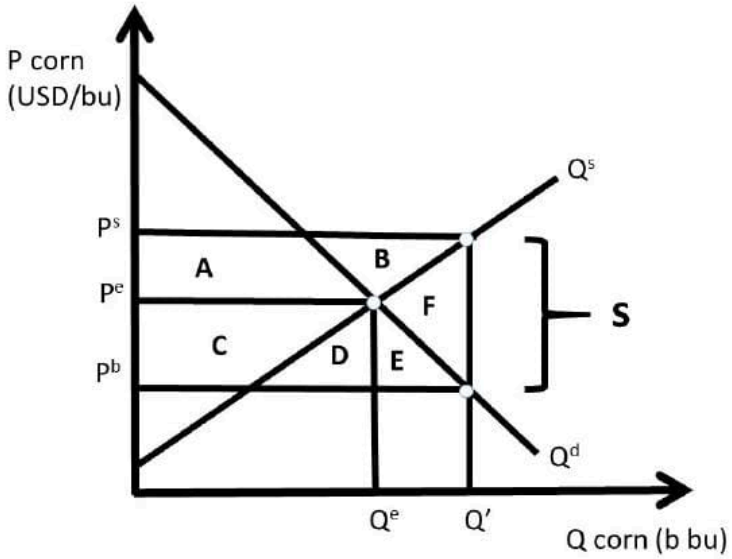


Figure $12.6.1$: Corn Subsidy

Welfare Analysis of a Subsidy

The welfare analysis of the subsidy compares the initial market equilibrium with the post-subsidy equilibrium.

$$\Delta CS = +C + D + E,$$

$$\Delta PS = +A + B,$$

$$\Delta G = -A-B-C-D-E-F,$$

$$\Delta SW = -F,$$

and

$$DWL = F.$$

Both consumers and producers gain from the subsidy, but at a large cost to tax payers (the government).

Quantitative Welfare Analysis of a Subsidy

Suppose that the inverse demand and supply of corn are given by:

$$P_b = 12-2Q^d,$$

and

$$P_s = 2 + 2Q^s,$$

Where P is the price of corn in USD/bu, and Q is the quantity of corn in billion bushels. Market equilibrium is found where supply equals demand: $Q^e = 2.5$ billion bu of corn and $P^e = P_b = P_s = 7$ USD/bu of corn (Figure 12.6.2).

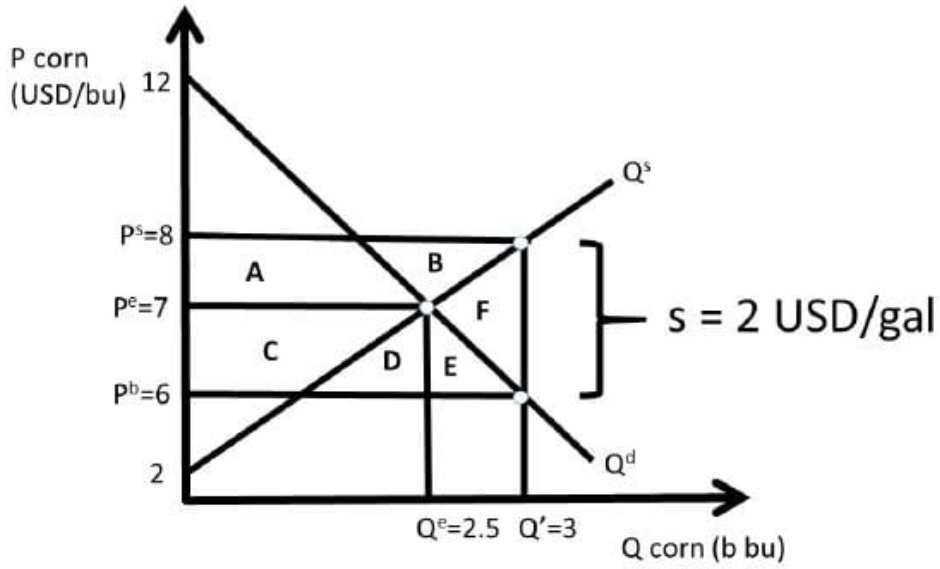


Figure 12.6.2: Corn Subsidy

With the subsidy, the price relationship is given by:

$$P_s = P_b + s.$$

Assume that the government sets the corn subsidy equal to 2 USD/bu. Substitution of the inverse supply and demand equations into the price equation yields:

$$2 + 2Q^s = 12–2Q^d + 2$$

Since $Q^d = Q^s = Q'$ after the tax:

$$4Q' = 12$$
$$Q' = 3 \text{ billion bushels of corn.}$$

The quantity can be substituted into the inverse supply and demand equations to find the buyer's and seller's prices.

$$P_b = 6 \text{ USD/bu},$$

and

$$P_s = 8 \text{ USD/bu}.$$

These prices are shown in Figure 12.6.1. The welfare analysis is:

$$\Delta CS = +C + D + E = +2.75 \text{ USD billion}$$
$$\Delta PS = +A + B = +2.75 \text{ USD billion}$$
$$\Delta G = –A–B–C–D–E–F = –6 \text{ USD billion}$$
$$\Delta SW = –F = –0.5 \text{ USD billion}$$
$$DWL = F = +0.5 \text{ USD billion}$$

Note again that the change in social welfare equals the sum of the welfare changes due to the tax: $\Delta SW = \Delta CS + \Delta PS + \Delta G$. Although the deadweight loss is not large, the government cost is large, making subsidies effective in helping producers and encouraging consumption of the good, but expensive for society.

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12.7: Immigration

Labor-intensive agriculture such as fruit and vegetable production in high income nations employs immigrant workers and pays low wages. These workers offer an enormous contribution to the agricultural economy through hard work in the production of food and fiber. However, it is possible that immigration can have a negative impact on rural towns, since the provision of public services such as medical facilities, schools, and housing for low-wage workers is often costly.

Most farm workers in the USA are immigrants, in spite of the massive labor-saving technological change over many decades. Technological change has occurred in many crops through mechanization and the use of agricultural chemicals: over time, machines and chemicals have replaced farm workers in the USA and other high income nations. The number of persons employed on US farms has been stable for several decades, due to two offsetting forces: (1) a large increase in the production of hand-harvested fruits and vegetables, and (2) rapid labor-saving technological change. Most of these farm workers live in "farm work communities," defined as cities with a population under 20,000 that are typically poor and growing rapidly.

In theory, the economic impact of immigration on rural communities could be either positive or negative. New immigrants can stimulate job and wage growth through induced economic activity from the increased demand for housing, food, clothing, and services. However, it is possible that immigration and growth in the local labor supply could result in lower wages and displaced employment opportunities for existing workers. The actual economic outcome is highly complex, dynamic, and difficult to measure. Immigration has resulted in the description of the USA as a "melting pot" of people and groups all nationalities, ethnicities, races, and religions. Immigration is often controversial, as existing groups may clash with more recent immigrants.

Welfare Analysis of Immigration: Short Run

Welfare analysis can be usefully utilized to better understand the economic impact of immigration. Adjustments take time, so initial impacts can differ markedly from long run impacts. The economic impacts depend crucially on both the number of migrants and the skill level of new migrant workers. Economic theory suggests that the destination, or receiving nation has large economic benefits from immigration, but there are winners and losers. Who wins and who loses depends on the wage structure, and availability and mobility of capital, as explained below.

It is important to emphasize that if capital is mobile, and can adjust quickly, and technology can adapt to changing labor composition, then the economy with migrants is a larger version of the original economy before immigration. In this case, the native-born workers are neither winners nor losers. Economic adjustments to new immigrants require time, and it is during the transition to the new workers that winners and losers occur.

When immigration occurs, goods that are produced using migrant labor have an increase in production. In Figure $12.7.1$, the wage rate is the price of labor, the initial demand for labor is given by Q_0^d, and the labor supplied by native workers (original workers in the receiving nation) is Q_0^s, which is assumed to be perfectly inelastic at L_0 million workers. The real-world labor supply is not fixed, as it is shown in Figure $12.7.1$, as higher wages will result in more work supplied to the market. However, the inelastic model illustrated in Figure $12.7.1$ is good approximation of labor markets: the qualitative results of the model accurately depict the real world.

The initial, pre-immigration labor market equilibrium occurs at E_0, characterized by wage rate W_0 and labor supply L_0. The total social welfare in this market is the sum of producer surplus and consumer surplus $(SW = PS + CS)$. This is the area under the demand curve at $L_0(= ABD)$. Recall that the workers are the suppliers of labor, thus producer surplus is the economic value of worker well-being. The consumer in this case is the firms, since the employers purchase (hire) labor. The consumer surplus in the labor market shown here is the economic value to the business firms, or employers.

Before immigration occurs, producer surplus is the entire rectangle (BD). The supply curve is vertical in this case, causing the area under the supply curve to be nonexistent. The workers receive this amount of income, since area BD is equal to the wage rate times the quantity of labor employed in the economy $(W_0 \cdot L_0)$. Firms, or employers of workers, receive the consumer surplus, which before immigration occurs is equal to area A in Figure $12.7.1$.

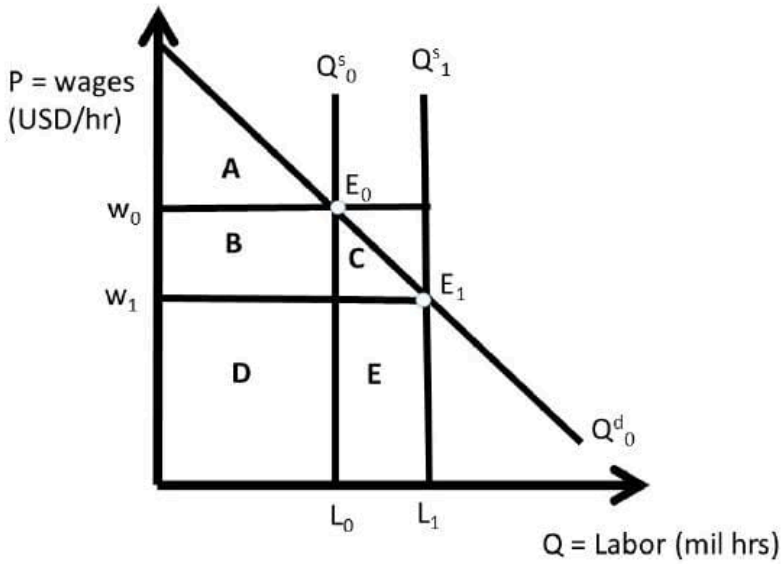


Figure 12.7.1: Welfare Analysis of Immigration Impact on Labor Market: Short Run

After immigration occurs, the labor force is increased by the number of migrants (M): $L_1 = L_0 + M$. In the short run, no adjustments in the labor and capital market take place, and the result of an increase in the quantity of labor is a decrease in the price of labor: the wage rate falls from W_0 to W_1. Native workers lose area B in producer surplus, with a new level of economic surplus equal to $D(W_1 \cdot L_0)$. Migrants receive wage rate W_1, and migrant earnings are equal to area $E(W_1 \cdot M)$. Presumably, the wage rate earned in the receiving nation is larger than the wage rate available in the immigrants' nation of origin. The wage rate is also likely to be large enough to induce workers to change locations, which can be a costly transition. Employers in the receiving nation are the winners, as consumer surplus (economic value of the firms who hire either native workers or migrants) increases from area A before immigration to area ABC after immigration.

The welfare analysis of immigration can be summarized in the usual way:

$$\begin{aligned}
\Delta CS = &\text{ employer gains } = +B + C \\
\Delta PS_L = &\text{ native worker gains } = -B \\
\Delta PS_M = &\text{ migrant worker gains } = +E \\
\Delta SW = &\text{ net gain to entire economy } = +C + E
\end{aligned}$$

Notice that there is a net gain in total economic activity due to immigration: the magnitude of economic activity in the receiving nation is larger after immigration occurs. This is due to the influx of new resources, bringing economic value and spending. This differs from government interventions in the free market economy. This is because government programs and policies all result in a loss of voluntary exchange between buyers and sellers, and dead weight loss. In the case of labor immigration into a nation, more voluntary exchange takes place, with large overall economic benefits to the receiving nation. The controversy surrounding immigration is the distributional effects: in the short run, native workers lose, due to decreasing wages. As the economy adjusts to the new workers, the benefits become larger and the negative impacts are diminished, as will be explained in the next section.

Welfare Analysis of Immigration: Long Run

Workers and firms can make many adjustments once the new migrants join the economy. In an economy with many types of skilled and unskilled workers, native workers can take jobs in areas of their comparative advantage, and invest in human capital (education and training) to allow them to increase wages by moving out of low paying jobs and into high paying jobs. Given sufficient time, migrants can do this too, and will move into higher paying jobs as new waves of immigration occur.

Migrants who bring capital or work skills with them can enter growing sectors, such as technology, medicine, and services. The demand for labor in these areas is large and growing, so wages continue to increase together with new workers entering the economy.

In the long run, this type of adjustment in capital and labor markets, together with technological change, will result in economic

growth, and broad-based wage and income growth in the receiving economy. The USA has had high levels of immigration simultaneous with high and growing levels of income for most of its history: immigration has catalyzed economic growth in the high income nations of the world. This desirable outcome does require change, adjustment, and in many cases labor migration, both occupational and locational. Growth mandates change, and change is often difficult. This is one of the major features of free markets and free trade. When economic agents are free to make decisions in their own interest, great things can happen. But improvement requires change. When workers and their families are free to locate where they desire to live and work, economic growth is likely to occur, but the transition can be challenging, and when cultures and values differ, controversy can occur.

The long run effects of immigration can be seen in Figure 12.7.2. New workers joining the economy cause an increase in the aggregate demand for goods in the economy, and this economic growth entices firms to produce more goods. More production requires more workers, and the demand for labor increases from Q_0^d to Q_1^d. The long run equilibrium is found at E_1. The increase in labor demand offsets the downward pressure on wage rates, resulting in wages returning to their original level, W_0. The economy grows, so consumer surplus (economic value of employers, or business firms) increases to include the area under the demand curve and above the new price line: AFG. Native worker earnings are restored to their initial level (BD), and migrant worker surplus is increased to CHE.

The overall economy gains significantly once these adjustments have occurred. Adding more resources to an economy in the long run, given sufficient time for the transition to occur, will yield large economic growth, as the economy is growing by the size of the new migrant labor force.

$$\begin{aligned}
\Delta CS = &\text{ employer gains } = +F+G \\
\Delta PS_L = &\text{ native worker gains } = 0 \\
\Delta PS_M = &\text{ migrant worker gains } = +C+H+E \\
\Delta SW = &\text{ net gain to entire economy } = +C+E+F+G+H
\end{aligned}$$

The potential gains from immigration can be thwarted during periods of economic recession, when the overall demand for goods increases at a decreasing rate. This economic stagnation can lead to a decrease in the demand for labor. When native workers face poor economic conditions, they are less likely to favor new migrants.

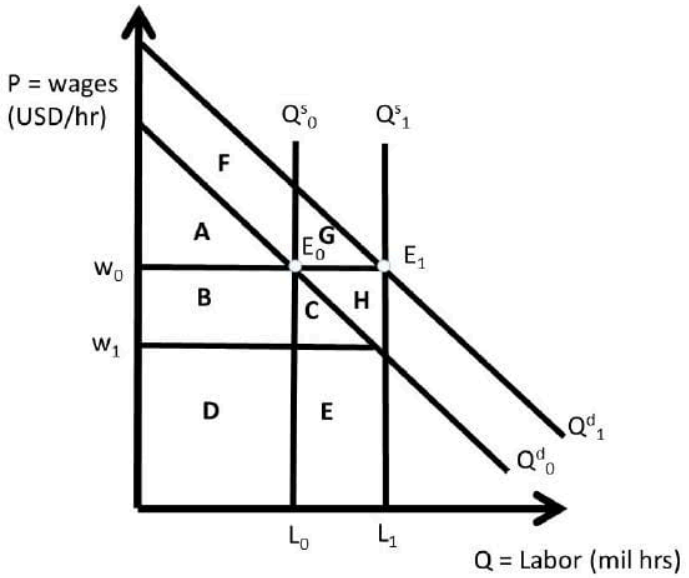


Figure 12.7.2: Welfare Analysis of Immigration Impact on Labor Market: Long Run

In agriculture, re cent immigrants perform many tasks that native workers would not do at the low wages offered to migrants. These tasks can include meatpacking, chemical application, and harvesting fruit and vegetables. The USA currently allows millions of workers to enter the country and work in farm jobs. If this supply of workers were to be eliminated, the cost of labor would rise enormously and the cost of food would increase. To examine the gains and benefits of migration of agricultural workers, the next section broadens the welfare analysis to include a model of two nations: the receiving nation and the nation of migrant origin.

Welfare Analysis of Labor Immigration into the USA from Mexico

To demonstrate the effects of the movement of labor from one nation to another, the three panel diagram of Section 1.6.3 can be usefully employed. The welfare analysis of agricultural labor migration from Mexico to the USA provides a summary of who wins, who loses,, and by how much. The analysis demonstrates that both Mexico and the USA have net gains from labor migration. However, as in all economic changes, there are winners and losers. Figure $12.7.3$ shows labor movements for the receiving nation (USA) in the left panel, and the source nation (Mexico) in the right panel. The trade sector is represented in the middle panel.

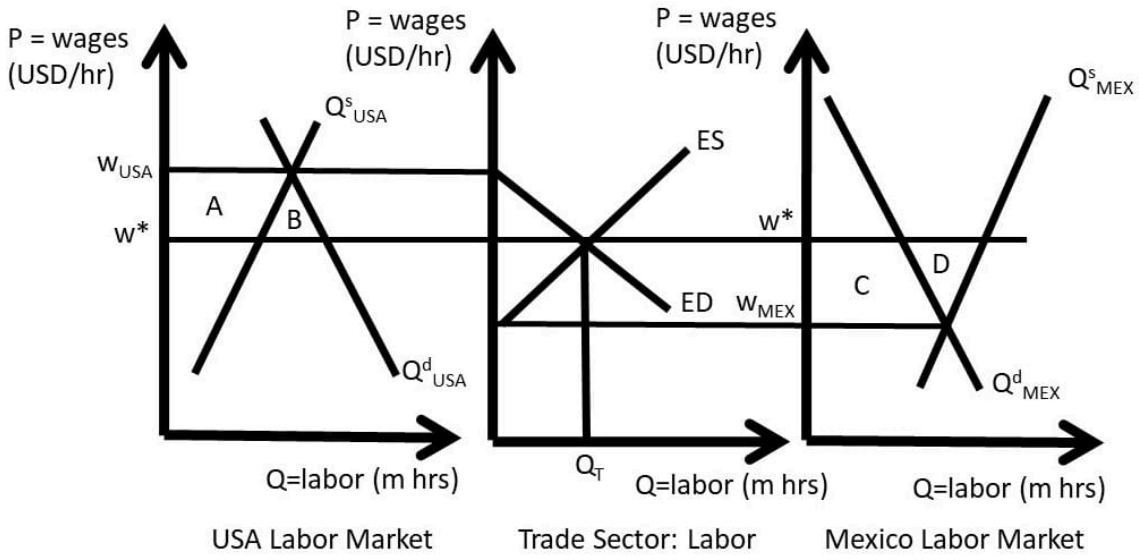


Figure $12.7.3$: Welfare Analysis of Farm Worker Immigration into the USA from Mexico

If the two nations have isolated labor markets, wages in the USA (W_{USA}) are higher than wages in Mexico (W_{MEX}). This wage differential $(W_{USA} > W_{MEX})$ provides the motivation for workers to leave Mexican jobs and migrate to the United States. When the movement of labor is possible, the number of migrants is shown in the middle panel, equal to Q_T million hours of work. If Q_T hours of work are transferred from Mexico to the USA, the wage rates are equalized at W^* in both nations. Note that this model ignores exchange rates and transportation costs of migration.

The graphical model demonstrated in Figure $12.7.3$ also assumes freedom of movement between the two nations. In agriculture, there is considerable freedom for farm workers to enter the USA from Mexico to supply labor to farms. The H-2A Temporary Agricultural Program allows foreign-born workers to legally enter the United States to perform seasonal farm labor on a temporary basis for up to 10 months. The seasonal needs of crop farmers (fruit, vegetables, and grains) can be met with this program, but most livestock producers, (ranches, dairies, and hog and poultry operations) are not able to use the program. An exception is made for livestock producers on the range, (sheep and goat producers), who can use H-2A workers year-round.

The welfare analysis in Figure $12.7.3$ shows the same results for labor as were obtained for commodities such as wheat in Section 1.6.3. Winners include consumers (employers) in the importing (receiving) nation, and producers (workers) in the exporting (source) nation. In this case, US farmers who employ migrant workers are made better off by area $(A + B)$, but native workers (USA workers employed prior to immigration) are made worse off by area A. The gains and losses are due to the decrease in wages from W_{USA} to W^*. The movement of workers out of Mexico results in gains for Mexican workers (area $C + D$), but losses for employers of workers in Mexico (area C). This is due to the wage increase in Mexico from W_{MEX} to W^*.

Both origin and receiving nations have net benefits: area B in the USA and area D in Mexico. This result explains why immigration has been a large, significant feature in US history (the United States is often referred to as a “Nation of Immigrants”). The gains and losses in each nation demonstrate why immigration continue to be controversial issue: large economic gains and losses in each nation.

In the long run, the gains to immigration are large for the recipient nation. This is for two reasons: (1) migrant workers are most often complementary to native workers: low-skill immigrants combine with high-skill native workers to enhance productivity for all workers in the receiving nation, and (2) increased population generates increased demand for all goods and services in the USA, resulting in enhanced economic conditions for all workers in the receiving nation.

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12.8: Welfare Impacts of International Trade

The welfare analysis of international trade can be conducted using the three-panel diagram (Figure $12.8.1$). The welfare impacts on wheat consumers and producers can be calculated by measuring the changes in consumer surplus and producer surplus before trade (time $t = 0$) and after trade (time $t = 1$). The welfare changes for the exporting nation are shown in the left panel of Figure $12.8.1$. Prior to trade, the closed economy price is P_e at the closed economy market equilibrium, where $Q^s = Q^d$. After trade, export opportunities allow the price to increase to the world price P_w. Quantity supplied increases and quantity demanded decreases. Consumers lose, since the price is now higher $(P_w > P_e)$ and the quantity consumed lower. The loss in consumer surplus is equal to area A, the area between the two price lines and below the demand curve: $\Delta CS = -A$. Producers receive a higher price $(P_w > P_e)$ and a larger quantity, and an increase in producer surplus equal to the area between the two price lines and above the supply curve: $\Delta PS = +A + B$ (Figure $12.8.1$).

The net gain to all groups in the exporting nation, or change in social welfare (SW), is defined to be $\Delta SW = \Delta CS + \Delta PS$. Thus, $\Delta SW = +B$, since area A represents a transfer of surplus (dollars) from consumers to producers in the exporting nation (USA). Interestingly and importantly, the exporting nation is better off with international trade $\Delta SW > 0$. However, not all individuals and groups are made better off with trade. Wheat producers in the exporting nation gain, but wheat consumers in the exporting nation lose. Trade has a positive overall net benefit.

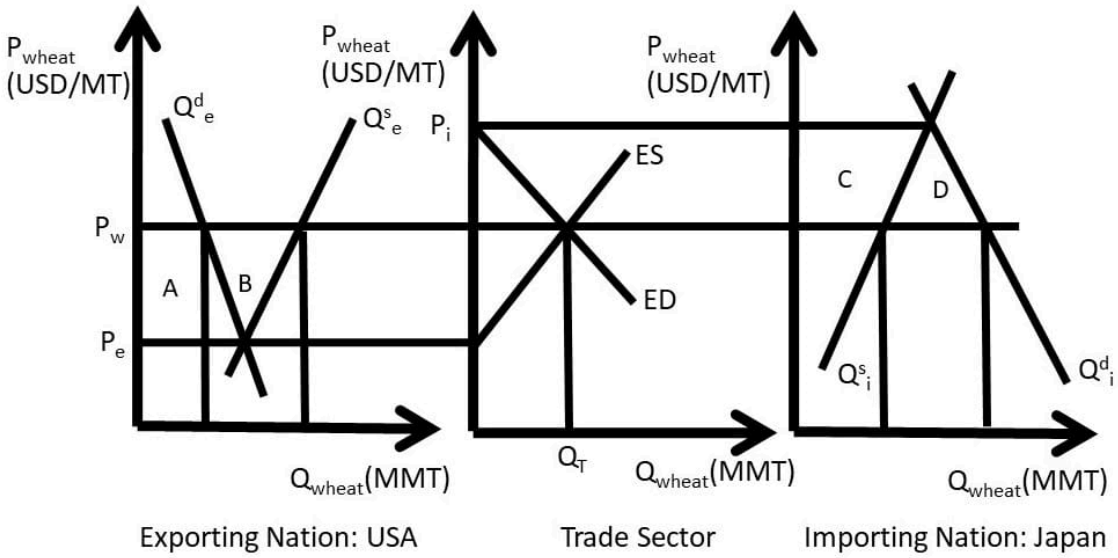


Figure $12.8.1$: Welfare Impacts of International Trade in Wheat

In the importing nation, consumers win and producers lose from trade (right panel, Figure $12.8.1$:). The pre-trade price in the importing nation is P_i, and trade provides the opportunity for imports $(Q^d > Q^s)$. With imported wheat, the market price falls from Pi to the world price P_w. Quantity demanded increases and quantity supplied decreases. Consumers gain at the lower price $(P_w < P_i)$: $\Delta CS = +C + D$. Producers lose at the lower price $(P_w < P_i)$: $\Delta PS = -C$. The net gain to the importing nation, or change in social welfare (SW) is $\Delta SW = +D$. The area C represents a transfer of surplus from producers to consumers in the importing nation. As in the exporting nation, the net gains are positive, but not everyone is helped by trade. Producers in importing nations will oppose trade. This is a general result from out model of trade: producers in importing nations will oppose trade, since they face competition from imported goods.

The results of the three-panel model clarify and explain the politics behind trade agreements. Politicians representing the entire nation will support the overall benefits from trade, brought about by efficiency gains from globalization. However, representatives of constituent groups who are hurt by trade will oppose new free trade agreements. A large number of trade barriers are erected to protect domestic producers from import competition, including tariffs, quotas, and import bans.

The world is better off due to globalization and trade: the global economy gains areas $B + D$ from producing wheat in nations that have superior grain production characteristics. These efficiency gains provide real economic benefits to both nations. However, globalization requires change, and many workers and resources will have to change jobs (and many times locations) to achieve

the potential gains. Labor with specific skills and other inflexibilities will have high adjustment costs to globalization. However, there have been huge increases in the incomes of trading nations due to moving resources from less efficient employments into more efficient employment over time.

The three-panel diagram highlights who gains and who loses from trade. Producers in exporting nations and consumers in importing nations gain, in many cases enormously. Producers in importing nations and consumers in exporting nations lose, and in many cases lose a great deal. Industrial workers and textile workers in the USA and the EU used to be employed in one of the major sectors of the economy. Today, these jobs are in nations with low labor costs: China, Indonesia, Malaysia, and Viet Nam are examples.

Should a nation support free trade? The economic analysis provides an answer to this question: unambiguously yes. The overall benefits to society outweigh costs, with the net benefits equal to areas B and D in Figure $12.8.1$. Economists have devised the **Compensation Principle** for situations when there are both gains and losses to a public policy.

Compensation Principle = A decision rule where if the prospective winners gain enough to compensate the prospective losers, then the policy should be undertaken, from an economic point of view.

The actual compensation can be difficult to achieve in the real world, but the net benefits of the program suggest that if society gain from the policy, it should be undertaken.

Agricultural producers in most high income nations are subsidized by the government. These subsidies can be viewed as compensation for the impacts of the adoption of labor-saving technological change over time. Technological change has made agriculture in the USA and the EU enormously productive. However, it has led to massive migration of labor out of agriculture. Subsidies can be viewed as the provision of compensation for the massive substitution of machines and chemicals for labor in agricultural production.

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12.9: Problem Sets

Exercise 12.1

Why can price ceilings create shortages?

Answer available at the end of this section.

Exercise 12.2

Why can price ceilings create shortages?

Answer available at the end of this section.

Exercise 12.3

What is the primary objective of a price support? Who benefits?

Answer available at the end of this section.

Exercise 12.4

What happens when the government purchases surplus under a price support?

Answer available at the end of this section.

Exercise 12.5

How does a quantitative output restriction affect price and quantity?

Answer available at the end of this section.

Exercise 12.6

What is an import quota and why is it used?

Answer available at the end of this section.

Exercise 12.7

Who gains and who loses from an import quota?

Answer available at the end of this section.

Exercise 12.8

What is the difference between a specific tax and an ad-valorem tax?

Answer available at the end of this section.

Exercise 12.9

Who pays a tax — buyers or sellers?

Answer available at the end of this section.

Exercise 12.10

How do subsidies affect consumers, producers, and taxpayers?

Answer available at the end of this section.

Answers

Exercise 12.1

A price ceiling sets a maximum legal price that sellers can charge. It is designed to keep essential goods more affordable for consumers, particularly during times of scarcity or price spikes — for example, capping food prices during emergencies to prevent price gouging. When set below equilibrium, it lowers prices for consumers but can create shortages because producers are less willing to supply the product at the lower price.

Exercise 12.2

A binding price ceiling (below equilibrium) increases quantity demanded but reduces quantity supplied. Since buyers want more at the lower price and producers provide less due to reduced profitability, quantity demanded exceeds quantity supplied. The result: a shortage — often accompanied by rationing, long lines, or black markets.

Exercise 12.3

A price support sets a minimum legal price — typically above equilibrium — to help producers earn a higher, more stable income. In agriculture, governments use price supports to protect farmers from volatile markets and low prices. Producers benefit because they receive a guaranteed higher price; however, consumers face higher prices and reduced quantity demanded.

Exercise 12.4

If a price support causes surplus production, the government may buy the excess. This keeps prices artificially high, ensuring producer income, but taxpayers bear the cost of purchasing and storing or disposing of surplus. Consumers lose (pay higher prices), producers gain (sell at a high guaranteed price), and society experiences deadweight loss due to inefficiency.

Exercise 12.5

A quantitative restriction limits the amount producers can supply. This reduced supply raises market price. Producers may gain if demand is inelastic (consumers still buy despite higher prices), but if demand is elastic, producers could lose revenue. No physical surplus occurs, but consumers pay more and buy less, creating deadweight loss.

Exercise 12.6

An import quota limits how much of a foreign good can enter a country. It is typically used to protect domestic industries — like sugar producers — from lower-cost international competition. By restricting imports, domestic prices rise, benefiting producers who can now sell at higher prices.

Exercise 12.7

Gainers: Domestic producers (higher prices and production) and the government (quota revenue from selling import permits).

Losers: Consumers (pay higher prices and consume less).

Because resources shift to less efficient producers, there is **deadweight loss** — society is worse off overall.

Exercise 12.8

Specific tax: A fixed amount per unit sold (e.g., $0.50 per gallon of gas).

Ad-valorem tax: A percentage of the product's price (e.g., 8% sales tax).

Both raise buyer prices and reduce seller revenue, but ad-valorem taxes increase with price changes.

Exercise 12.9

The burden (tax incidence) is shared by buyers and sellers depending on elasticity. The tax creates a wedge between consumer and producer prices.

If **demand is inelastic**, consumers bear more of the tax.

If **supply is inelastic**, producers bear more.

Exercise 12.10

Subsidies lower the price consumers pay and raise the price producers receive.

Consumers benefit (lower prices)
Producers benefit (higher revenue and output)
Although both consumers and producers gain, society incurs a **deadweight loss** because government spending exceeds the value created.
Taxpayers fund the subsidy, creating a government cost

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13: AGRICULTURAL ECONOMIC CASE STUDIES

13.1: Opportunity Costs
13.2: Marginal Analysis
13.3: Elasticity
13.4: Prohibition

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13.1: Opportunity Costs

Agricultural Economics: Opportunity Costs

1.0 Introduction

Economics is a social science and is primarily concerned with the study of human decision-making. Decision-making involves making choices between competing alternatives. For example, (i) should I go to class today or sleep in; (ii) should I walk to campus or drive my car; and (iii) should I major in agricultural economics or animal science? In all of these and other decisions that we make, we have to make trade-offs. That is, to make one choice we have to give up something else. In economics, we formalize this trade-off or what has to be given up. We call this trade-off between making competing choices an **opportunity cost**. This chapter will introduce you to the concept of an opportunity cost; present different aspects of opportunity costs; and take you through a couple of detailed case studies about how opportunity costs are calculated and assessed. The case studies are provided to help illustrate the identification and calculation of opportunity costs. These case studies will help you to examine opportunity costs in different decision-making contexts and include questions that will help you go through the associated economic decision-making process.

1.1 Learning Objectives

At the end of this chapter you should be able to:

(1) *Define what an **opportunity cost** i*s; and

(2) *Be able to understand how to assess and calculate an **opportunity cost** in different problem situations*.

2.0 What is an Opportunity Cost?

By definition, an **opportunity cost** of making a choice or decision is the *value of the next best alternative that you gave up to make that choice or decision*. More specifically, an opportunity cost is the *value of a resource in its next best alternative use*. The use is what a firm or decision-maker could have done instead of making the choice or decision they did. While a person has the option of making many different choices, it is important to recognize that the opportunity cost only considers the value of the next best alternative, not of all the other possible choices or uses of a resource. This is an important distinction to keep in mind [1,2].

A couple of examples may help to solidify this idea.



Picture: Sleepy Student [3]

Example 1: As an undergraduate student, you usually have the option of going to class. Each day you have to decide if you will attend class or do something else. The other options could include sleeping in, going to the park, having lunch, studying for another class, watching a movie, etc. The *opportunity cost* of choosing to attend class is the value of the next best alternative. Assume in this case that you could narrow down the choice to either going to class or sleeping in. The opportunity cost would then be the lost value you would have received from sleeping in a couple of extra hours (i.e. the value of that rest). This value could be measured in different ways, including time, alertness, or even satisfaction.



Picture: Restaurant Investment? [4]

Example 2: Consider a restaurant owner deciding on whether to open a new restaurant on the other side of town from his current location. The owner has saved $300,000 to invest in the new restaurant. The owner was approached by a good friend to invest that money in the stock market instead, where he could have earned a 15% annual return on the investment. Assume this is the next best alternative. The opportunity cost of investing in the new restaurant is the value of using the money (or resource) in its next best alternative. That is, investing the money in the stock market. In this case, we can calculate the monetary value of the opportunity cost, which represents the lost value or return from the investment. This value would be equal to $300,000 × 0.15 = $45,000. The value of the opportunity cost here is what the owner could have earned from the investment, not the $300,000, because the owner already has the $300,000 in their possession.

Example 3: Watch the following video. This video provides a brief explanation of *comparative advantage,* an important concept in economics. A *comparative advantage* exists when an individual has a superior or better ability to undertake an activity using their resources relative to other individuals [2]. For example, a trained accountant has a *comparative advantage* in preparing taxes compared to a carpenter given their specialized training and skills in accounting, which reduces the use of resources (e.g. time and labor) for them in this task. When examining comparative advantages we have to take into account opportunity costs. That is, we determine if a comparative advantage exists based on the opportunity costs. Go back to the example with the accountant and carpenter and preparing taxes. Consider the amount of time used in preparing the taxes. For the accountant, preparing a tax return may take 2 hours, while for the carpenter it may take 8 hours. Based on the amount of time it takes, the accountant has a comparative advantage with respect to time in preparing tax returns. The carpenter would be better off spending that time building, as he would lose 6 hours of his time if he prepared the tax return, which could be done by the accountant in 2 hours. That is, the opportunity cost of having the carpenter prepare a tax return is equal to 6 hours instead of the accountant. That time likely could be put to better use.

YouTube Video

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Comparative Advantage [5]

Question #1

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The three examples illustrate that opportunity costs can have actual monetary values, but can also be measured in other terms, such as lost time, satisfaction, rest, etc. There are other aspects of opportunity costs to take into account, as well. These are outlined below.

2.1 Aspects of Opportunity Costs

Here we talk about different aspects of opportunity costs that you will need to be aware of.

(1) *Opportunity costs only consider the value of the next best alternative.* - While firms and individuals face many choices or alternatives for every decision they make, opportunity costs are the value of **only** the next best alternative. By focusing on the next best alternative, it makes sure that people examine all the potential choices or alternatives available to determine that next best alternative. Furthermore, including opportunity costs in calculating the cost of making a decision using the next best alternative helps to make sure that we are making the best or optimal choice with the information we have available. In economics, when we calculate the cost of making a decision we take into account the actual monetary cost out of pocket, which we call the *accounting cost,* and the value of the resources being used in their next best alternative. We refer to these costs as *economic costs.* That is:

economic costs = accounting costs + opportunity costs.

(2) *The value of an opportunity cost does not necessarily have to be in monetary terms.* - As illustrated in Example 1, an opportunity cost does not have to take a monetary value. The value of the opportunity cost could be measured in the satisfaction lost or the minutes of sleep (time) lost. This is illustrated in the following video about an entrepreneur's decision to keep their coffee shop.

YouTube Video

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Coffee Shop Economic Decision Making [6]

Question #2

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(3) *All resources used have opportunity costs attached to them.* - All the resources used in completing a task or job have an associated opportunity cost [2]. Consider the case of deciding to plant corn on your farm next year. The primary resources used to plant the corn include the land the corn is planted on, the labor needed to manage the corn crop, the capital (or machinery) needed for the corn enterprise, and the operating capital (or money) needed to buy the inputs (e.g. seed, fertilizer, pesticides, etc.) to grow the crop. The opportunity cost of the land could be the value the farmer could earn by renting the land to a neighboring farmer. The opportunity cost of the labor (or farmer's time) could be the lost income from working off the farm at another job. The opportunity cost of the capital (or machinery) could be the value of that machinery being used in another enterprise. Finally, the opportunity cost of operating capital could be the return we would earn by investing that money in the stock market over the growing season. The overall or total opportunity cost of deciding to plant corn would be the sum of the values of all these opportunity costs.

(4) *Every decision may have one or more associated opportunity costs* - As illustrated in point (3) above, a decision can have multiple opportunity costs that need to be considered, one for each resource that would be used and its next best use. This aspect especially becomes useful when examining problems from an economic perspective, as economics is concerned with the allocation of scarce resources.

(5) *Taking into account opportunity costs helps individuals make the best "economic" choice.* - By taking into account opportunity costs, a decision-maker has to explicitly consider potential alternative choices and/or uses for their resources for the decision being made. Furthermore, the decision-maker has to rank these choices by valuing them in some manner to identify the best and next best alternatives. Thus, the decision-maker ensures that they make the choice that makes the best use of their resources, making the best "economic" choice.

Question #3

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To explore these aspects of opportunity costs we consider two detailed case studies below. The case studies will take you through a detailed decision-making situation and have you contemplate the potential opportunity costs and their associated values.

3.0 Case Study 1: To go or not to go to college?

The purpose of this case study is to examine the opportunity cost of going to college. While many of you have already chosen to attend college, did you consider the opportunity cost of that decision? The video below provides an overview of the decision-making process one may go through in deciding to go to college. Use this information to examine the college decision and answer the questions asked here in the case study. The video below will help to provide a basis to consider the aspects of this decision process.

YouTube Video

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View this YouTube Video online

Should I go to College? [7]

3.1: The Opportunity Cost of Earning a Bachelor's Degree

A significant decision lying ahead of most high school graduates is whether or not to attend college and obtain a college degree. The concept of opportunity cost can help us understand whether going to college is the right decision, or if you would be better off working after high school. To be able to consider this decision, we need to know the difference in earning potential from earning a college degree. To do this, we examine the net earnings (after expenses are accounted for) for each possible choice over a 15-year time horizon (or period of time) starting when a student is a freshman.

Consider a student who wants to attend Kansas State University. The total cost of attending Kansas State University includes 4 primary costs. The largest cost of attendance is tuition, which averages $9,500 per year. Tuition is closely followed by housing, which averages $8,400 per year. On top of housing, food expenses need to be included, which amounts to approximately $100 a week for groceries, providing a total food cost of $5,200 per year. Miscellaneous expenses then add up to $4000 per year. These expenses include books, supplies, going out to eat, concerts, athletics, gas, and other vehicle expenses, as well as clothing, travel, parking permits, etc [8]. Thus, assuming a degree is completed in four years, the total expense of attendance at Kansas State University adds up to $108,400. That is:

Total expenses of college: (9,500 + 8,400 + 5,200 + 4,000) x 4 = $108,400.00

Assume the student has the good fortune of having access to scholarships, grants, and a part-time job on campus while earning their degree at Kansas State University. We will assume the student (i) receives a scholarship for $2,000 per year and (ii) has a part-time job on campus that pays $12.00/hour. The student works 20 hours a week during the school year (36 weeks). During the summer, the student can work full-time (40 hours per week) at a job that pays $13.00/hour. The summer is 12 weeks in length. The total earnings by the student from the scholarship and job during their college career is $67,520. That is:

Total earnings during college: (2,000 + ($12 x 20 x 36) + ($13 x 40 x 12)) x 4= $67,520.00

After graduation, assume the student can find a job that pays an annual salary of $55,000. While the student now earns significantly more than they did in college, their living expenses are expected to double (after tuition is dropped). Individuals that have graduated and have higher incomes, will likely spend more money on higher quality items and more items in general. Living expenses for a college graduate are assumed to be $35,200 per year. Thus, a college graduate in industry will earn a net of $19,800 per year. That is:

Net earnings per year for a college graduate in industry: $55,000 - $35,200 = $19,800.00

The next best alternative for the student, if they did not attend college, is to find a full-time job after graduating high school. Assume a graduate from high school will earn on average, $15/hour working 40-hour weeks for 50 weeks of the year (2 weeks off for vacation). At this wage rate, the high school graduate will earn $30,000 per year. Assume a high school graduate will accrue

living expenses totaling $22,000 per year (a slight increase in expenses over a college student). Thus, a high school graduate will earn $8,000 net per year. That is:

Net earnings per year for a high school graduate: $30,000 - $22,000 = $8,000

We now have the needed information to calculate the total net earning from both options available to the high school graduate: go to college or take a full-time job.

Question #4

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Question #5

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The total net earnings from each of these options will allow us to assess what is the best "economic" decision and the opportunity cost of going to college.

Question #6

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Question #7

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While this provides one example, the question of whether college is worth it for a particular individual is going to be dependent

on the individual, where you go to school, how you pay for school, and what career path you choose, among others.

Question #8

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Now consider the opportunity cost or decision of going to graduate school.

3.2: The Opportunity Cost of Earning a Masters Degree

Following graduation from Kansas State University, and with a superb Agricultural Economics degree, a student has a few paths they might take. Many students wonder whether or not to go to graduate school. Fortunately, opportunity cost applies to this decision, as well. In this continuation of the above case study, you will do more of the calculations yourself. Again, answers will be provided with the questions to help you review and learn. Finally, as with the decision to go to college or not, we need to consider the earnings after earning a graduate degree, so for this example, we will consider a 10-year time horizon after graduation from K-State.



Graduation [9]

Now consider a student who has just recently graduated from Kansas State University. This student has to decide to find a job in industry or pursue a Master of Science degree (MS) in Agricultural Economics. The MS will take the student 2 years to complete, upon which they will obtain a job in industry.

In graduate school, graduate students have the opportunity to receive a tuition waiver and/or a graduate research assistantship to help with the cost of graduate school. The tuition waiver covers all in-state tuition. The graduate research assistantship hires the student as a part-time university employee and provides them with a stipend for living expenses. Based on competitive rates, assume the annual stipend for the student is $17,000 per year. The assistantships are year-round, and most students do not work during their master's program outside of school. Expenses for a grad student are similar to those for an undergraduate student, except that we will assume they receive a tuition waiver. Housing runs an average of $8,400 per year. Food expenses need to be included, which are approximately $100 a week, totaling $5,200 per year. Miscellaneous expenses add up to $4000 per year. Finally, we assume the student is responsible for books and fees, which come to $1000 per year. Totaling all the expenses for the

student while earning their MS degree over 2 years, barring any extenuating circumstances is equal to $37,200.

Now assume that after earning their MS degree, the student finds an industry job that pays an annual salary of $75,000. Assume living expenses after graduation are $35,200 per year. Use this information to answer the following questions.

Question #9

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Question #10

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Question #11

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Alternatively, if a student were to choose not to go to graduate school, they would earn approximately $55,000 per year from their first industry job and their living expenses would be $35,200 (as before). We will assume they stay in the same job for all 10 years.

Use this information to answer the following questions.

Question #12

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Question #13

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Question #14

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4.0 Case Study 2: Investing in Agricultural Livestock

Many farms in Kansas and around the nation raise livestock. One of the most significant livestock industries is cattle. Kansas ranks 3rd in the nation for the size of its cattle livestock industry. As of the beginning of 2018, Kansas had 6.3 million cattle, almost twice the state's human population. This industry generated revenues of over $7.8 billion in 2016 and was responsible for over $12.9 billion in direct and associated economic activities in 2012 [10].



Kansas State University Cattle [11]

To be able to do economic assessments of livestock enterprises on farms, a common tool is the use of enterprise budgets, which provide a detailed outlay of the costs that are faced by a livestock producer. For this case study, enterprise budgets were developed for a rangeland-based ranching operation that included production activities for stocker cattle and is based on an actual livestock operation in Kansas [12]. Stocker cattle are weaned calves grazing pastureland that are allowed to grow to a mature size that will be later moved to a feedlot.

With this information, consider the case of a rancher who owns and operates a 500-head stocker cattle ranch on 5000 acres in central Kansas. The rancher has recently received a significant inheritance from past relatives of $200,000 in cash and 2000 acres of rangeland. The rancher is interested in estimating the opportunity cost of purchasing an additional 200 head of stocker cattle this upcoming year, which would require both land and capital. Assume that each additional acre of rangeland and every dollar of the inheritance would be used in raising the additional 200 head of stocker cattle.

Provided the mortality rate remains low (i.e. below 2%), there is an opportunity for profit. The tables below provide a breakdown of the returns and additional costs per head of cattle for the coming year, providing us with a basis for opportunity cost analysis for the land and capital resources [12].

A breakdown of the returns per head of cattle

Return Per Head	
Price at Market ($/cwt)	$165.00
Initial Weight at Purchased (lbs)	550
ADG (Average Daily Gains) (lbs)	1.8
Weight at Sale (lbs)	820
Sale Value ($/cwt)	$138.00
Revenue Per Head ($)	$1,131.60
Less Cost of Animal Purchase Price	$907.50
Less Death Loss (2%)	$18.15
Return Per Head	$205.95

Additional costs per head of cattle

Additional Costs Per Head	
Supplemental Mineral and Salt	$6.00
Veterinary Drugs and Supplies	$15.00
Commissions and Marketing	$10.00
Professional Fees	$2.00
Miscellaneous	$8.00
Additional Costs per Head	$41.00

If the rancher decides not to purchase an additional 200 head of stocker cattle, the next best alternative would be to rent out the rangeland at $16 per acre and invest the $200,000 in the stock market at an annual interest rate of 6% for the grazing season (which is approximately 5 months or 41% of the year).

The rancher is interested in whether the net benefits of purchasing an additional 200 head of stocker cattle outweigh the net benefits of the next best alternative. Use this information to answer the following questions.

Question #15

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Question #16

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Remember, that an opportunity cost can represent the value of a resource in its next best use. The farmer had two resources that would be needed to manage the 200 additional stocker cattle: land and operating capital. The land is the additional 2000 acres they inherited and the operating capital is the $200,000 they inherited (or the money needed to purchase the cattle and inputs).

Using this information, determine the opportunity costs of land and operating capital for the farmer.

Question #17

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Question #18

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Question #19

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5.0 Concluding Remarks

This chapter introduced you to the concept and aspect of opportunity costs used in economics. The notion of an opportunity cost allows decision-makers to take explicit account of the alternatives available to them to make sure that they are making the best "economic" decisions. This was illustrated in detail in both case studies examining the decision to earn a college degree and purchase additional stocker cattle on a ranch. Whether we recognize it or not, when making decisions and taking account of alternative choices or options, we are taking into account the opportunity costs of those decisions.

Question #20

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6.0 References

[1] Anderson, D.A. *Economics by Example*. New York, NY: Worth Publishers, 2007.

[2] Barkely, A. and P.W. Barkley. *Principles of Agricultural Economics*, 2nd ed. New York, NY: Routledge, 2016.

[3] Image courtesy of D Sharon Pruitt through Wikimedia Commons, under license CC BY 2.0.

[4] Image courtesy of Flickr, under license CC Public Domain Mark 1.0.

[5] Video courtesy of The Land Geek through Youtube, under license CC BY Attribution 3.0 Unported.

[6] Video courtesy of Saylor Academy through Youtube, under license CC BY Attribution 3.0 Unported

[7] Video courtesy of BU Newsservice through Youtube, under licencse CC BY Attribution 3.0 Unported.

[8] Kansas State University, Office of Student Financial Assistance, Undergraduate Students 2017-2018, Costs. Available at: http://www.k-state.edu/sfa/cost/undergraduate.html.

[9] Image courtesy of Quan Nguyen through Wikimedia Commons, under license CC Attribution-ShareAlike 3.0 Unported. No changes were made to the image.

[10] Kansas Livestock Association. "Economic Impact of the Kansas Livestock Industry." 2018. Available at: https://www.kla.org/industryeconomics.aspx.

[11] Image courtesy of K-State Research and Extension through Flickr, under license CC BY 2.0.

[12] D. McCollum, personal communication, 2018.

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13.2: Marginal Analysis



Grains [1]

1.0 Introduction

Economics is the study of human decision-making and the allocation of scarce resources among competing ends. The choice to use more scarce resources to undertake an activity is made at the **margin**. For example, when allocating your time to study for an exam, you may decide to allocate an hour, initially. If you feel more time is needed to understand the material after an hour has passed, you may decide to study for an additional hour. These study decisions are made on the margin. On the margin, refers to the additional resources needed to make a choice, complete an activity, or take an action. The designated hour to study and the additional hour for studying are marginal decisions. Thinking on the margin is essential in understanding the impact of each additional resource consumed, sold, or gained. It is key to thinking like an economist! Foundational to a thorough understanding of economics is the idea of **marginal analysis**. This type of analysis is crucial in making informed decisions as a producer or consumer in any market. Marginal analysis is used to compare the additional benefits of an activity to the additional costs incurred by the same activity to meet specified objectives.

Marginal analysis comes into many of the decisions we make. Weighing the additional benefits and costs of making a decision is something that is experienced by everyone. This is the essence of marginal analysis! Whether you realize it or not, marginal analysis is something you do every single day, from deciding to eat that last slice of pizza to pushing yourself through one last rep on the bench with those heavy weights. We undertake marginal analysis in deciding whether or not to go to class each day, by deciding which is more essential at that given moment; another nap, lunch with your friends, a quick run, or learning the class material.

In addition to explicitly considering other alternatives, another benefit of learning marginal analysis more formally is learning you do not need to make decisions by starting from the beginning. Let's go back to the studying example. If you've been studying for an exam for 2 hours for your principles of economics course and you're weighing the decision of whether or not to study for another hour, you are utilizing marginal analysis. We don't decide every single hour whether or not we should study at all! Consider another example involving farmers, who use the same sort of logic. Assume a farmer is contemplating deciding to invest in more land for their farm. The farmer doesn't evaluate whether or not it would be profitable to farm their entire operation with the acquisition of the new land. The costs, revenues, and profit for the land the farmer already owns are known. It is the additional (or marginal) costs and revenues incurred by incorporating the new land into the farming operation that they would be concerned with.

The purpose of this chapter is to introduce you to the concept of **marginal analysis**, present different marginal concepts often

used in economics, and begin to present to you how to think "on the margin". We define what "on the margin" means and alternative marginal concepts in the next section. In Section 3, we learn about marginal analysis and different techniques used to conduct marginal analysis. Finally, in Section 4, we present three case studies that apply the concepts and approaches used in the chapter to examine profit maximization for a firm, a problem of pollution abatement in the area of environmental economics, and an application of partial budgeting to the adoption of conservation practices on-farm.

1.1 Learning Objectives

At the end of this chapter you should be able to:

(1) *Define what "**on the margin**" means and identify alternative marginal concepts in economics;*

(2) *Calculate **marginal values** for different economic decision situations (e.g. for consuming and producing goods and services);* and

(3) *Conduct **marginal analysis** using optimization rules and partial budgeting.*

Throughout the chapter, there are many examples to illustrate the concepts we talk about and the case studies will provide in-depth examples that will allow you to walk through situations of calculating marginal values and conducting marginal analysis.

2.0 "On the Margin"



Tractor Production Line [3]

This section of the chapter will introduce the concept of "**on the margin**", its importance in economic analysis, and different marginal concepts often used in economics. The notion of "on the margin" is central to thinking like an economist.

2.1 What do “on the margin” and marginal mean?

The term **marginal** is used by economists to describe the additional benefits and costs incurred when one more unit or level of an activity or choice is made. For example, this could be eating one more piece of pizza, producing one more tractor, or studying for one more hour. Benefits and costs can include how "full" you feel, an increase in production costs, or your performance on an exam. “On the margin” is essentially a description of the change that occurs when the amount or level of a choice or activity is being changed incrementally. The marginal change is measured as the additional benefit or cost from the change in the amount or level of an activity or choice.

Marginal changes in economics are often illustrated as the change in the benefits or costs with a one-unit change in the amount or level of a choice or activity being undertaken. For example, consider a government deciding whether or not to build an additional nuclear power plant in their country. The capital required for this kind of decision usually only allows for a single unit of the good to be considered at a time. Marginal changes do not have to be in one-unit increments though. Consider the production of lollipops, which a candy producer may produce in the hundreds of thousands of units. Asking the question “Should I produce one more lollipop?” may seem ludicrous. However, the company may be interested in the marginal decision to open an additional production line to produce 100,000 lollipops and want to know what the additional or marginal cost would be of that decision. Thus, **"on the margin"** refers to the additional or incremental decrease or increase in benefits or costs from making an incremental change (i.e. one unit change) in a choice or activity. We will explore multiple marginal concepts in this chapter and examine how decisions can be made "on the margin" using *marginal analysis*.

2.1.1 The Difference Approach to Calculating Marginal Values

We can often calculate marginal changes quantitatively. Marginal changes are mathematically calculated by taking the incremental change in the value of the benefit or cost being examined over the incremental change in the value of the amount or level of the activity or choice being considered. (Mathematically, this ratio is the slope of the secant line between two points.) We call this the **difference method** for calculating marginal changes. An alternative and more exact approach would be to use the first derivative of a function measuring the benefit or cost as a function of the amount or level of the choice or activity being undertaken, which is addressed more in the aside below. The most important thing is to understand the distinction between the two. We will not have you calculate marginal values using the first derivative, but it is important to understand the difference. Both methods estimate marginal changes and both represent rates of change (or slopes) of a benefit or cost outcome (function) of interest. If you are curious or have taken calculus in the past, take a look at the aside below for more information on the marginal calculated using the first derivative.

Aside: For those of you who have taken calculus, the term “marginal” corresponds to the slope or the first derivative of a function. These derivatives are referred to as an “instantaneous rate of change”, which is where the marginal concept arises from. Derivatives of a function are a fundamental part of understanding any type of function and its unique behavior. These derivatives are used in physics, engineering, economics, finance, mathematics, and many other fields. In economics, for example, functions capturing profit take on certain shapes. The shape of the profit function is determined by the costs and revenues of the operation, or the “costs and benefits”. Analyzing the first derivative of the profit function gives us the contribution (whether positive or negative) of another unit of production to profit (i.e. marginal profit), which helps us determine the maximum profit for a firm and at what level of production it is achieved at. Mathematically, the derivative of a function $y = f(x)$ is represented as $\frac{\partial y}{\partial x} = \frac{\partial f(x)}{\partial x}$, where y is the outcome variable (e.g. benefit or cost), x is the independent variable (i.e. amount or level of activity or choice being made), and ∂ can be interpreted as the "the change in". The first derivative is the slope of the function, which can also be written as $f'(x)$, where the $'$ stands for the first derivative.

The **difference approach**, which is what we will predominantly use here, utilizes what's known as the secant line between two points on a function (or curve on a graph) to calculate the marginal change between those two points. The secant line is the line that passes through the two points of interest. The difference method estimates marginal changes by calculating the slope of the secant line, which may be a crude estimate at times. Using the difference approach, marginal changes or values are calculated as the change in the outcome variable (Y) divided by the change in the independent variable (X) (i.e. activity or choice) using the formula:

$$\frac{change\ in\ Y}{change\ in\ X} = \frac{\triangle Y}{\triangle X} = \frac{Y_1 - Y_2}{X_1 - X_2} \tag{13.2.1}$$

where $\triangle$ represents the "change in" and (X_1, Y_1) and (X_2, Y_2) are two data points needed to perform the calculation. It is heavily advised that you become as familiar with this equation as you can, as it is commonly used in many economics classes. For those of you who may be curious or have taken calculus in the past, take a look at the following aside for some more information on the difference between the difference approach and the derivative approach.

Aside: Typically, for calculating marginal changes, the difference approach (which uses the slope of the secant line) is less exact than the derivative approach (which uses the slope of the line tangent to the function at the point of interest). However, mathematically, as the two points used to calculate the difference approach become arbitrarily closer together, the estimates between the two methods will become closer in value. You may think of this as the secant line itself becoming closer and closer (as you choose points closer and closer together on the function) to the line of tangency at the point where the derivative method is used to calculate the slope of a function. Another note to consider is the notation contrast between the two. The difference approach utilizes the capital Greek letter delta, $\triangle$, which means "change in", while the derivative approach utilizes a script d (∂) (which can be pronounced several ways, but includes the name "dee" and "dabba") which means an "infinitesimally small change

in" [5].

2.2 Aspects of Thinking "On the Margin"

Marginal analysis is a fundamental and important economic concept that is used in explaining how individuals and entities make decisions. There are a few key aspects encompassing marginal analysis that are important to take into consideration. Understanding the difference between average and marginal concepts, as well as understanding the properties of curves used in marginal analysis are important and will come up in this chapter.

2.2.1 Average vs Marginal

One of the single most important distinctions in economics is understanding the difference between the concepts of *average* and *marginal*. While both can be helpful in understanding production, costs, revenues, profits, consumption, and a host of other decision-making contexts, they are quite distinct in their interpretation. Mathematically, an *average* is just a sum of the items under consideration in a set divided by the count (or number of items) in the set. Economists use an average to determine average production, costs, revenues, and profits to examine the efficiency of a process. That is, how efficient is the process under consideration over a set amount of time and/or space. For example, in physical production, the average tells us how much output we are able to obtain from a unit of input considering the entire production process over a set amount of time or space. In contrast, *marginal* refers to an incremental step and does not look at the entire process under consideration. Marginal changes focus on what is needed to obtain the next step or produce the next unit. Continuing the physical production example, in production, marginal changes may focus on how much additional output can be produced from a single unit of input. In production, marginal changes provide a way to assess the productivity of the physical production process under consideration.

2.2.2 Tendencies of Marginal Curves.

Marginal curves are governed by certain tendencies in economics. By knowing the general tendency of a marginal curve, economists can use their judgment to quickly ascertain the nature of whatever they are studying. Oftentimes, marginal changes within a process can be represented as a function or curve on a graph. We call these *marginal curves,* which can be linear or nonlinear. A linear marginal curve (a straight line) will have a constant slope or rate of change. When the marginal curve is nonlinear, then the marginal change will differ from point to point as you move along the curve. For example, a typical production function will change on the margin as you adjust the level of inputs. A typical representation of a production function (top graph in Figure 1) and other related curves are provided in Figure 1 below.

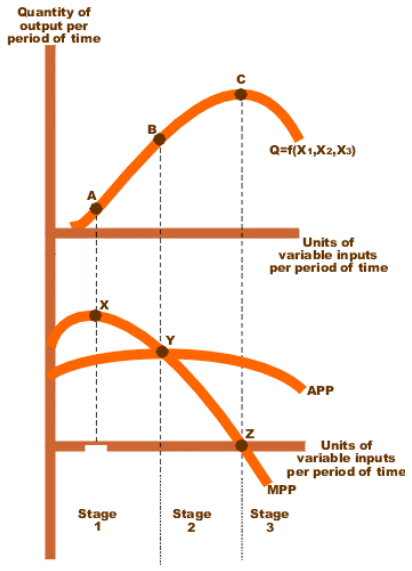


Figure 1: Production Function and Related Curves [5]

As seen in Figure 1, the typical production function is nonlinear. Thus, the marginal change in output as input use is increased

will change as you move along the curve from right to left. Also shown in Figure 1, is the marginal curve, denoted here as the MPP curve. The MPP curve here is nonlinear and not constant due to the nonlinear nature of the production function in the top graph. A marginal curve that arises from a nonlinear curve can increase or decrease at certain points. For a production process, note that the MPP curve first increases and then decreases, meaning the productivity of the production process is changing as more input is added to the production process (i.e. as you move from left to right in the graph).

Taking things one step further, we can look at the rate of change (or slope of the) marginal curve. (If you were understanding the marginal before as a slope of a curve, then the tendency would then be the "slope of the slope".) Now, instead of saying a marginal curve is increasing, we can go a step further and say the process being presented is increasing at an increasing or decreasing rate. For example, go back to Figure 1 and the generic physical production process being considered. Notice, that the marginal curve (the MPP curve) first increases, then decreases. Thus, the slope of the marginal curve is first positive (i.e. increasing rate) and then becomes negative (decreasing rate). When the slope of the MPP curve is positive, we say that the production process or production function is increasing at an increasing rate. When the slope of the MPP curve is negative, but above zero, we say that the production process or production function is increasing at a decreasing rate. When the slope of the MPP curve is negative (< 0), we say that the production process or production function is decreasing at an increasing rate. These tendencies allow us to talk about economic processes in more detailed ways, providing useful information about productivity and efficiency.

Question #1

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2.3 Marginal Concepts Used in Economics

Marginal analysis can be applied to nearly every single decision we make, but it is perhaps most useful when we can quantify the marginal benefits and marginal costs under consideration. This subsection examines different marginal concepts used in economics, which include marginal concepts related to production, profit, revenue, utility, amongst others. It is important to emphasize that, marginal benefits and marginal costs will be dependent on the situation or decision under consideration, but the concepts here can be useful for decision-making in a number of different contexts.

2.3.1 Marginal Benefit

In general, a *marginal benefit* is the additional (or incremental) benefit from making a choice or decision. In economics, marginal benefit is often the additional benefit (e.g. revenue or satisfaction) from an additional unit of an input, output, good or service that is used in consumption or production by a person or firm. Marginal benefits are “situationally dependent” and are often based entirely on an individual’s perceived benefits. For example, the marginal benefit or additional satisfaction someone receives from consuming an additional slice of pizza will be dependent on how much they like pizza and their own anatomy. We can quantify marginal benefit at times too. For example, marginal benefits can include the additional revenue or profit a firm receives from producing and selling another unit of a good or service. Other examples of marginal benefits include the marginal benefit derived by a firm from the income they earn over capital within a given quarter or from a rise in the worth of their stock. There are times when it may be difficult to quantify marginal benefits. For individuals, marginal benefits may only be portrayed by emotions and not directly measurable, such as feeling good for doing a good deed or helping a person in need. Thus, the measure for marginal benefits varies widely, depending on the question being asked. In this chapter, we will focus on marginal benefits that

are primarily quantifiable.

Question #2

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2.3.2 Marginal Revenue

Marginal revenue (MR) is a type of marginal benefit. Marginal revenue is defined as the additional revenue earned by a firm from selling an additional unit of a good or service. It can be calculated as:

$MR = \frac{\triangle TR}{\triangle Q}$, where TR = total revenue, and Q = total quantity.

Consider a firm that operates in a perfectly competitive market (like some farmers and ranchers). These firms are known as *price takers*. That is, they have no control over the market price for the sale of their commodities or output and must accept the market price as given. A perfectly competitive wheat farmer would not be able to negotiate with their local coop or grain elevator for a higher price for their wheat, but would instead take the given market price when they sell their wheat. Thus, firms in a perfectly competitive market will receive a constant marginal revenue, the market price. For perfectly competitive firms, $MR = P$, where P is the market price for the good being considered. For every unit of good that is produced and sold by a perfectly competitive firm, the firm will receive the market price of that good, which will be its marginal revenue. Although total revenue will increase with each additional unit of output, marginal revenue remains constant.

Let's look at an example to look at the concept of marginal revenue. Consider Farmer Jane, who is looking at selling her corn at market price, which has been quoted at $3.71/bu. Assume Farmer Jane is a perfectly competitive corn producer. The table below provides the output from corn production in bushels, market price in dollars per bushel, total revenue from selling different levels of output, and the marginal revenue from selling each additional bushel of corn. You see that the marginal revenue of selling each additional bushel of corn is equal to the market price for a bushel of corn in this example.

Output of corn production

Output (Bu)	Price ($/bu)	Total Revenue	Marginal Revenue
1	$3.71	$3.71	$3.71
2	$3.71	$7.42	$3.71

Output (Bu)	Price ($/bu)	Total Revenue	Marginal Revenue
3	$3.71	$11.13	$3.71

Question #3

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Marginal revenue in a perfectly competitive market is quite literally, the market price for the good. This will not be the case when firms begin to exhibit market power or the ability to influence the market price. Markets with different organizational structures (such as monopolies) will have firms with marginal revenues that will be influenced by their level of market power.

2.3.3 Marginal Product

Firms are interested in the productivity of their production processes for goods and services. This productivity can be measured by the *marginal product* of the production process at a given point in time. Marginal Product (or MP) is defined as the additional output (i.e. good or service) produced from one additional unit of input. It is sometimes also referred to as marginal physical product (or MPP), as well. Mathematically, the marginal product is:

$$MP = \frac{\triangle Y}{\triangle X}, \text{ where } Y \text{ is a given output and } X \text{ is a given input.}$$

Marginal product is typically associated with a given input and we often refer to the marginal product of that input. For example, we could be interested in the marginal product of labor (or MP_L) or the marginal product of capital (or MP_K), which are used to evaluate the productivity of increasing or decreasing labor or machinery (capital) in a production process. The marginal products of labor and capital can be mathematically defined as:

$$MP_L = \frac{\triangle Output}{\triangle Labor}, \text{ and } MP_K = \frac{\triangle Output}{\triangle Captial}$$

To help put this into practice, consider the following example. Assume you are a producer of no-till planters. The primary input into the production of planters is steel. Assume that if you increase the amount of steel used in the production process from 100 to 150 tons, then the number of no-till planters that can be produced will increase by 100 units. What is the marginal product of steel for the additional 100 tons of steel used in the production of no-till planters? Recall, $MP = \frac{\triangle Y}{\triangle X}$. We are told the change in output, $\triangle Y = 100$ no-till planters. The increase in the amount of input used is $\triangle X = 150 - 100 = 50$ tons of steel. Then the marginal product of steel, $MP_{Steel} = \frac{100}{50} = 2$ no-till planters per ton of steel added to the production process. Notice that the units for the marginal product are per unit of input. Put another way, each ton of steel added to the production process between 100 and 150 tons, increases the number of no-till planters produced by 2.

Querstion #4

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A concept that combines marginal revenue and marginal product is *marginal revenue product* or MRP. The marginal revenue product is the additional revenue generated from the output sold as a result of adding one more unit of input to the production process. That is, if you increase the amount of input used by one unit, then output will increase. If you then sell that additional output, you will gain additional revenue, which is the MRP. The marginal revenue product can be defined as:

$$MRP = \frac{\triangle TR}{\triangle X} (= MR \times MP = \frac{\triangle TR}{\triangle Y} \times \frac{\triangle Y}{\triangle X} = \frac{\triangle TR}{\triangle X}),$$

where TR is total revenue, Y is output and X is input. The relationship in parentheses emphasizes how MRP is connected directly to marginal revenue and marginal product.

A final aspect of marginal product relates to a very important property of production processes in economics. This is the ***Law of Diminishing Marginal Returns***. This law states that holding all other inputs constant, at some point in a production process, the additional output produced from adding additional units of a specific input will decrease. That is, the marginal product of the production process will decline. An example of this economic law in action is a farmer hiring additional workers without buying more equipment for them to use. Each additional laborer added to their operation costs the same amount of money, while the amount of work to be done does not increase, due to the lack of additional equipment. Thus, the productivity of each additional worker is lower, until theoretically, the marginal product of labor of the next worker is zero, and perhaps negative. (A negative marginal product may arise here as employees demotivate each other or argue over use of the equipment to get their jobs done.) This concept has a broader application too. Consider what happens as you increase the consumption of a good. While the marginal benefit received by that good may increase initially, eventually, at some point the marginal returns from consuming that good will decrease with each additional unit consumed. We refer to this in economics as the *Law of Diminishing Marginal Utility*, which is very similar to the Law of Diminishing Marginal returns, but describes an aspect of consumption of a good or service. We can see this in everyday life when we sit down for lunch. Consider purchasing a 12-inch sub at a sandwich store. While the first bite of your sandwich may be "to die for," and the next bite is still very good, each additional bite isn't as good as the first. By the time you get to the end of your sandwich, you may start to wonder whether or not it was worth the $8.00 you paid.

Watch the following video to help better understand the concepts learned here.

YouTube Video

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Diminishing Marginal Returns [https://www.youtube.com/watch?v=xLSRMt-wWAM]

Use the video to answer the following question.

Question #5

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2.3.4 Marginal Cost

In general, *marginal cost* is the additional cost that is incurred from making a decision or choice "on the margin". We are often able to calculate a quantitative value for marginal cost in dollars. Marginal costs are just the opposite of marginal benefits, and likewise, are situationally dependent. Marginal costs are often characterized in financial terms, such as the marginal cost of

production or consumption of goods and services. However, marginal costs can be based entirely on an individual's perceived costs. Opportunity cost can be realized through marginal terms, as well. Participating in an activity will incur certain costs at the margin, and some of those costs are characterized by the lost opportunity to participate in another activity. Thus, opportunity costs can be viewed as a type of marginal cost.



Marginal Cost of spraying herbicides on an additional crop field [6]

From a production standpoint, marginal cost is the change in total cost from producing an additional unit of output. Marginal cost can be mathematically defined as:

$MC = \frac{\triangle TC}{\triangle Y}$, where TC is total cost and Y is output.

Consider the production of sprayers used on a farm to apply herbicides. Assume a manufacturer of sprayers increases production per day from 100 units to 150 units. The total cost of 100 units is equal to $3 million, while the total cost of producing 150 units is $5 million. What is the marginal cost of each sprayer for producing the next 50 sprayers? Using the formula above, $\triangle TC = \$5,000,000 - \$3,000,000 = \$2,000,000$ and $\triangle Y = 150 - 100 = 50$, so that $MC = \frac{\$2,000,000}{50} = \$40,000$ per sprayer. You should recognize that marginal cost here is reported per unit of output.

Now consider the following question:

Question #6

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From a production standpoint, marginal product and marginal cost are related. Marginal product shows the marginal or additional gain in output as more input is used for production, while marginal cost shows the additional cost of producing an additional unit of output. Note that marginal cost is defined in terms of changes in output. We can look at marginal cost from a change in input use in the production process too. For this, we use the concept of marginal factor cost (MFC). $MFC = \frac{\triangle TC}{\triangle X}$, where X is the input being examined. The relationship between marginal cost and marginal product of a production process is explored more in the following video.

YouTube Video

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View this YouTube Video online

Marginal Product and Marginal Cost [7]

Answer the following question after watching the video.

Question #7

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View this Interactive Content online

Let's now consider another example using marginal cost. Consider the firm "AGSPI", which is interested in entering the market for commercial drones that are specifically used in agriculture (e.g. remote sensing and crop mapping). After consulting with another prominent firm in the market, they have been able to determine the expected costs of production for drones. These costs are given in the table below.

Expected costs of drone production

Output	Total Cost	Average Total Cost	Marginal Cost
1	580.30	580.30	560.90
5	2537.50	507.50	422.50
10	4300	430.00	290.00
15	5512.50	367.50	202.50
20	6400	320.00	160.00
25	7187.50	287.50	162.50
30	8100	270.00	210.00

Output	Total Cost	Average Total Cost	Marginal Cost
35	9362.50	267.50	302.50
40	11200	280.00	440.00
45	13837.50	307.50	622.50
50	17500	350.00	850.00

Notice that the total cost (2nd column) will increase with each set of 5 additional drones produced. Average Total Cost (3rd column) is the total cost divided by the level of output. For example, at a production level of 15 drones, the average cost will be $\frac{\$5512.50}{15} = \$367.50$ per drone. Of interest here is the behavior of Total Cost and Marginal Cost as output increases. Recall, that all production processes will exhibit the Law of Diminishing Marginal Returns, which tells us as production continues to increase, productivity (measured as marginal product) will decrease. In essence, this means that as more output is produced, it takes more and more input to produce each additional unit of output. This implies that the marginal cost of that additional unit of output will increase, as well. Remember, the use of more input means higher costs to produce each unit of output. Notice as total output increases, marginal cost is increasing. This is due to declining productivity (i.e. the Law of Diminishing Marginal Returns). The impact on the total cost of production is that total costs are increasing at an increasing rate. Use all this information to consider the following questions.

Question #8

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Question #9

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Understanding the nature of marginal cost and marginal revenue is tremendously important in the next section, in which we will cover marginal profit. If you have struggled with the previous sections concerning marginal cost and marginal revenue, you may want to review them before moving on to the marginal analysis and case study sections of this chapter.

2.3.5 Marginal Profit

In doing economic analysis we are often interested in the net benefit of making a choice. In general, the net benefit of a decision *on the margin* is the difference between the marginal benefit and the marginal cost of that decision. For a profit-maximizing firm,

the net benefit can be characterized by *marginal profit*, which is defined as the following:

$$Marginal/profit = \frac{\triangle \pi}{\triangle Y}, \text{ where } \pi \text{ denotes firm profit, and } Y \text{ is output.}$$

Marginal Profit is the profit received from producing an additional unit of output of a good or service. Marginal profit is often strictly interpreted in terms of currency. This contrasts with marginal benefits and costs, which can be measured in a variety of ways. For a firm, marginal profit from producing an additional unit of output is the difference between the marginal revenue and marginal cost of that unit of output. That is:

$$Marginal/profit = MR - MC \tag{13.2.2}$$

Similar to the derivation of marginal costs and marginal revenues, marginal profit is the slope or first derivative of the profit function for the firm. Knowledge of the marginal profit of a good or service can be very useful in a firm's decision-making process. It can help to identify when it is no longer profitable to produce or shut-down, which occurs when a firm can no longer cover its fixed costs in the short-run. This is illustrated in the example below.

Let's go back to our example concerning drone production by "AGSPI". We will assume AGSPI operates in a perfectly competitive market, where they have no market power and take the market price for drones as given. That is, AGSPI is a price-taker. The market price for a drone is $350. Using this information, AGSPI asks their finance department to examine the drone production process and they estimate the following cost and revenue information that is provided in the table below.

Cost of drone production

Output	Total Cost ($)	Total Revenue ($)	Marginal Cost ($)	Marginal Revenue ($)	Marginal Profit ($)
1	580.30	350.00	580.30	350.00	-230.30
5	2537.50	1750.00	489.30	350.00	-139.30
10	4300.00	3500.00	352.50	350.00	-2.50
15	5512.50	5250.00	242.50	350.00	107.50
20	6400.00	7000.00		350.00	172.50
25	7187.50	8750.00	157.50	350.00	192.50
30	8100.00	10500.00	182.50	350.00	167.50
35	9362.50	12250.00	252.50	350.00	97.50
40	11200.00	14000.00	367.50	350.00	-17.50
45	13837.50	15750.00	527.50	350.00	-177.50

Output	Total Cost ($)	Total Revenue ($)	Marginal Cost ($)	Marginal Revenue ($)	Marginal Profit ($)
50	17500	17500.00	732.50		-382.50

Use the above information to answer the following questions.

Question #10

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Question #11

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Question #12

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When looking at the marginal profits in the table for AGSPI, you will notice at first marginal profit is negative, which may be the case for specific firms due to high fixed costs, resulting in high average fixed costs at the start of production. Thus, at first, AGSPI is earning an economic loss (negative profit). After 10 drones have been built though, the marginal profit becomes positive. Thus, for each drone produced, the total profit is increasing by the amount of marginal profit. Total profit for the firm is maximized up to the point that marginal profit becomes zero (or negative again in the table). Use this information to answer the following question.

Question #13

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2.3.6 Marginal Rate of Substitution

The last marginal concept we will examine in this section is the *marginal rate of substitution* (*MRS*). From a production perspective, the marginal rate of substitution is a measure used by economists to examine the tradeoff between producing two goods (e.g. minivans versus full-size vans) or the substitutability between different inputs (e.g. machinery and labor), among other uses. From a consumption perspective, the marginal rate of substitution examines the tradeoff between the consumption of goods that a consumer can choose between (e.g. breakfast cereal and oatmeal) and maintain the same level of satisfaction from the consumption of those goods. Mathematically, the marginal rate of substitution is given by:

$$MRS = \frac{\triangle X_1}{\triangle X_2} \tag{13.2.3}$$

where X_1 is the first good or input being considered and X_2 is the second good or input being considered. From a production perspective, MRS measures the amount of good (or input) X_1 that can be produced (or substituted) by giving up one unit of good (or input) X_2. From a consumption perspective, the MRS measures the amount of good X_1 that can be substituted by giving up one unit of good X_2. Let's look at an example from a production perspective using inputs.

Consider a livestock producer who is preparing feed rations for his cattle. The farmer has two inputs that he can substitute between for part of the rations, soybean (X_1) and distillers dried grains (DDGs) (X_2) (both measured in lbs), to provide additional protein for the ration. Assume, the marginal rate of substitution between the two is 0.75. The MRS tells us that the livestock producer can substitute 1 lb of DDGs for 0.75 lbs of soybeans and maintain the same level of protein in the ration. Now answer the following question.

Question #14

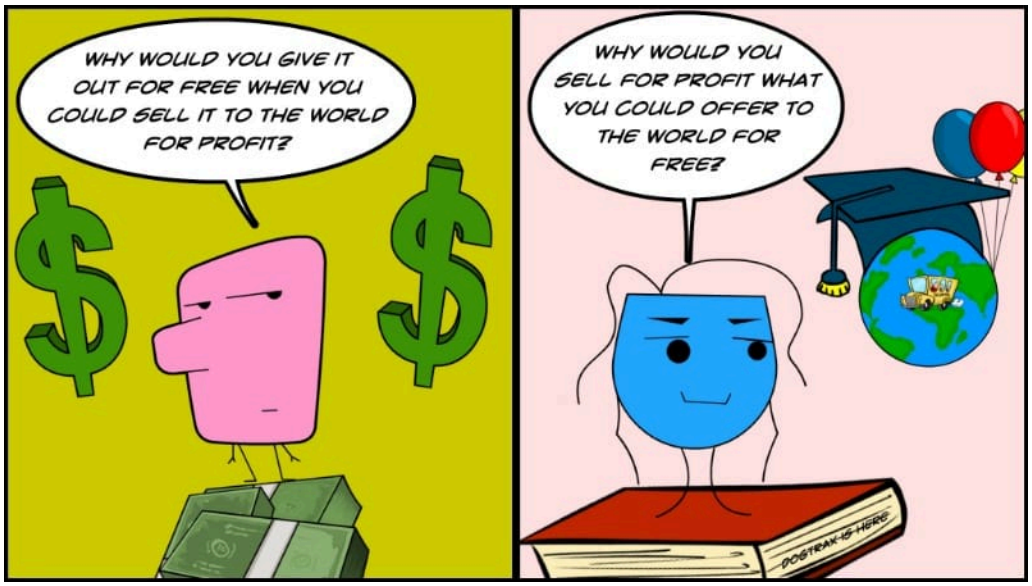
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3.0 Marginal Analysis

This section of the chapter examines how to use the marginal concepts presented in the previous section to conduct *marginal analysis*. Recall from earlier in the chapter, that marginal analysis is used to compare the additional benefits of an activity to the additional costs incurred by the same activity to meet specified objectives. We will examine two approaches often used in economics to conduct marginal analysis. The first is based on *optimization rules* and the second is *partial budgeting*.

3.1 Marginal Benefit (MB) versus Marginal Cost (MC)



Profit or Not [8]

Economists recommend that individuals, firms, and/or organizations consider both the positive attributes or marginal benefits (MB) and negative attributes or marginal costs (MC) of decisions or choices they are faced with. Such consideration means weighing the marginal benefits against the marginal costs of that choice or decision. Individuals and firms should consider all relevant benefits and costs, whether they directly or indirectly impact the individual or firm. Even when an individual or entity has an opportunity to largely benefit directly without much internal cost, there can be *externalities* involved. Externalities are impacting third parties who do not have direct involvement in the choice, decision, or action being taken. Externalities can be positive and negative, meaning other external benefits and costs may result from a given choice or decision, which should also be considered. In addition, decision-makers want to take account of *opportunity costs or* the next best thing they could do with the resources they are using for the decision or choice being made.

Thus, all relevant additional benefits and costs of a choice or decision should be considered by individuals, firms, and organizations in their decision-making processes. To help guide these decisions, economists will often employ *optimization rules*. Optimization rules can be mathematically derived from optimization-type problems, such as firms trying to maximize profit or minimize cost when producing their goods and services, but these derivations are well beyond the scope of this chapter.

In this subsection, we will focus on a general rule for comparing MB and MC. An individual, firm, or organization should consider enacting a choice or decision as long as the marginal benefits outweigh the marginal costs. Mathematically, this can be represented as:

$$MB >= MC \tag{13.2.4}$$

That is, if the marginal benefits are greater than or equal to the marginal costs of the choice or decision then an individual, firm, or organization should, from an economic perspective, make that choice or decision.

To explore this consider the following situation: You have to make an effort each morning to go to class during the week. Pick one

weekday this coming week. Now consider the following questions.

Question #15

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Question #16

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Question #17

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The optimization rules considered in the next two subsections will be based on this general optimization rule but will allow for the numerical computation of MB and MC.

3.2 Profit Maximization

In economics, we often assume that firms are profit maximizers. The assumption can be justified by the fact that firms must earn profit to remain in business. However, it is important to recognize that this may not be the firm's only objective. Other motives that drive firms include minimizing risk, cost minimization, promoting environmental sustainability, and charity.

The assumption of profit maximization provides for a relatively strong optimization rule for production decisions made by firms. That is, can a profit-maximizing rule be determined that helps a firm decide how much to produce in the short-run? First, let's present the rule and then we will discuss it. **A firm will maximize profit in the short-run by producing up to the point where (1) marginal revenue (MR) equals marginal cost (MC), and (2) marginal cost cuts marginal revenue from below**.

The second condition helps to make sure that the firm gets through the initial phase of production where marginal profits may be negative. That is, firms may have high fixed costs, which can result in significantly higher marginal costs at the start of production that only begin to decrease as production increases (i.e. as average fixed costs decline). Thus, marginal profit $(MR - MC)$ at the beginning or in the initial stages of production may be negative, but will likely become positive as the level of production increases (as seen in the example with AGSPI in section 2.3.5). So in the initial stages of production, a firm will try to produce until $MarginalProfit > 0$. (If the firm is unable to reach a point in the production process where marginal profit is positive, then it will have to shut down and stop production.)

Now let's turn our attention to the first and most significant part of this optimization rule for profit maximization, that a firm will produce up to the point where $MR = MC$. To begin to explain why the above optimization rule works, first remember that for a

firm selling a single unit of output, the marginal benefit MB) is the marginal revenue (MR) or price they receive for selling that unit of output. The marginal cost (MC) of producing the unit of output will be the actual marginal cost in dollars (which includes variable cost, fixed cost and opportunity cost for that unit of output). Marginal profit for the unit is then $MR - MC$. If a firm is a profit maximizer, then it will produce and sell an additional unit of output if the marginal profit for that unit is greater than or equal to zero, i.e.

$$MarginalProfit \geq 0 \tag{13.2.5}$$

Remember, that $MarginalProfit = MR - MC$, so the above rule, implies that the profit-maximizing firm will want to produce and sell an additional unit of output, if:

$$MR - MC \geq 0 \tag{13.2.6}$$

This implies a firm should produce as long as $MR \geq MC$ (i.e. they are still earning money on the additional unit of output being produced).

To dive a bit deeper, assume the firm is at a point of production in the short-run, where marginal profit is positive. The firm wants to determine the level of output to produce that will maximize its total profit. As long as marginal profit is positive, total profit will increase. It is only when marginal profit becomes negative that the firm will stop increasing production, as total profit will decrease. Thus, the firm will want to produce as long as the marginal profit is positive, but not when the marginal profit is negative. This condition suggests the firm will want to produce up to the point where $MarginalProfit = 0$. At this point, the firm is making no additional profit from producing more output. That is, the additional profit from the next unit of output is zero. If they go past this point in the production process, marginal profit will become negative, decreasing total profit. Given that $MarginalProfit = MR - MC$, a profit-maximizing firm should produce up to the point where $MR - MC = 0$ or:

$$MR = MC \tag{13.2.7}$$

which is our optimization rule given by (1). The profit-maximizing optimization rule can be applied to many types of firms in many types of markets.

Let us return to the AGSPI example previously explored, considering the production of agricultural drones. The table below provides information about Total Cost, Total Revenue, Marginal Cost, Marginal Revenue, and Marginal Profit for different levels of output (or production) for AGSPI. Now let's use this information to apply the profit maximization rule.

New analysis of drone production output.

Output	Total Cost ($)	Total Revenue ($)	Marginal Cost ($)	Marginal Revenue($)	Marginal Profit ($)
1	580.30	350.00	580.30	350.00	-230.30
5	2537.50	1750.00	489.30	350.00	-139.30
10	4300.00	3500.00	352.50	350.00	-2.50
15	5512.50	5250.00	242.50	350.00	107.50
20	6400.00	7000.00		350.00	172.50
25	7187.50	8750.00	157.50	350.00	192.50

Output	Total Cost ($)	Total Revenue ($)	Marginal Cost ($)	Marginal Revenue($)	Marginal Profit ($)
30	8100.00	10500.00	182.50	350.00	167.50
35	9362.50	12250.00	252.50	350.00	97.50
40	11200.00	14000.00	367.50	350.00	-17.50
45	13837.50	15750.00	527.50	350.00	-177.50
50	17500	17500.00	732.50		-382.50

Type caption for table (optional)

We already had you explore in section 2.3.5 how many drones AGSPI should produce. Let's see if you were correct (see Question 13). Using the profit-maximizing optimization rule for a firm, according to condition (2), AGSPI should produce at least 15 drones, as this is the point where they begin to earn a positive marginal level of profit per drone. Now we turn to condition (1), which states we should produce up to the point where $MR = MC$ and not beyond (i.e. as long as $MR \geq MC$). If we look at the table, marginal profit remains positive up to the production of 35 drones. At this point $MR > MC$. If AGSPI produces 40 drones, then marginal profit becomes negative, reducing total profit, because $MR > MC$. While in the table we do not have a level of production given where $MR = MC$, we want to make sure we do not choose a level of production past this point where marginal profits become negative. In many examples using tables with production, cost, and revenue information, this will likely be the case. Thus, we want to find the highest level of production where $MR \geq MC$ (i.e. marginal revenue is still greater than marginal cost) or marginal profit is positive, which occurs for AGSPI at a production level of 35 drones. Thus, AGSPI's profit-maximizing level of production is 35 drones.

Question #18

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To see an additional example, view the following video below.

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Apple Orchard Profit Max Example [9]

Use the video to answer the following two questions.

Question #19

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Question #20

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3.3 Partial Budgeting (Marginal Budgeting)



Farmer Decisions [10]

Making decisions as a manager will often have an impact on the bottom line. Thus, managers must consider the impacts of their decisions on marginal benefits or revenue and marginal cost. Thus, we have to consider how each decision will impact the profitability of our firm or operation. A very useful technique known as ***partial budgeting*** exists to aid in the making of these decisions and incorporates many of the marginal concepts we discussed in this chapter**.** Partial budgeting is a technique that provides a formal way to estimate the expected marginal change in profit from a particular decision for a firm or operation [11]. For example, partial budgeting can be used to assess the impacts of proposed changes in crop rotations or livestock enterprises on a farm or ranch. Partial budgeting can be viewed as a formal way to conduct profitability analysis by allowing for the comparison of multiple decisions or changes in a production system, providing the manager guidance on how to best maximize profit or meet their goals. In addition, if you consider the profitability of the next best alternative not made, then partial budgeting can also

provide one way to estimate the *opportunity cost* of a given decision.

Partial budgets only consider (i) *marginal revenue*s or changes in revenue and (ii) *marginal cost*s or changes in production costs or expenses of a decision, management changes, or technology adoption. Given that we are often in the midst of production or activity when making decisions, aspects of the production situation or activity ***not*** affected by the decision being assessed are excluded from the partial budget. The goal of using partial budgeting is to determine if the proposed decision or change will result in a positive marginal change in profitability. The approach "tallies" the net change based on marginal changes in revenues (benefits) and costs [11-12].

In addition to the financial or monetary estimates that can be derived using partial budgets, personal and social factors can also be incorporated. These factors can include level of risk; desire for personal time for leisure and family; workload on employees; equitability; impacts on the environment; and other factors that are difficult to quantify but are important to the overall firm or operation [11]. Personal and social factors are included in the partial budgets as qualitative components and should also be considered in the marginal decision-making process.

To complete a partial budget, a decision-maker can use the following six steps that are adapted from Kay et al. [11] and Bergtold et al. [12]. The steps are as follows:

Step 1: Identify the proposed change in the production system, activity, or operation. For example, on a farm, the proposed change might be to change crop varieties, adopt no-till, or increase herd size. If you are considering multiple changes, then prepare a separate partial budget for each.

Step 2: Positive Marginal Revenue Changes: Record additional revenues (i.e. changes in marginal revenue). List marginal increases in current revenues and/or new revenue sources generated from the decision being considered.

Step 3: Marginal Cost Reductions: Record marginal decreases or reductions in production or other monetary costs (e.g. cost-savings) from the decision being considered.

Step 4: Marginal Cost Increases: Record marginal increases in or new costs from the decision(s) being considered.

Step 5: Reductions in Marginal Revenue: Record marginal decreases or reductions in revenue, as well as lost revenue sources from the decision being considered.

Step 6: Calculate the marginal change in profit (or net return or other objective measure) by subtracting the negative marginal changes (Step 4 and Step 5) from the positive marginal changes (Step 2 and Step 3). If the difference is positive, there is a net economic benefit or marginal gain from adopting the change or making the decision. If the difference is negative, there is a net economic loss or marginal loss. If the marginal change is zero, the decision to adopt the change may be based on the significance of the personal or social factors being considered.

These changes can be put into a partial budgeting form, which is provided below. A case study example illustrating the use of partial budgets will be provided in the case study section of the chapter.

PARTIAL BUDGET	
Decision being considered: *(Step 1)*	
Additional (Marginal) Costs: *(Step 4)*	Additional (Marginal) Revenue: *(Step 2)*
Lost (Marginal) Revenue: *(Step 5)*	Lower (Marginal) Costs/Cost-Savings: *(Step 3)*
(A) Total additional costs and lost revenue: $_____	**(B) Total additional revenue and lower cost/cost-savings:** $_____
Net Marginal Change in Profit (B minus A): *(Step 6)* $_____	

4.0 Case Studies

Marginal analysis can aid in making decisions at both the individual and firm level. This section will provide you with a set of case studies using marginal analysis in a variety of topics and will apply what you have learned in this chapter. An emphasis on understanding the material will be important for these applied problems.

4.1 Profit Maximization in Production from an Input Perspective

The purpose of this case study is to examine profit maximization for a firm but from an input perspective. That is, how much input should the firm apply to maximize output. The optimization rule here is based on the general profit maximization rule for determining the optimal level of output for a firm, producing up to the level of production where $MR = MC$. For our purposes, in this case study, we will modify this optimization rule for the input perspective. As examined in section 2.3.3, the marginal revenue from the additional use of one unit of input is referred to as the marginal revenue product (MRP). MRP will replace MR in the optimization rule. The additional cost of one unit of input is called the marginal factor cost (MFC) and this will replace MC in the optimization rule. Thus, for a firm that wants to maximize profit from production from an *input perspective*, the firm will produce as long as $MRP \geq MFC$ or up to the point or level of production where:

$$MRP = MFC \tag{13.2.8}$$

The logic behind this optimization rule is very similar to that for the output perspective as presented in section 3.2.



Fertilizer Application [13]

The applied example here will examine the economic optimal level of nitrogen fertilizer to apply to maximize return (or profit) for a corn crop being produced by a farmer. The example will utilize corn production data from Debertin [14] with some modifications.

Consider a farmer who is planting corn on a field in the Corn Belt. The farmer is trying to determine how much fertilizer to apply to maximize her profit on that field from corn production. The farmer has worked with her local extension agents at the nearby land grant university to assemble the information in the table below. The first column indicates the potential amount of nitrogen in lbs that can be applied to the corn crop. The second column provides the expected corn yield at the given level of nitrogen. The first two columns represent the expected corn production schedule for the farmer. Each row represents the agronomic and economic effect of applying an additional 20 lbs of nitrogen to the corn crop. The third column provides the marginal product of fertilizer ($MP_{fertilizer}$) for each additional pound of fertilizer applied to the corn crop at that level of production. The fourth column is the expected price of corn at harvest. The fifth column is the marginal revenue product from fertilizer application ($MP_{fertilizer}$). The fifth column is the marginal factor cost of nitrogen MFC or the cost of nitrogen per pound, which is assumed to be $0.55 per pound. The last column is the marginal profit from applying an additional pound of nitrogen and is calculated as the $MRP_{fertilizer} - MFC$. Use this information to answer the following questions. The blanks in the table are left for you to fill in (i.e. on a separate piece of paper).

Effects of fertilizer on crop production and marginal profit.

Nitrogen (lbs)	Corn Yield (bu/ac)	Marginal Product of Fertilizer (bu/lb)	Corn Price ($/bu)	Marginal Revenue Product of Fertilizer ($/lb)	Marginal Factor Cost of Nitrogen ($/lb)	Marginal Profit ($/lb)
0	0	---	$4.50	---	---	---
20	16	0.80	$4.50	$3.60	$0.55	$3.05
40	35	0.95	$4.50	$4.28	$0.55	$3.73
60	55	1.00	$4.50	$4.50	$0.55	$3.95

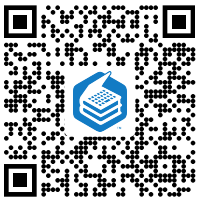
Nitrogen (lbs)	Corn Yield (bu/ac)	Marginal Product of Fertilizer (bu/lb)	Corn Price ($/bu)	Marginal Revenue Product of Fertilizer ($/lb)	Marginal Factor Cost of Nitrogen ($/lb)	Marginal Profit ($/lb)
80	76	1.05	$4.50		$0.55	
100	94	0.90	$4.50		$0.55	
120	111	0.85	$4.50		$0.55	
140	124	0.65	$4.50		$0.55	
160	133	0.45	$4.50		$0.55	
180	137	0.20	$4.50		$0.55	
200	138	0.05	$4.50		$0.55	
220	135	-0.15	$4.50		$0.55	

Nitrogen (lbs)	Corn Yield (bu/ac)	Marginal Product of Fertilizer (bu/lb)	Corn Price ($/bu)	Marginal Revenue Product of Fertilizer ($/lb)	Marginal Factor Cost of Nitrogen ($/lb)	Marginal Profit ($/lb)
240	104	-1.55	$4.50	-$6.98	$0.55	-$7.53

Question #21

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Question #22

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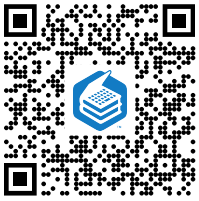
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Question #24

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4.2 Environmental Economics and Pollution Abatement

In economics, market transactions or decisions (e.g. driving to work or planting a crop) may not take account of the full impact of the transaction or decision on society or the environment. That is, individuals and businesses may engage in economic activity (consuming and producing goods and services) without considering the impact this has on the rest of society. If this activity has a negative impact on society or the environment, then we say that this economic activity may result in a *negative externality*. We

define a *negative externality* as a situation where the parties in the market transaction or decision being considered (through the market price) do not fully account for all the costs of the market activity on society (or third parties), such as health impacts, pollution, etc. [15]. The impact on society or a third party includes potential harm or loss of welfare, which is uncompensated. Of particular interest in this case study is the ability to use *marginal analysis* in examining the economics of negative externalities. That is, we can use the notions of marginal benefit and marginal cost to examine when it is economically optimal to take account of negative externalities in society. The following video provides additional information on externalities.

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Externalities Video [16]

Question #25

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We will use the case of water pollution as our example. Consider a farmer who plants a majority of their peanut crop next to a river. The farmer has not yet adopted conservation practices, such as vegetative or field buffers, that would prevent run-off from their crop field from flowing into the river. The farmer bases their peanut production system on what his parents did in the 1990s, given that his parents earned a good income producing peanuts. The production of peanuts requires a significant application of pesticides that may potentially leach or run-off the field after application into the river and other streams or lakes [17,18]. Downstream is a small town that uses the river for drinking water and recreation (swimming and fishing). Local environmental safety officials have tested the water and found that current water levels contain an unsafe level of pesticides that make it hazardous for residents to use. The local officials have determined that the primary source of the pollution originates from the farmer's peanut field upstream. After consulting with the local town council, they want to try to find a way to encourage the farmer to reduce their use of pesticides or put in conservation measures, such as conservation buffers, to make the water safe again. The conservation buffer, also known as a field buffer or vegetative strip helps to absorb some of the excess pesticides that may run off the field. They decide to look for and consult an environmental economics professor at the local university for an answer.

The environmental economics professor tries to explain the problem from an economic point of view to the local environmental safety officials. She indicates that the decision to reduce pollution to an “economically optimal level” is determined using marginal analysis. She indicates that it is unlikely an optimal solution from a market perspective will eliminate all of the pollution too. She explains that, first, one must consider the marginal benefit of the economic activity undertaken by the farmer. That is, for each unit of pesticide applied to the peanut crop by the farmer, the farmer will earn additional benefit (e.g. from higher crop yields), but it is likely the case that this marginal benefit will decrease as more pesticide is applied due to the *Law of Diminishing Marginal Return*, (see section 2.3.3 for more information on this concept). Decreasing marginal yields from additional pesticide applications or higher rates means that a farmer is marginally earning less revenue with each additional unit of pesticide applied, assuming crop prices are constant. This change is similar to marginal revenue but is referred to as *marginal revenue product* MRP or the marginal change in total revenue from a one-unit change in pesticide use (i.e. $MRP = \frac{\triangle TR}{\triangle X}$). Assume the cost of a unit of pesticide is $\$W$. Then the marginal cost of a unit of pesticide, known as the *marginal factor cost* MFC is $\$W$ (*i*.e. $MFC = \frac{\triangle TC}{\triangle X} = \$W$).

She goes on to discuss that the concepts in the prior paragraph can now be used to help determine the marginal benefit, or what we will call the *marginal net private benefit* ($MNPB$) to the farmer growing the peanut crop. The marginal net private benefit or

$MNPB$ is in essence the marginal profit from using an additional unit of pesticides or $MNPB = MRP - MFC$ [19]. Given that MRP is likely decreasing as more pesticide is applied and MFC is constant (e.g. $\$W$), then $MNPB$ will be decreasing, as well. The $MNPB$ Curve is illustrated in Figure 1. As crop output increases with additional pesticide use, $MNPB$ decreases. So due to the Law of Diminishing Marginal Returns, $MNPB$ will be decreasing for the farmer with additional application of pesticides due to less yield from each additional unit of pesticide being applied.

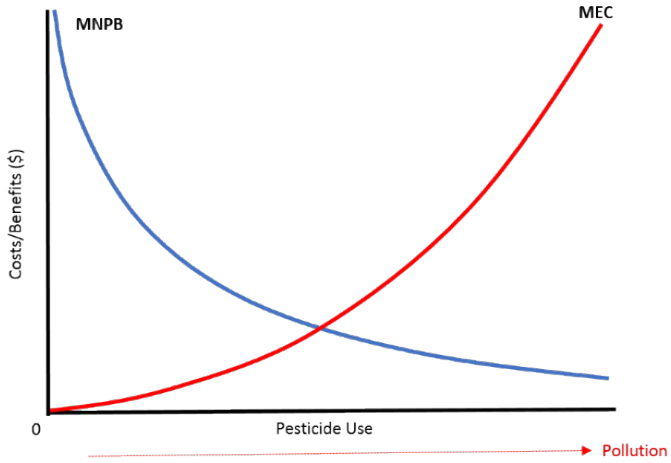


Figure 1: Marginal Net Private Benefit (MNPB) and Marginal External Cost (MEC) Curves for the Farmer Pesticide Problem.

It is important to note that $MNPB$ does not take into account any costs to society or third parties. These costs, known as negative externalities, are characterized in this example by health impacts and loss of recreation felt along the river downstream. In addition, it is emphasized that there is no direct economic incentive in the market for the farmer to adjust their behavior.

The other curve in Figure 1 is the Marginal External Cost (MEC) curve [19]. As crop output increases, driven by the increasing use of pesticides by the farmer (holding all else constant), the amount of pesticide leaching or running off the field increases. This type of leaching or run-off that impacts the river and the small town downstream is known as *non-point source pollution*, as it is usually difficult for environmental safety officials to pinpoint the exact source of the pollution (e.g. the starting point). Thus, as shown in Figure 1, as pesticide use increases, so does the nonpoint source pollution (designated by the red arrow below the X-axis). The increased pollution in the water leads to water quality problems for residents using the water for drinking water and watering livestock, as well as the lost recreational use of the small river due to potential health hazards. These problems can be assigned a monetary cost, which could be equal to actual health costs; the cost of buying bottled water or filters; the cost of lost recreational income from use of the river; etc. We refer to the costs as *external costs*. These external costs increase with the level of pollution. Each additional unit of pesticide use increases the external cost to society, which we refer to as the *marginal external cost*, represented by the MEC curve in Figure 1 [19].

The economist points out that the environment can deal with some level of pollution or waste through natural processes. Thus, it may not be economically optimal to prevent all pollution or eliminate all waste from production processes. So at what point, from an economic point of view, is the *optimal level of pollution*? This point occurs where $MNPB = MEC$, that is where the marginal net private benefit is equal to the marginal external cost. This occurs where an additional unit of pesticide results in an increase in marginal net private benefit to the farmer equal to the marginal external cost to society (or the citizens of the small town). In this sense, it may be *socially optimal* to make sure that the gains from private production are not at the expense or greater than the costs to society. This occurs where $MNPB = MEC$. Thus, the optimal level of pollution here may be economically and socially optimal, maximizing the net welfare of society (or all residents of the local community). It should be noted, that there are other

ways and criteria used to assess the impacts on society and its welfare, as well.

Question #26

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The condition that $MNPB = MEC$ is an equilibrium condition. That is, from an economic point of view there is not an incentive for society to move away from this point. To see this, consider the following questions that explore what would likely happen if $MNPB$ was not equal to MEC.

Question #27

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Question #28

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Many conservation programs exist at the local, state, and federal governmental level. For example, the USDA Natural Resource Conservation Service (USDA- NRCS) administers the Environmental Quality Incentives Program (EQIP) to incentivize farmers to adopt and add conservation practices on their farms to improve soil health, reduce soil erosion, improve water quality, sequester carbon, etc. USDA-NRCS incentivizes farmers by offering monetary incentives to adopt conservation practices in their farming operations. (For more information on this program see: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.) One practice that can help to reduce run-off from fields that may result in pesticides getting into water bodies, such as a river, is vegetative or field buffers. USDA-NRCS refers to these as conservation buffers, which they define as: “small areas or strips of land in permanent vegetation, designed to intercept pollutants and manage other environmental concerns” [20].

Consider the situation where the small town decides to incentivize the peanut farmer to install conservation buffers along their fields adjacent to the river and the farmer agrees to do this. Assume there is no net change to $MNPB$ for the farmer (assuming the cost-share covers the cost of installation). For the small town, for each unit of pesticide applied to the fields adjacent to the river, less pollution now runs-off into the river. This results in lower marginal external costs. Thus, the adoption of conservation practices can help to potentially increase the net benefit of private production to society by potentially reducing external costs to

society overall.

Question #29

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Question #30

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4.3 Partial Budgeting and Conservation Adoption

Partial budgeting provides a very organized and formal way of conducting marginal analysis of decisions using monetary values. To illustrate the use of this technique, let's consider a farming example that is adapted from Bergtold et al. [12]. Farmer Jane farms 600 acres of cotton conventionally in Southeast Kansas. A long-term goal is to move to a conservation tillage system (utilizing no-tillage equipment and management). No-tillage is defined as a crop production system in which seeds are planted into soil that has not been tilled. No-tillage practices are also known as no-till, zero tillage, and direct seeding. No-tillage systems may require equipment modifications and weeds are controlled using herbicides rather than cultivation [21].



No-Till [2]

To assess the transition from a conventional to a no-tillage system, Jane looks for data online and finds studies providing cotton yield differences between conventional and no-tillage production. Jane determines that transitioning to no-tillage from conventional tillage will result in a 60-pound-per-acre increase in cotton yield. After talking with her local farm dealer, she is also able to purchase a slightly used no-till planter costing $15,000. The useful life of the planter is expected to be seven years with

a $1,000 salvage value. Jane can take out a loan to purchase the planter with an annual interest rate of 5 percent. Additionally, Jane can determine that repair and insurance rates should be 2 and 2.5 percent, respectively, of the net value of the used planter, $14,000; (the net value is the actual cost minus salvage value). Below is a partial budget chart outlining the partial budgeting analysis for this case study. The cost of the new planter is expected to be $5.63 per acre, which is equal to the interest cost of $1.25 per acre ($\frac{\$15,000 \times 0.05}{600}$), plus repair costs of $0.47 per acre ($\frac{\$14,000 \times .02}{600}$), plus insurance costs of $0.58 per acre ($\frac{\$14,000 \times 0.025}{600}$), as well as depreciation costs of $3.33 per acre ($\frac{\$15,000 - \$1000}{7 \times 600}$).

Assume that the price of cotton lint (which is the yield from cotton that is sold) is $0.85 per pound.

Question #31

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Converting to no-tillage can help farmers reduce costs by reducing the number of passes made across the field for tillage operations no longer performed (like disking, harrowing, cultivation, plowing, etc.). Let's assume, that Jane can eliminate two tillage passes (a disking and deep tillage operation) each year on her 600 acres of cotton. The production cost savings is estimated to be $20 per acre. Given that Jane is in southeast Kansas, she wants to further protect and enhance the productivity of the soil in her new no-tillage crop production system, so Jane decides to plant a cover crop at a cost of $25 per acre. Cover crops are crops planted between regular cash crops in rotation to provide mulch to cover the soil, enhance soil fertility, and help suppress weeds. The cover crop is not expected to change cotton yield but will help maintain soil fertility and reduce soil erosion.

Given that cultivation will no longer be used to control weeds in the field, the no-tillage system will require the use of herbicides with additional passes for herbicide applications during the growing season. The expected cost of the additional herbicide applications is $18 per acre, which includes cover crop termination in the spring and weed control during the summer months.

The partial budgeting table below is partially filled out. The questions will guide you through the analysis and filling out of this Table. It could be useful to print out the Table (copy and paste to a word processor) and use it to guide you through the questions.

PARTIAL BUDGET	
Decision being considered: Transitions from a conservation tillage cotton production system to no-tillage cotton production system with a cover crop.	
Additional (Marginal) Costs: (*Step 4*) **$/acre** No-Till Planter Cost (per year per acre) Cover Crop Cost per acre. Herbicide Application Cost per acre. Lost (Marginal) Revenue: (*Step 5*) **$/acre**	Additional (Marginal) Revenue: (*Step 2*) **$/acre** Increase in cotton yield per acre. Lower (Marginal) Costs/Cost-Savings: (*Step 3*) **$/acre** Reductions in tillage passes.
(A) Total additional costs and lost revenue: $_____	**(B) Total additional revenue and lower cost/cost-savings:** $_____
Net Marginal Change in Profit (B minus A) $_____	

Querstion #32

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Question #33

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Question #37

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5.0 Concluding Remarks

In this chapter, we introduced you to the marginal concepts that are central to an economic way of thinking, including marginal benefit, marginal revenue, marginal cost, and marginal profit, among others. These concepts are used in conducting marginal analysis, which can be done using different methods. Two presented here are the use of optimization rules, such as a firm maximizing profit for the production of a single good up to the point where $MR = MC$ and MC cuts MR from below. Another important and useful tool presented was partial budgeting, which is a tool used by many firms and producers today. Finally, you were presented with some case studies to expand on these topics and present how they can be used in analyzing decisions.

Question #38

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6.0 References

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[4] Wikipedia. "ðð". Available online at: https://en.Wikipedia.org/wiki/%E2%88%82.

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[10] Image courtesy of Keith Wellner (USDA, Agricultural Research Service) via Free Stock Photos, under license CC0 1.0 Universal.

[11] Kay, R.D., W.M. Edwards and P.A. Duffy. 2004. *Farm Management*. 5thed. New York: McGraw Hill.

[12] Bergtold, J.S., A. Smith, M. Lamb and L. Duzy. 2019. “Conservation Economics: Budgeting, Cover Crops and Government Programs.” In: *Conservation Tillage Systems: Production, Profitability and Stewardship*. J. Bergtold and M. Sailus (eds.). USDA-SARE. 2020.

[13] Image courtesy of Lynn Betts and the USDA, Natural Resource Conservation Service via Wikimedia Commons, within the Public Domain.

[14] Debertin, D.L. 1986. *Agricultural Production Economics,* 2nd ed. Upper Saddle River, NJ: Pearson Education.

[15] Barkley, A. and P.W. Barkley. (2016). *Principles of Agricultural Economics*. 2nded. New York, NY: Routledge.

[16] Video courtesy of Darin Bell via Youtube, under license CC BY 3.0 Attribution Unported.

[17] Kvien, C.K., A.K. Culbreath, J.W. Wilcut, S.L. Brown and D.K. Bell. (1993). Peanut production in systems restricting use of pesticides based on carcinogenicity and leachability. *Peanut Science*20: 118 – 124.

[18] Roberson, P. (2009). High-yield, high-quality peanuts. *Delta Farm Press*. Online. Available at: https://www.farmprogress.com/peanuts/high-yield-high-quality-peanuts. (Accessed 03/29/2019).

[19] Pearce, D.W. and R.K. Turner. (1990). *Economics of Natural Resources and the Environment*. Baltimore, MD: The Johns Hopkins University Press.

[20] Natural Resource Conservation Service, USDA. Buffer strips: common sense conservation. Online. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/features/?cid=nrcs143_023568. Last Accessed: April 5, 2019.

[21] Derpsh, R. “What is No-Till Farming?” NO-Tillage, Sustainable Agriculture in the New Millennium. Available at: http://www.rolf-derpsch.com/en/no-till/what-is-no-till-farming/. Accessed: March 22, 2019.

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13.3: Elasticity

Agricultural Economics: Elasticity



Food Market [1]

1.0 Introduction

Perhaps one of the most useful concepts in economics is the notion of elasticity. Taken from engineering, economists adopted this term into their toolset to be able to provide an intuitive mechanism for examining the marginal changes in economic processes, such as changes in the prices of goods on the quantity demanded (consumed) or supplied (produced) of that good. Elasticity can help us answer questions like (i) how much should a firm produce?; (ii) how will a change in demand impact a firm's sales?; (iii) how much can a firm charge for a product given a competitor's position in the market?; and (iv) should the government tax a particular good to raise more revenue for public programs? All of these decisions revolve around a marginal change in one variable in response to a marginal change in another variable. A *marginal change* is defined as the addition of one or more units of a given economic variable (e.g. goods produced) to the current level of that economic variable We call this relative or marginal response an **elasticity**.

This chapter will introduce you to the concepts of elasticity, present different forms of elasticities found in economics, and take you through a set of detailed case studies about how elasticity can be calculated, interpreted, and used. The case studies will show you how elasticity is one of the most important concepts in economics.

1.1 Learning Objectives

By the end of this chapter, you should be able to:

(1) *Define the concept of an elasticity*;

(2) *Calculate and interpret different types of elasticities, including own price elasticities, price elasticities, and income elasticities;* and

(3) *Be able to use the concept of elasticity in different economic problem situations.*

A few case studies are provided that help illustrate the calculation and usefulness of elasticities. These case studies will help

you to examine elasticities in different decision-making contexts and include questions to help you review and go through these examples on your own. In addition, the case studies will present you with some additional concepts related to elasticities and extend how they are useful in different economic situations and decision-making.

2.0 What is Elasticity?

The concept of elasticity originally arose in the fields of engineering and physics. Elasticity refers to the capability of a body that has been strained to recover its size and shape after deformation. Another perspective is how easily an object can be stretched [2]. It is this latter definition that gives rise to the notion of elasticity in economics. From an economic perspective, it is how much an economic variable can be "stretched" or how responsive that variable is to a given change in another economic variable.

By definition, **elasticity** is the *responsiveness of one economic variable to a marginal change in another related economic variable*. Mathematically, elasticity can be defined as the *percentage change in one variable in response to the percentage change in another variable*. When used as a single term, elasticity usually refers to "own-price elasticity", which is a measure of the percentage change in the quantity demanded or supplied of a good in response to a percentage change in the "*own*" price of that same good. By "own" price, we mean the price of the good or service we are examining. The ability of an elasticity to capture this responsiveness or marginal change in economics makes the concept of elasticity especially important in conducting *marginal analysis*, one of the main tools used in economics. For example, elasticity is very useful in measuring the responsiveness of consumers' demand to different output prices, income, and other economic variables, which can help provide a basis for firms or businesses to make more profitable production and marketing decisions. These decisions include how much to spend on advertising, offering discounts, increasing/decreasing production, which markets to sell in, and many more [3,4].

Elasticity can be represented mathematically. It is the mathematical formula and calculation that illustrates the usefulness of this concept in economics.

To begin, elasticity is the relationship between two economic variables. Let Y represent the economic variable of interest, say the quantity demanded of a good. We are interested in how responsive Y is to a change in another related economic variable X, say the price of that same good. To be able to calculate an elasticity using data, we need, at a minimum, two points of data. Let these two points be (Y_1, X_1) and (Y_2, X_2). We are interested in the marginal change ($\triangle$) in each variable. That is:

Marginal Change in Y: $\triangle Y = Y_2 - Y_1$; and

Marginal Change in X: $\triangle X = X_2 - X_1$

We want to make the changes *unitless*. That is, to compare the marginal change in one variable to a marginal change in another variable in more general terms, we can use the percentage changes of each variable. As the two variables are measured in percentage changes, the units cancel out [3]. In addition, using percentage changes helps to avoid problems of scale or differences in the units of the variables being examined. To do this, we convert the above marginal changes into percentage changes (%$\triangle$) by:

Percentage change in Y: $\% \triangle Y = \frac{\triangle Y}{Y_1}$

Percentage change in X: $\% \triangle X = \frac{\triangle X}{X_1}$

We can put these together to calculate an elasticity. Using the two variables defined here, the elasticity is the percentage change in Y given a percentage change in X. The elasticity (E) can be calculated as:

$$E = \frac{\% \triangle Y}{\% \triangle X} = \frac{\triangle Y}{Y_1} \times \frac{X_1}{\triangle X} = \frac{\triangle Y}{\triangle X} \times \frac{X_1}{Y_1} \tag{13.3.1}$$

The formula given by equation (1) is known as a *point elasticity*, as it is calculated relative to the point (Y_1, X_1). It should be noted here that the point (Y_2, X_2) could have been used instead.

We will show another related formula known as the *arc elasticity* in section 2.1.1, as it provides a more accurate estimate of the marginal changes being captured by the elasticity in some cases.

The elasticity formula is a general formula, which can be used to look at the responsiveness of a large number of economic variables to marginal changes in other economic variables. Substituting different economic variables into equation (1) gives rise to a multitude of different elasticity measures, as will be seen in this and the next section.

The *interpretation* follows from this mathematical formula. The formula in equation (1) tells us by how much Y will change as a percentage, given a 1% change in X. Consider the case where Y is the quantity supplied of shoes, and X is the price of shoes, then E here represents the own price elasticity of supply for shoes (to be discussed in more detail later). If say $E = 1.5$, then a 1% increase in the price of shoes (X), will increase the quantity supplied of shoes (Y) by 1.5 %. Now consider the following question.

Question #1

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In general, elasticities are classified into three separate categories based on the responsiveness of the economic variable of interest Y to a change in another economic variable \(X\. The three categories, which are based on the absolute value of the elasticity, are:

1. Elastic: $\mid E \mid > 1.0$

2. Unitary Elastic: $\mid E \mid = 1.0$

3. Inelastic: $\mid E \mid < 1.0$

Question #2

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We now turn to looking at different types of elasticities commonly used in economics, how to compute them, and how to interpret them. The following video provides a review of this material and focuses on the own price elasticity of demand, which you will encounter in the next section.

YouTube Video

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Question #3

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2.1 Types of elasticities

As mentioned earlier, numerous types of elasticities are useful in economics. We want to examine a number of these in this section. All of these elasticities are calculated using the same formula, the only difference being the economic variables involved. For now, we will focus on 3 fundamental elasticities: own price elasticity of demand and supply, cross price elasticities, and income elasticities.

2.1.1 Arc vs. Point Elasticities

We presented equation (1) initially as the formula for calculating elasticity. While point elasticity can be useful, this measure is highly dependent on the point being chosen and does not take into consideration the information from other points (or data) used to calculate the elasticity.

An alternative formula advocated in economics is the *midpoint arc elasticity formula* or, more commonly known, the ***arc elasticity formula***. This measure uses the average of the points in the formula, rather than one point, as in the point elasticity formula. That is, an arc elasticity is calculated using the following formula:

$$E = \frac{\triangle Y}{\triangle X} \times \frac{\overline{X}}{\overline{Y}} \tag{13.3.2}$$

(2)

where $\overline{Y} = \frac{Y_1+Y_2}{2}$ and $\overline{X} = \frac{X_1+X_2}{2}$. That is, instead of using the point (Y_1, X_1), we use the averages of the two points, $(\overline{Y}, \overline{X})$, to calculate the elasticity.

The use of the arc elasticity formula was advocated by R.G. D. Allen, especially for the case when using elasticities to look at comparative statics for market demand and supply. The arc elasticity has the following useful properties: (1) it is symmetric with respect to the two economic variables being examined, (2) it is not dependent on units of measure, and (3) it is equal to one for the own price elasticity of demand and supply if total revenues or expenditures (price times quantity) at the two points being examined are equal. [6].

2.1.2 Own Price Elasticity

The own-price elasticity (more often referred to as just "elasticity") measures the change in quantity (Q) demanded or supplied as a result of a change in the price (P) of the good. The own price elasticity can be represented as a mathematical function, based on equation (2), as:

$$E = \frac{\% \triangle Q}{\% \triangle P} = \frac{\triangle Q}{\triangle P} \times \frac{\overline{P}}{\overline{Q}} \tag{13.3.3}$$

More specifically, there are two own price elasticities of interest. These are:

Own price elasticity of demand: This elasticity is represented by the Greek letter η and it measures the responsiveness of consumers' consumption or quantity demanded of a good or service to a change in the market (or own) price of that good or service. These elasticities are usually negative, following the Law of Demand. The own price elasticity of demand (η) is calculated as:

$$\eta = \frac{\% \triangle Q^D}{\% \triangle P} = \frac{\triangle Q^D}{\triangle P} \times \frac{\overline{P}}{\overline{Q^D}} \tag{13.3.4}$$

(3)

where Q^D is the quantity demanded of the good or service being examined.

Own Price elasticity of supply: This elasticity is represented by the Greek letter ϵ and it measures the responsiveness of a firm's production or quantity supplied of a good or service to a change in the market price of the good or service being produced. These elasticities are usually positive, following the Law of Supply. The own price elasticity of supply (ϵ) is calculated as:

$$\epsilon = \frac{\% \triangle Q^S}{\% \triangle P} = \frac{\triangle Q^S}{\triangle P} \times \frac{\overline{P}}{\overline{Q^S}} \tag{13.3.5}$$

(4)

where Q^S is the quantity supplied of the good or service being examined.

Own price elasticities are classified into three separate categories, as seen earlier, based on the responsiveness of the quantity demanded or supplied to a change in the market price of the good or service being examined. The three categories are:

1. Price Elastic: $\mid \eta \mid > 1.0$ or $\epsilon > 1.0$

2. Unitary Elastic: $\mid \eta \mid = 1.0$ or $\epsilon = 1.0$

3. Inelastic: $\mid \eta \mid < 1.0$ or $\epsilon < 1.0$

From a demand perspective, goods that are price elastic have changes in quantity demanded that are greater than 1% when the (own) price changes by 1%. These goods may have many substitutes in consumption, and as price increases, consumers will substitute these goods for cheaper goods. Goods that are price inelastic have changes in quantity demanded that are less than 1% when price changes by 1%. As such, these goods tend to have fewer substitutes and include products like food staples, cigarettes, and alcohol. The use of substitutes/complements in consumption/production will be more closely examined using cross price elasticities.

Based on this information, consider the following question to test your understanding.

Question #4

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Now let's look at how to calculate and interpret own price elasticities of demand and supply by examining the market for bananas.



Bananas at Market [12]

For this example, assume the demand schedule for bananas for a small group of people is given in the table below.

Banana demand schedule

Price of Bananas (P)	Quantity Demanded of Bananas (Q)
$1	8
$2	6
$3	4
$4	2

Along a linear demand curve, the own price elasticity of demand will change as you move down the curve (as the price decreases). Let's consider what the own price elasticity of demand will be going from $1 to $2 (a price increase). To calculate the elasticity, we will use the arc elasticity formula given by equation (3).

For this calculation, we are given the following two points, (P_1, Q_1^D) = $(1, 8)$ and (P_2, Q_2^D) = $(2, 6)$, from the demand schedule. To calculate the arc elasticity, we first need to find the change in the market price and quantity demanded. These are given by:

$$\triangle Q^D = 6 - 8 = -2 \text{ and } \backslash(\triangle P = 2\text{-}1=1\backslash).$$

Second, we will need the average quantity demanded and price, which are given by:

$$\overline{Q^D} = \frac{6+8}{2} = 7 \text{ and } \overline{P} = \frac{2+1}{2} = 1.5$$

Plugging these values into the formula for the own price elasticity for demand given above gives:

$$\eta = \frac{\triangle Q^D}{\triangle P} \times \frac{\overline{P}}{\overline{Q^D}} = \frac{-2}{1} \times \frac{1.5}{7} = \frac{-3}{7} = -0.4 \tag{13.3.6}$$

rounded to the first decimal place. The value of the elasticity is negative due to the Law of Demand and it indicates that demand for bananas is price inelastic between $1 and $2.

How do we interpret this elasticity? The calculated own price elasticity of demand for bananas tells us that for every 1% increase in the price of bananas (P), consumers in the small group will decrease their consumption or quantity demanded (Q^D) by 0.4%, and vice versa. Now let's consider what would happen if the price of bananas increased by 5% when the current price is between $1 and $2. Remember that for each 1% increase in price, the quantity demanded of bananas decreases by 0.4 %. If the price increases by 5%, then the quantity demanded will decrease by 5 x 0.4% = 2%.

Now let's have you calculate and interpret the own-price elasticity of demand using the above example.

First, let's calculate the elasticity of demand for bananas between $2 and $3

Question #5

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Question #6

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n your own, you can now calculate the average quantity and average price that will be needed to calculate the arc elasticity of emand for bananas between $2 and $3 using equation (3). Once you have these values answer the next question.

Question #7

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Now try the calculation fully on your own and interpret some of the results obtained.

Question #8

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For the next two questions, refer back to your answer to Question #7.

Question #9

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Question #10

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Calculating and interpreting the own price elasticity of supply will follow the same procedures as in the above example and text.

2.1.3 Income Elasticity of Demand

We now begin to look at factors that impact demand (and supply) other than the own price. Remember these are referred to as determinants of demand (and supply). The following video provides a review of the income elasticity of demand. Watching this will help understand how elasticity can be used to look at the impact of changes in determinants of demand on the demand for a good or service.

YouTube Video

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Income Elasticity of Demand [8]

As a review for the coming discussion, answer the following question:

Question #11

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We focus on income as a determinant of demand in this subsection to introduce the income elasticity of demand or income elasticity for short. This elasticity measures the percentage change in quantity demanded in response to a percentage change in consumers' income. We will designate the income elasticity of demand as E^I. Income elasticity can be calculated using the following mathematical formula:

$$E^I = \frac{\% \triangle Q^D}{\% \triangle I} = \frac{\triangle Q^D}{\triangle I} \times \frac{\overline{I}}{\overline{Q^D}} \tag{13.3.7}$$

(5)

where I is income, $\triangle I = I_2 - I_1$, $\overline{I} = \frac{I_1+I_2}{2}$ and $\overline{Q^D} = \frac{Q_1^D+Q_2^D}{2}$. The formula is calculated using two points (I_1, Q_1^D) and (I_2, Q_2^D).

Four different types of goods are relatively important concerning income elasticity of demand: normal, necessity, luxury, and inferior goods. The definition and presentation of these types of goods should be reviewed. The income elasticity can indicate the type of good being examined as follows:

· Normal Goods: $E^I > 0$

o Necessity Goods: \(0

o Luxury Goods: $E^I > 1$

· Inferior Goods: $E^I < 0$

Normal goods are those goods with a positive income elasticity. That is, an increase in income will increase the consumption of a normal good. Normal goods can be broken down into two sub-categories: necessity and luxury goods.

Necessity goods are goods considered to have a positive income elasticity but are less than one in value. A 1% increase in income results in a less than 1% increase in the consumption of the good. Examples of necessity goods may include rice, beans, and corn.

Luxury goods are goods that consumers consume more of as income increases at an increasing rate. That is a one percent increase in income results in a larger than one percent increase in consumption of the good. Examples of luxury goods for consumers could include yachts, expensive wines, art, and jewelry.

Inferior goods are goods with a negative income elasticity. That is, an increase in income will result in a decrease in consumption of an inferior good. Possible inferior goods for consumers include public transportation, generic foods, and off-brand electronics.

Let's now consider an example of how to calculate and interpret income elasticity. Consider a farmer whose farm income increases from $75,000 to $90,000 per year. Earning $75,000 a year, the farmer would go and play 10 rounds of golf. Earning $90,000 a year, the farmer would now go and play 15 rounds of golf.

What is the income elasticity of demand for golf for the farmer between these two levels of income? To answer this question, we will use equation (5). Our two data points are $(I_1, Q_1^D) = (75,000, 10)$ and $(I_2, Q_2^D) = (90,000, 15)$. Using these two points we can compute:

$$\triangle I = 90,000 - 75,000 = 15,000$$

$$\triangle Q^D = 15–10 = 5$$

$$\overline{I} = \frac{75{,}000+90{,}000}{2} = 82,500 \text{ and}$$

$$\overline{Q^D} = \frac{15+10}{2} = 12.5$$

Plugging all of this into equation (5) gives:

$$E^I = \frac{\triangle Q^D}{\triangle I} \times \frac{\overline{I}}{\overline{Q^D}} \times \frac{5}{15,000} \times \frac{82,500}{12.5} = 2.2 \tag{13.3.8}$$

The income elasticity calculated tells us that a one percent increase in income for the farmer increases their playing or consumption of golf by 2.2 percent. This makes golf a luxury good for the farmer.

Now consider what happens when the farmer's income decreases from $75,000 to $50,000. In this case, the farmer will reduce their playing of golf from 10 games to 7 games. Use this information to answer the following questions.

Question #12

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Question #13

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Income elasticities are important to consider because as income grows for consumers in the economy, the demand for goods and services will grow, as well. For elastic goods, as income increases, consumption of these goods will increase at an increasing rate. For inelastic goods, as income increases, consumption of these goods will increase at a decreasing rate. This type of information can be useful for firms planning marketing and production decisions, as well as governments looking to plan fiscal policy. For example, if a government wants to determine recession-proof goods or consumer staple stocks that will be produced in enough quantities for consumers in times of economic hardships, the government may want to look for highly income inelastic goods [14].

2.1.4 Cross Price Elasticity

Another important elasticity that captures the effects of changes in determinants of supply and demand is cross price elasticity. Cross price elasticity measures the quantity change of one good in response to a change in the price of another good. For example, butter and margarine, which are not produced together, impact the price and quantity demanded/ supplied by one another inversely. That is, they are substitutes. This relationship can be captured by the cross price elasticity. What we will find is that the cross price elasticity can be applied to both demand and supply.

Cross price elasticity of demand: This measure captures the responsiveness of consumers' consumption (quantity demanded) of a good or service in response to a change in the price of a related good or service. As with other elasticities, this can be captured using percentage changes. The cross price elasticity of demand here is represented by the symbol σ_X^D. The formula for the cross price elasticity of demand for a good concerning the price of good X is given by the following function:

$$= \sigma_X^D = \frac{\% \triangle Q^D}{\% \triangle P_X} = \frac{\triangle Q^D}{\triangle P_X} \times \frac{\overline{P_X}}{\overline{Q^D}} \tag{13.3.9}$$

(5)

where P_X is the price of the related good $\overline{P}_X = \frac{P_{X,1}=P_{X,2}}{2}$.

Cross price elasticity of supply: This measure captures the responsiveness of firms' production (quantity supplied) of a good or service in response to a change in the price of a related good or service. As with other elasticities, this can be captured using percentage changes. The cross price elasticity of supply here is represented by the symbol σ_X^S. The formula for the cross price elasticity of supply for a good concerning the price of good X is given by the following function:

$$= \sigma_X^S = \frac{\% \triangle Q^S}{\% \triangle P_X} = \frac{\triangle Q^S}{\triangle P_X} \times \frac{\overline{P_X}}{\overline{Q^S}} \tag{13.3.10}$$

where P_X is the price of the related good $\overline{P}_X = \frac{P_{X,1}=P_{X,2}}{2}$

Depending if one is looking at demand or supply, the cross price elasticities can be categorized into two different categories: substitutes or compliments, based on their sign, as follows:

(i) Substitutes:

· Substitutes in Consumption: $\sigma_X^D > 0$

· Substitutes in Production: $\sigma_X^S < 0$

(ii) Complements:

· Complements in Consumption: $\sigma_X^D < 0$

· Complements in Production: $\sigma_X^S > 0$

Recall, that substitutes are goods that are produced or consumed as an alternative to the original good.

Substitutes in consumption are goods that impact the price and quantity demanded of one another in the same direction. That is, as the price of a substitute good increases, the consumption of the good being examined increases, and vice versa. An example of substitutes in consumption are tortilla chips and potato chips. A consumer will tend to buy more of the cheaper product to minimize their expenses on food.

Substitutes in production are goods that impact the price and quantity supplied of one another inversely. That is, as the price of a substitute in production increases, the production of the good being examined decreases, and vice versa. An increase in the price of the substitute will increase revenue from that good for the producer. Assuming costs are unchanged, it is now more profitable for the producer to produce more of the substitute good, as they now earn more revenue relative to the other good. For example, farmers must usually decide how many different crops to plant each year to maximize their profit. These crops, e.g. corn, sorghum, soybean, wheat, and cotton are often substitutes in production.

Complements in consumption are goods that impact the price of a related good and quantity demanded of the good of interest inversely. That is, as the price of a complement in consumption increases, the consumption of the good of interest decreases, and vice versa. An example of goods that are complements in consumption include cake and frosting. As the price of cake increases, you will likely purchase less frosting, given you consume less cake.

Complements in production are goods that are produced together. Therefore, if the price of a complement in production increases, the production of the good of interest will increase, and vice versa. For example, peanut oil and peanut meal must be produced together, as peanut meal is a byproduct from the production of peanut oil. In fact, peanut meal has its own market and can be used for a number of different uses, including as a feed source for livestock. This makes peanut oil and peanut meal complements in production.

Let's examine the use of cross price elasticity by looking at the production of ethanol and a byproduct of the production process,

distiller's dried grains (DDGs). DDGs are a good source of protein for livestock feed rations.

Question #14

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Ethanol Plant [10]

Assume that 5 billion gallons of ethanol are produced and the price of DDGs is $90 per dry ton. A change occurs in the market over time increasing the production of ethanol to 6 billion gallons and the price of DDGs changes to $100 per ton. Use this information and the above material on cross price elasticities to answer the following questions [11].

Question #15

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Question #16

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2.2 Important Aspects of Elasticity

Much of the importance, calculation, and interpretation of different types of elasticities was discussed in the prior subsections of this section of the chapter. In this short subsection, we want to highlight briefly two points to keep in mind about elasticities.

(1) While several different elasticities were presented above, there are many more used in the field of economics. As stated earlier the relationship of many economic variables can be summarized using an elasticity. That is, elasticities can be used in general to compare many different relationships between two economic variables. It is a widely applicable and used concept in the field of economics and other related disciplines. You will encounter some additional elasticity measures in the case studies below.

(2) Elasticities provide a generalizable and intuitive way to not only capture the sign (e.g. positive or negative) of the relationship between two economic variables, but elasticities provide a measure that captures the magnitude of this relationship (i.e. if it is elastic or inelastic). These properties allow the use of elasticities to do "back of the envelope" types of calculations for a quick assessment of changes in the market or of policy changes that are accessible and understandable by more lay groups (who may not fully understand economics). These quick assessments though should be placed in context, as the use of an elasticity usually assumes that all other variables are held constant. That is, when using elasticities we are implicitly invoking the notorious *ceteris paribus* clause often encountered in economic analysis.

The remainder of the chapter provides some in-depth case studies to provide you with more practice in using, calculating, and interpreting different elasticity measures.

3.0 Case Studies

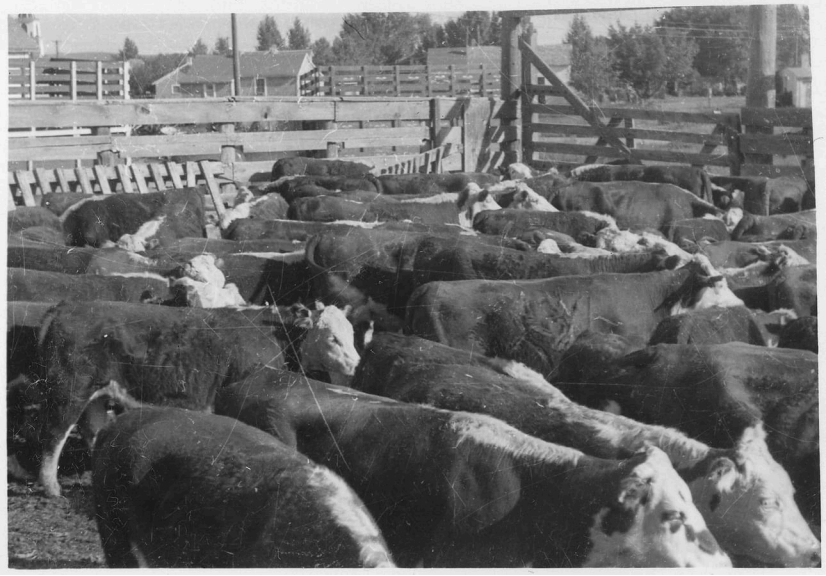
In this section of the chapter, we examine three in-depth case studies on beef demand, parking demand on campus, and agricultural land use.

3.1 Beef Demand and Cattle Producer Competitiveness

The own price elasticity of demand may be one of the most useful elasticity measures in economics. It is a crucial and highly important measure for agribusiness to take account of and try to determine. Knowing or having an accurate prediction of the own price elasticity of demand can help a firm figure out how much product to produce; the effect of sales, discounts, or other promotions on their product; allow them to be more competitive in the market; determine the impact of government taxing policies; among other benefits [3,4]. The purpose of this case study is to examine the impact of knowing the own price elasticity of demand for beef on agribusiness firm decision-making.

Consider the following:

From the late 1940's to the late 1960's, leaders of the cattle industry urged producers to be conservative about their cattle herd sizes to improve cattlemans' market positions. At the same time, recommendations from academic livestock and range researchers focused on improving range management practices as a means of increasing range carrying capacity and in turn beef output. The motivation for this research was in part due to the rising demand for beef during the period following World War 2. Cattle producers were being pushed by industry leaders to decrease their output to increase the price received per pound (lb.) of beef, while simultaneously range researchers were looking to increase beef production, provided that beef prices would not decrease significantly as the quantity of beef increased [12]



Cattle Yard Circa 1950s [13]

From a beef producer's standpoint, the own price elasticity of demand is arguably a very important economic measure to estimate and understand. Unfortunately, it can also be one of the hardest measures to accurately determine. Many researchers and agribusinesses use historical data from the past to figure out or estimate the own price elasticity of demand for beef in the market. A cattle producer will be interested in deciding the best course of action for the future, but this decision can be enhanced by knowing the own price elasticity of demand in the market and past market trends. The table below provides historical data for the beef market, including the beginning period beef price, ending period beef price, the beginning quantity of beef consumed in the market for a period, the ending quantity of beef consumed in the market for a period, the average price over the period, and the average quantity of beef consumed over the period [12].

All the quantities in the table are in lbs per capita.

Prices of beef

	Beginning Price	End Price	Beginning Quantity	Ending Quantity	Average Price	Average Quantity
1947-1951	$42.42	$56.30	69.6	56.1	$47.59	63.22
1952-1956	$53.21	$37.89	62.2	85.4	$42.08	77.46

Type caption for table (optional)

We are interested in estimating the own price elasticity of demand for beef and determining how changes in the price of beef will impact the beef market and producers' decisions. The following questions ask you to use the arc elasticity formula given by equation (3) to answer the following questions. For these calculations use the average price and quantity provided in the above

table instead of calculating $\overline{P}$ and $\overline{Q^D}$.

Question #17

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Question #18

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The own price elasticity of demand for beef is concerned with how the quantity demanded of beef changes as a percentage, because of a one percent change in price. Producers may likely be interested in the inverse relationship, as well. Given that price and quantity in the market are simultaneously determined, producers may want to know the effect a one percent change in the quantity demanded has on the price of beef.

Inversely related to the own price elasticity of demand, *price flexibility* shows the percentage change in price as a result of a one percent change in quantity demanded (or consumed). Price flexibility has the inverse interpretation of price elasticity. Each can be used separately to derive the percentage change in price or the percentage change in quantity demanded of a good. We introduce price flexibility as an alternative elasticity measure that may also be useful for market analysis. Price flexibility is denoted here by the symbol λ and is mathematically represented as:

$$\lambda = \frac{\% \triangle P}{\% \triangle Q^D} = \frac{1}{\eta} \tag{13.3.11}$$

where η is the own price elasticity of demand. Thus, if you know the own price elasticity of demand, you can easily calculate the price flexibility and vice versa.

For example, assume the price elasticity of demand (η) for a good is -0.90. The elasticity can be interpreted as follows: a 1% increase in the price of the good would decrease the quantity demanded by 0.90%. The price flexibility for the good can then be calculated as ($\frac{1}{\eta}$) or $\frac{1}{-0.90} = -1.12$. The price flexibility can be interpreted as a 1% increase in the quantity demanded of the good will decrease the price of the good by 1.12%. Just as the own price elasticity of demand is negative, so will the corresponding price flexibility.

Question #19

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Consider a 5% increase in total beef consumption following 1951. That is consumption is now equal to $1.05\% \times 56.1 = 58.91$ lbs per capita after the increase. The price flexibility can help us determine if we need to increase or decrease herd size by determining

the corresponding percent change in price. In our case, the percent change in quantity is +5%.

To determine a % change in price given a percent change in the quantity demanded, it is useful to know the price flexibility (λ). The resulting percentage change in price from a given percentage change in the quantity demanded can be derived from the price flexibility equation. If one knows the price flexibility and the given percent change in Q^D then the percentage change in price can be found using the following formula:

$$\% \triangle P = \lambda \times \% \triangle Q^D \tag{13.3.12}$$

Question #20

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As seen in the discussion above, knowing the own price elasticity of demand and price flexibility can have a significant impact on a producer's bottom line, primarily through their total revenue (TR). TR is impacted because it is a function of both the market price and quantity sold. From the above example, if the quantity demanded of beef increases by 5% in the future, then we know the price will decrease due to the Law of Demand. The price flexibility in Question #19 gives us the expected percentage change in price.

Assume that it is the year 1957. We use the historical information from the period 1947 to 1951 to estimate the own price elasticity of demand, assuming the livestock industry improves in the near future similar to the average conditions in that period. The ending beef price in 1956 and the current price for us is $37.89. The current level of consumption (ending quantity demanded in 1956) is 85.4 lbs per capita. A 5% increase in consumption results in an increase in consumption from 85.4 to 85.4 x 1.05 = 89.67 lbs per capita.

Question #21

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Before the change in demand, total revenue for beef producers was TR = $37.89 x 85.4 = $3235.81. After the increase in the quantity demanded and the resulting change in price, TR = $3164.45. Thus, producers would know to expect their TR to fall and to lower their prices and increase their herd size marginally to be able to remain competitive in the market, assuming producers are in a perfectly competitive market. If a producer did not lower their price, they would likely make even less sales and even lower TR, reducing their profitability more than they may have expected. Thus, knowing the market and the associated demand elasticities can help a firm to remain competitive and profitable.

3.2 Parking Demand on University Campuses

Applications of elasticity may impact you even closer to home. Consider the issue of parking on college campuses. The own price elasticity of demand plays a role even here.



University Parking [14]

Consider the following:

Parking availability for dorms at many universities is relatively more substantial than for students who live off campus and pricing for parking permits may be relatively high. A reason for this is that students who live on campus have fewer options for parking their cars than students off campus. Thus, the demand for parking on campus by students living on campus is greater than for those living off campus. University parking services can take advantage of this when determining how much to price parking permits and how many parking spots to offer. These decisions will be impacted by the own price elasticity of demand for parking spaces by students living on campus.

Parking services at universities are in place to manage parking, but they can also generate revenue for the university. Thus, it may be reasonable to assume that their objective is revenue maximization. From this point of view, parking services would want to charge the highest possible price for a permit that maximizes the number of students parking in their lots. Considering there are limited viable parking substitutes (e.g. parking on side streets around campus) available to students living on campus and the close proximity of parking lots to the dorms (compared to other options); the own price elasticity of demand for on-campus parking can be thought of as "relatively inelastic". Let's assume the own price elasticity of demand is -0.25.

Assume parking services are attempting to maximize potential revenue for the coming school year and assume costs remain unchanged (due to no change in the size of the parking lot). Then the primary factor of importance for maximizing parking revenues is the total revenue to parking services.

Assume that there are 1000 parking spaces available and that parking services can charge whatever they see fit for each parking space. We know that parking services charged $200 per spot last year, and 850 of the spots were used. Use this information to answer the following question.

Question #22

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When considering total revenue (TR), we are interested in how changes to the price of parking permits impact the quantity demanded of the permits (as this will impact how many are sold) and in turn, impacts TR. Remember from the previous case study

that $\% \triangle P = \lambda \times \% \triangle Q^D$, where λ is the price flexibility. This equation can be rewritten as a function of $\% \triangle P$ and the own price elasticity of demand, as well (η). That is $\% \triangle Q^D = \eta \times \% \triangle P$.

Considering the information above and that the own price elasticity of demand for parking permits is -0.25, consider a 10% increase in the price of parking permits for the following question.

Question #23

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For the following questions, refer to the original price of $200 and the original quantity demanded of 850 permits. Let's analyze

how the 10% change in price would impact revenues earned by the parking services.

Question #24

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Question #25

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Question #26

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Question #27

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This case study shows how the own price elasticity of demand may provide insight into economic thinking and decisions in our everyday lives. University parking services usually deal with a demand for parking that is highly inelastic. In this situation, as the case study illustrates, by increasing the price of parking permits, parking services can substantially increase revenues earned, while still limiting the number of spots left unfilled.

3.3 Price Elasticities and Agricultural Land-Use

While much work is done using own price and cross price elasticities to examine the effects of price changes on the quantity demanded of goods and services, these elasticities play a role in examining the supply side of the market, as well. This case study will examine the use and interpretation of own price elasticities of supply, cross price elasticities of supply, and input price elasticities of supply. To be able to put these into context, we will examine the supply of corn from a land use perspective.



Corn Field [15]

Corn is one of the primary crops grown in Kansas and around the rest of the nation. In 2017, there were 5,200,000 acres of corn harvested in Kansas. This area represents a production of over 680 million bushels of corn [16]. The supply of corn in the Kansas market is a function of the (own) price of corn, the prices of other crops, and the prices of inputs. The Law of Supply indicates that as the (own) price of corn increases, the quantity supplied of corn will increase. This could be interpreted from a land use perspective too: as the price of corn increases, the amount of land devoted to corn production increases. In this respect, we can talk about the supply of corn based on the number of acres planted for corn. We can examine the responsiveness of corn supply in terms of acreage to a change in the price of corn using our **own price elasticity of (acreage) supply**. This elasticity measures the percentage change in the acreage supplied or planted given a 1 percentage change in the own price of corn. For example, if the own price elasticity of acreage supply is 0.8, then a 1% increase in the price of corn will increase the acreage planted to corn by 0.8%.

While a change in the (own) price of corn directly impacts the quantity supplied, changes in prices of related crops and inputs will cause supply to change. That is, the supply curve will shift as changes in these other prices change, as they are determinants of supply. Elasticities can be used here to examine the responsiveness of supply to changes in one of these other prices or determinants. Consider the two following concepts:

(i) **Cross price elasticity of acreage supply**: This elasticity measures the percentage change in acreage devoted to a given crop to a 1% change in the price of another crop. The crops can be complements or substitutes in production. For example, if the cross price elasticity of acreage supply for corn for the price of soybeans is 0.5, then a 1% increase in the price of soybeans will increase the acreage devoted to corn production by 0.5%. When these elasticities are positive, the two crops being considered are complements in production (e.g. they may be grown in rotation). When these elasticities are negative, the two crops being considered are substitutes in production (i.e. they compete for the same area of land).

(ii) **Input price elasticity of supply:** This elasticity measures the percentage change in the acreage devoted to a crop to a 1% change in the price (or cost) of an input to produce that crop. For example, if the input price elasticity of acreage supply for corn for the price of labor is 1.5, then a 1% increase in the wage rate paid for labor on the farm will result in a 1.5% decrease in the amount of land devoted to corn production.

All of these elasticities are calculated in the same manner as presented in section 2.0. The only difference for an acreage supply elasticity is that the change in quantity is the change in the amount of land devoted to the production of the crop.

To be able to illustrate the use of these concepts, let's consider the production of irrigated corn in western Kansas. Al-Sudani [17] did a statistical analysis of the factors influencing the amount of land devoted to irrigated corn production in western Kansas between 2003 and 2015. The focus on irrigated corn production was due to its crop revenue generation and scarcity of water for corn production in this region of the state. We will focus on the estimated acreage supply elasticities for corn for different prices found in the study.

Al-Sudani [17] estimated the following acreage elasticities:

· Own price elasticity of acreage supply for corn = 0.66;

· Cross price elasticity of acreage supply for corn with respect to sorghum = -0.38;

· Cross price elasticity of acreage supply for corn with respect to soybean = -0.03; and

· Input price elasticity of acreage supply for corn with respect to fertilize price = -1.19.

These elasticities can be used to explain how the amount of acreage devoted to corn production changes when different commodity and input prices change in the market. This information would be useful to industry (e.g. cooperatives, elevators, traders) and farmers for marketing and planning their next growing season. Use this information to answer the following questions about the likely impact of different changes in the market.

Question #28

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Question #29

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Question #30

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Question #31

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4.0 Concluding Remarks

Elasticity is an important economic measure and can be a highly influential factor and aid when making economic decisions. Elasticities provide a readily accessible way to conduct marginal analysis for a multitude of problem situations. Elasticity has applications ranging across all reaches of economics as illustrated by the examples and case studies examined in this chapter. We have gone over a few of the essential elasticities, however, there are many more that assist in helping to examine different relationships between economic variables. Elasticity is a useful tool to utilize for producers, consumers, and policy-makers and applies to our everyday lives.

Question #32

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5.0 References

[1] Image courtesy of Luke Erickson through Pixabay, under license CC0 1.0 Universal.

[2] Merriam-Webster Dictionary. 2018. Elasticity. Available at: https://www.merriam-webster.com/dictionary/elasticity.

[3] Barkley, A. and P.W. Barkley. "Principles of Agricultural Economics" 2nd Edition. New York, NY: Routledge, 2016

[4] Barkley, Andrew, "The Economics of Food and Agricultural Markets" (2016). *NPP eBooks*. 12.

[5] Video courtesy of mjmfoodie through Youtube, under license CC BY Attribution 3.0 Unported.

[6] Allen, R. G. D. 1933. "The Concept of Arc Elasticity of Demand". *Review of Economic Studies* **1** (3): 226–229.

[7] Image courtesy of Pexels, under their licensing agreement.

[8] Video courtesy of econom through Youtube, under license CC BY Attribution 3.0 Unported.

[9] InvestingAnswers, 2018. "Income Elasticity of Demand." Available at: http://www.investinganswers.com/inco...ty-demand-2906.

[10] Image courtesy of freddthompson through Wikimedia Commons, under license CC BY-SA 2.0.

[11] Agricultural Marketing Service, USDA. 2018. "Weekly Distiller's Grain Summary." NW_GR115. Availalble at: https://www.ams.usda.gov/mnreports/nw_gr115.txt.

[12] Workman, J.P., S.L. King and J.F. Hooper. 1972. "Price Elasticity of Demand for Beef and Range Improvement Decisions." *Journal of Range Management* 25(5): 338 - 341.

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[16] USDA, National Agricultural Statistics Service. 2018. 2017 State Agricultural Overview: Kansas. Available at: https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=kansas.

[17] Al-Sudani, A. 2018. Essays in land use and water scarcity in Kansas. Ph.D. dissertation, Department of Agricultural Economics,

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13.4: Prohibition

Agricultural Economics: Prohibition



Prohibition Agents Destroying Barrels of Liquor in 1921 [1]

1.0 Introduction

In certain situations, to protect citizens and the social welfare of its people, governments may decide to *prohibit* the consumption or production of a good. *Prohibition* is a type of *command-and-control policy* that is used by governments to limit the consumption and/or production of a good or service for different reasons. The prohibition of goods and services has occurred throughout history for different reasons. The most notable example in U.S. history was the prohibition of alcohol in the 1920's. Other examples include the prohibition of drugs; legal ages for drinking and smoking; banning of plastic bags and straws; limiting or eliminating the presence of trans fats in foods; and the protection of endangered species... This chapter will explore what prohibition is, different examples of prohibition, and an in-depth agricultural example involving the prohibition of margarine in the U.S. In this exploration of prohibition, we will examine the economics of prohibition, the formation of black markets, and the unintended consequences of prohibition policies.

1.1 Learning Objectives

By the end of the chapter, you should be able to:

(i) Define and understand what prohibition is;

(ii) Recognize the use of prohibition policies by government in different circumstances; and

(iii) Understand and assess the economic implications of prohibiting the production or consumption of a good or service in the market.

This chapter will provide a rich set of historical and present examples about prohibition to help you understand the breadth of prohibition policies, how they are used, and the potential economic impacts of these policies. A detailed case study involving the prohibition of margarine is used to illustrate the economics of prohibition and provide a contextual situation for you to examine the effects of prohibition in an agricultural commodity market.

2.0 What is Prohibition?



Smoking Prohibition [3]

While the word "prohibition" may bring to mind images like the picture on the right, prohibition has been a subject of much economic debate in topics spanning from alcohol and smoking to environmental protection. By legal definition, ***prohibition*** is the ceasing or restraining of action by a stated party by the authority of a legitimate legal authority [2]. That is, prohibition is a law or legal requirement that requires individuals or groups to cease a particular activity or stop the production or consumption of a good or service. These laws are usually governmental policies enacted at the local, state, or federal level. There exists a wide range of prohibition laws and policies that have been put into place in history in many countries. Below we provide some examples and assessments of the prohibition of goods in the U.S. from the past to the present day.

2.1 Accounts of Prohibition

Prohibition policies have been used for many reasons, including making harmful products, such as alcohol and cigarettes, illegal; protecting the environment and endangered species; reducing the effects of pollution; protecting consumers (e.g. ban on trans fats); to promoting consumer safety; among other reasons. This section of the chapter will examine four different historical and current cases of prohibition of goods in different contexts and will highlight some of the different aspects of prohibition in each.

2.1.1. Alcohol Prohibition and the Volstead Act

The first account of prohibition we will examine is the most recognized prohibition policy in the U.S., alcohol prohibition. When we even think of the word "prohibition" in the U.S. or search for it online, we are most likely to think of this event in history. Thus, we examine the economic and policy impacts of U.S. alcohol prohibition.

Fueled by temperance groups like the Anti-Saloon League of America and the Woman's Christian Temperance Union (WCTU), the "war on liquor" began in the late 1800s in the United States. Beliefs about alcohol and the "evil" that it wrought on society were accepted by a large percentage of the public, as well as by women's groups, church groups, and politicians by the early 1900s. Alcohol had become increasingly popular since the 1850s, and by the early 1900s, more than 50 million barrels of beer were being produced in the U.S. [4] Views about the havoc that saloons in particular had upon society were becoming well-established lines of thought across the nation. The picture below provides one-way alcohol consumption was viewed during this time period. Alcohol prohibition may have made its way to the center stage sooner but was slow to come to fruition due to constraints on temperance groups, which were made up of a large population of women. During this time, women were not allowed to vote and thus had to act through other means to influence public opinion. In many cases, women were the ones witnessing what alcohol was doing to their families [4].



The Drunkards' Progress [5]

It wasn't until January of 1919 when the 18th Amendment to the Constitution was passed that alcohol prohibition became a reality. The 18th Amendment prohibited the "production, sale, and transport" of "intoxicating liquors", but did not define "intoxicating liquors" nor provide penalties. By October of the same year, the Volstead Act was passed, enforcing the 18th Amendment. The Volstead Act defined "intoxicating liquors" as any beverage containing more than 0.5% alcohol by volume and provided further that "no person shall manufacture, sell, barter, transport, import, export, deliver, or furnish any intoxicating liquor" [6]. Neither the 18th Amendment nor the Volstead Act included prohibiting the *consumption* of alcohol.

While many would argue that the 18th Amendment to the Constitution was highly debated and opposed, it was adopted much more quickly than other constitutional amendments. The Volstead Act was passed rather quickly itself (even after a presidential veto) and took effect in October 1919. Those who supported alcohol prohibition expected crime levels to drop in the years following the passing of the law. However, the prohibition of alcohol was especially difficult to enforce and failed to eliminate crime as expected. In fact, the 18th amendment may have led to a rise in organized crime across the country, as bootlegging of alcohol became even more profitable under a black market [7]. The consumption of alcohol dropped dramatically, and so in that way, prohibition was effective. Unfortunately, crime levels increased dramatically due to the large demand for alcohol and organized crime centered around the production and provision of illegal alcohol.



Raid at Elk Lake [8]

Proponents of prohibition continued to fully support the amendment during the time of alcohol prohibition. In the following quote by The Federal Council of Churches, church officials speak on the evils of alcohol.

> *"If serious evils have sprung up since prohibition, they are far less than the evils which arose from the liquor traffic prior to the amendment. The liquor traffic with the accompanying saloon was allied with political corruption, crime, gambling, and prostitution. It meant the wreckage of men and the degradation of families, which social workers and ministers saw constantly in their daily work." [9]*

While these impacts did occur, many would argue that the rise and impacts of organized crime, like Al Capone and his gang, were far worse than what prohibition set out to mend.

While prohibition was effective in reducing the consumption of alcohol, the continued demand for alcohol provided a strong incentive to produce alcohol on the black market. Due to the high transaction costs (e.g. fines, imprisonment, risk, etc.) of producing alcohol illegally, producers (also known as bootleggers) could charge significantly higher prices than before. The dissipation of the legal market via the 18th Amendment and the Volstead Act meant a surge of consumers willing to purchase alcohol illegally. The Volstead Act, created to enforce the 18th Amendment, was much more difficult to enforce than expected; as such, law-abiding citizens would break the law to obtain alcohol [7].

Under prohibition, many proponents of prohibition expected demand for clothing and household goods (such as soft drinks and candy) to increase, and developers expected rents and land values to increase as bars and saloons closed, improving living conditions in neighborhood communities. Theaters and other entertainment industries expected increases in ticket sales, as well. Throughout the prohibition period though, none of this occurred. In fact, revenues in the amusement and entertainment industries fell across the United States. Furthermore, restaurants failed as they could no longer provide alcohol. Overall, the economic impact of alcohol prohibition was negative, eliminating thousands of jobs in the alcohol and related industries, as well as a decrease in revenues and profits for the food, entertainment, and amusement industries [10]. A significant impact of prohibition on local, state, and federal governments was the significant loss in government revenues from taxation of alcohol, which many states relied upon to fund their budgets, by as much as 75%. The prohibition cost the federal government $11 billion in lost tax revenue. The impact of this lost revenue was a shift from using alcohol tax revenue to fund budgets to relying upon higher income taxes to fund government activities, which continues to this day [10].



Al Capone Mugshot [11]

Due to the inability of the Volstead Act to effectively enforce alcohol prohibition, organized crime increased. Where saloons once operated, now there existed speakeasies, as well as increases in political corruption [12]. In 1932, a wealthy industrialist by the name of John D. Rockefeller, Jr. stated in a letter:

> *"When Prohibition was introduced, I hoped that it would be widely supported by public opinion and the day would soon come when the evil effects of alcohol would be recognized. I have slowly and reluctantly come to believe that this has not been the result. Instead, drinking has generally increased; the speakeasy has replaced the saloon; a vast army of lawbreakers has appeared; many of our best citizens have openly ignored Prohibition; respect for the law has been greatly lessened; and crime has increased to a level never seen before." [12]*

The American people as a majority had begun to oppose the 18th Amendment by the end of the 1920s, and by the early 1930s a large political movement formed in opposition to prohibition.

By December of 1933, the 21st Amendment to the constitution was adopted, with a single purpose, to repeal the 18th Amendment. The 21st Amendment is considered unique. It is the only amendment to the Constitution with the sole purpose of repealing a prior amendment. While prohibition at the federal level ended in 1933, state prohibition of alcohol continued across the country. Mississippi was the last to repeal prohibition in 1966, while Kansas continued to prohibit public bars until 1987 [12].

While the alcohol prohibition ended in 1933, policies still exist that are influenced by alcohol prohibition. These policies include bans on sales of alcohol at supermarkets in certain states; state-controlled alcohol monopolies; regulations on shipping alcohol across state borders; alcohol franchise laws; and restricted sales of alcohol on Sundays [13].

Question #1

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2.1.2 Endangered Species Act

The Endangered Species Act (ESA) was a piece of legislation passed by Congress and signed into law in 1973. The purpose of the act was to conserve and protect plants and animals (and their habitats) that are determined to be endangered or threatened by extinction. [14-15]. A plant or animal is considered to be endangered if: (i) there is threat to their habitat that would cause the plant or animal to not be able to survive; (ii) the plant or animal species has been over-utilized for commercial, research or other purposes; (iii) the species is heading toward extinction due to diseases or threats by other predators; (iv) the animal or plant species is not adequately protected by existing policies or laws; or (v) natural or man-made factors are threatening the continued survival of the plant or animal species [15]. Habitat loss is considered the greatest threat to endangered species, so the ESA protects critical habitats of endangered animals and plants, which includes the land, water, and air necessary for the plant and animal's survival and recovery [15-16]. The following video provides some history and more information about the ESA.

YouTube Video

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Question #2

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The ESA is a type of *prohibition* in that it prevents individuals, firms and groups from trading, hunting, disturbing, or harming endangered and threatened plants and animals, as well as protecting all lands, water, and air designated as their critical habitat. One of the most referenced cases for the ESA is the Northern Spotted Owl. This owl species was listed as threatened under the ESA in 1990 [18]. The Northern Spotted Owl is primarily located in the old-growth forests of the Pacific Northwest from Northern California to British Columbia. Each owl pair requires up to 4200 acres of old-growth forest in Washington and 2300 acres of old-growth forest in Oregon and California to survive [19-20]. Logging was and has been a significant economic enterprise in regions of old-growth forest, where the Northern Spotted Owl resides. The presence of the logging industry and the listing of the Northern Spotted Owl as threatened has created significant controversy. This is evidenced by the fact that 60% of the habitat for the Northern Spotted Owl is available for logging or timber production [20]. There were suggestions of setting aside 8 million acres of land as critical habitat for the owl, which some projected could put 12,000 to 50,000 individuals out of work, which would amount to a loss of $470 million to $2 billion in income for these individuals [20-22] Thus, a significant economic conflict exists regarding the protection of this species and economic welfare of firms and individuals working in the logging and timber industry. While this example illustrates the economic issues that can arise from prohibition, it provides an example of the potential unintended consequences of prohibition.



Northern Spotted Owl [23]

One of the other potential unintended consequences of protecting the critical habitats of the Northern Spotted Owl is that it prevents timber harvest and clearing of the old-growth forests, increasing wildfire risk and damage. The Stewards of the Sierra National Forest indicate that protection of the Northern Spotted Owl under the ESA in California has reduced timber harvesting by as much as 90% in some areas. It was the timber harvesting, which is usually done by thinning the forest, that provided a significant mechanism in removing tinder that helped to reduce the impact of wildfires in these forests. The organization now argues that tree density in the Sierra National Forest in California is now 10 times what it should be due to the lack of thinning and harvesting of timber. When coupled with the extreme droughts California has faced in the recent past, this leads to increased risks of highly explosive and destructive wildfires that are harder to control. Furthermore, with the significant decrease in timber harvesting, the number of lumber mills has drastically decreased, meaning current resources or logistics to provide the needed

thinning of the forests are not available [24].

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2.1.3 Banning Plastic Straws



Plastic Straw [28]

A more recent example of prohibition is the movement by cities (e.g. Seattle and San Francisco) and some countries (e.g. England) to ban or prohibit the use of plastic straws. The movement to ban plastic straws started as a grassroots movement. As it grew, businesses, such as Starbucks, got involved and decided to stop using or supplying plastic straws. Eventually, governments started considering instituting policies to prohibit their use, as well [25].

Why plastic straws? Plastic consumption around the globe was over 300 million metric tons in 2015. Put another way, that amounts to about 25 metric tons of plastic used per person for the world's 7.6 billion people [25]. The campaign to ban plastic straws is born out of a larger goal to reduce our dependence on the use of plastic, which has had a significant impact on our environment. Plastic straws were targeted because they are an item that many individuals are exposed to and use every day that connects them to plastic [26]. Many people are advocating for going back to paper straws or abandoning the use of straws altogether. One potential side effect of the ban is that persons with disabilities may need the use of these straws, as some have argued that there are not enough alternatives or substitutes readily available in the market [27].

The prohibition on plastic straws stems from the same principles as the prohibition on plastic bags, to reduce our use of single-use plastics and plastic consumption. The video below is an advertisement released in the city of Seattle about going strawless. The video represents part of the marketing campaign to reduce plastic consumption, which comes at a cost to produce, representing one type of cost (i.e. marketing and promotion of the prohibition policy or movement) it takes to make prohibition an effective policy.

Click the link to watch the video below:

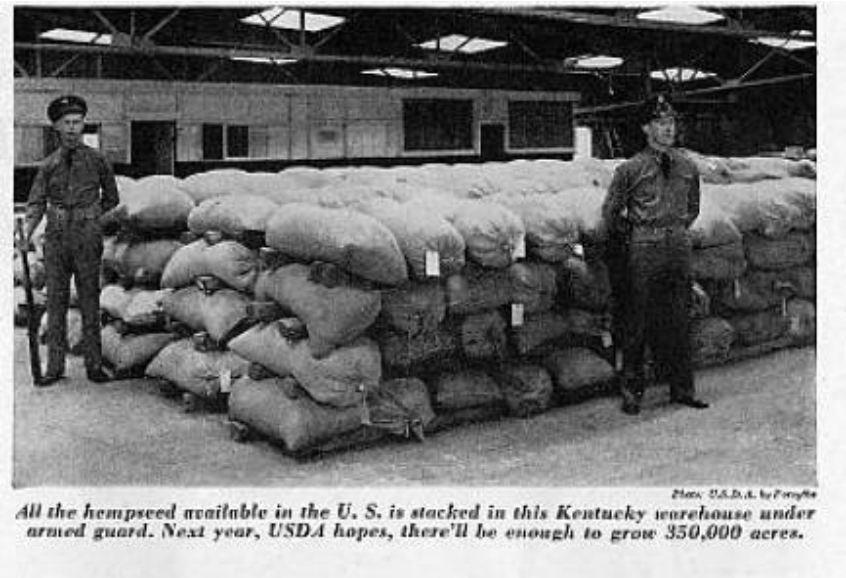
Sucker Punch [vimeo.com]

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2.1.4 Marijuana Prohibition and Legalization

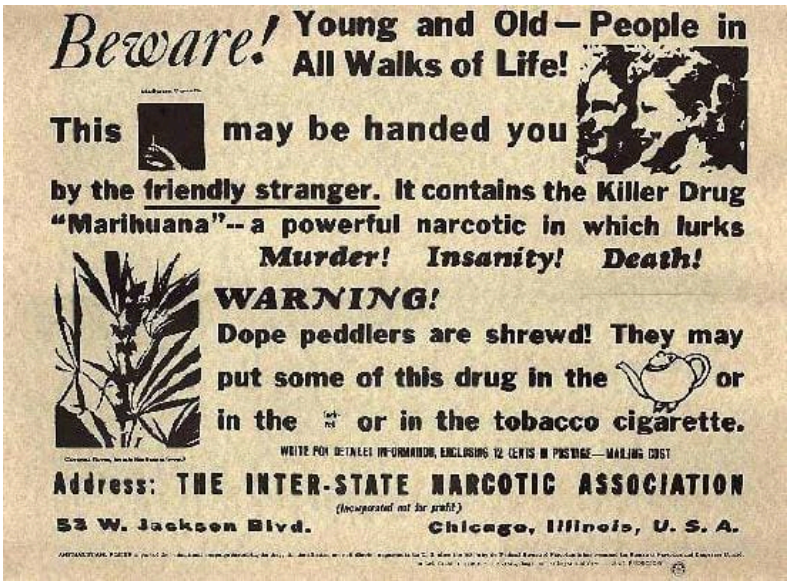


All the hempseed available in the U. S. is stacked in this Kentucky warehouse under armed guard. Next year, USDA hopes, there'll be enough to grow 350,000 acres.

Hempseed [30]

Use of hemp in the U.S. spans back as far as Jamestown and the early settlers of the American Colony. Hemp is a fiber used to make sails, clothing, and rope. Hemp is the male orientation of the cannabis plant. Marijuana is derived from the flowers of the female orientation of the plant and is used for recreational and medicinal purposes. In 1619, King James I declared that the American colonies would need to do more to support England. This decree required all Jamestown owners to grow and export 100 hemp plants each. The growth of hemp eventually became pivotal to the growth of the United States. In fact, as late as 1900, hemp appeared on the 10-dollar bill of the U.S. [29]. In 1970, President Nixon signed the Controlled Substances Act, making not only marijuana illegal, but regular hemp, one of the world's oldest domesticated crops, illegal, as well [31].

By 1850, marijuana was being used medicinally across the United States after its introduction in medicine a decade prior. Recreational marijuana use followed close behind, although mainly outside of the United States. Marijuana cigarettes were used by Mexican soldiers as early as 1874. At the same time, laws started being passed regulating pharmaceuticals and product labeling requirements started to arise. In 1905, the USDA identified 29 states that were labeling marijuana as “poison”. By 1906, the Pure Food and Drug Act was passed in Congress, requiring the accurate labeling of certain drugs, including marijuana. By 1910, revisions in legislation focused on labeling all narcotics as poisons and limiting the sale of marijuana by pharmacies to those customers with a doctor’s prescription. In 1938, the Federal Pure Food, Drug, and Cosmetics Act was passed, which remains in effect today, providing a specific framework for how prescription and non-prescription drugs and food are handled. Marijuana is still considered a dangerous drug under this act [29].



Marijuana Prohibition [32]

Successful in their campaign against alcohol, temperance groups began focusing their efforts on opiate drugs and marijuana. Between the years 1914 and 1925, twenty-six states passed laws prohibiting marijuana. The marijuana prohibition laws were uncontroversial and passed without much debate [33]. By the early 1930's, prohibition of alcohol was repealed via the 21st amendment of the constitution, although prohibition on drugs across the U.S. remained in effect. Marijuana and other drugs were blamed for crime, murders, suicides, robberies, and more. Much as proponents for alcohol prohibition focused on alcohol as the cause of these negative social impacts, proponents for marijuana prohibition blamed all of these social impacts on marijuana. Thus, the prohibition of drugs continued long after alcohol prohibition was repealed. Proponents of marijuana prohibition relied on fear tactics at times to continue this campaign. By the 1950s, there was no effort to distinguish between different types of drugs. All drugs were considered dangerous and addictive [33].

By the 1960's, views on marijuana prohibition began to change. Mainly due to the increase in the number of college students smoking marijuana, the number of incarcerations due to illegal drug use increased tenfold between 1965 and 1970. Thus, people began to question the penalties associated with marijuana use. It seemed to be rather extreme by certain groups to incarcerate some of the best and brightest minds in the country attending college for such a small offense as marijuana use [33]. Disregarding this change in attitude, marijuana was further restricted under the Comprehensive Drug Abuse Prevention and Control Act of the 1970s, which put marijuana in the most restrictive group of narcotics, prohibited even from medical use [33].



Elvis Presley meets President Nixon – 1970 [42]

President Nixon spent most of his time in office continuing his anti-marijuana campaign as part of the “War on Drugs.” Nixon’s director of the Narcotics Treatment Administration recalled that when he joined the administration the president told him, "You’re the drug expert, not me, on every issue but one, and that’s decriminalization of marijuana. If you make any hint of supporting decriminalization, you are history. Everything else, you figure it out. But that one, I’m telling you, that’s the deal.'" President Nixon ironically recruited Elvis Presley as a spokesperson for the War on Drugs circa 1970 [33].

Despite Nixon's continued push to keep marijuana illegal and the continued push for the "War on Drugs", more and more people were beginning to think that the harsh penalties applied to those who were caught using drugs were contrary to society's best interest. Thus, advocates for the legalization of marijuana have focused not on "drugs" but on the medical uses of marijuana and the social costs to the country from the prohibition of marijuana [33]. The "War on Drugs" continued for the next 40 years, with some relaxation of laws and enforcement. For example, in 1996, California passed the Compassionate Use Act, which made California the first state to legally allow the use of marijuana for medical purposes [31]. As of January 2018, nine states have legalized marijuana for recreational use to some degree, including Colorado, Washington, Alaska, California, Maine, Massachusetts, Nevada, Vermont and Oregon. While it is legal at the state level, it is still illegal under federal law [43]. Other states are now considering legalization and the federal government is considering how to deal with the situation.

The video below provides a perspective between two communities on the legalization of recreational use of marijuana in Colorado. The video presents some aspects of both sides of the current debate.

Click the link to watch the video below:

The Marijuana Divide [vimeo.com]

The Marijuana Divide [34]

Question #5

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Question #6

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2.2 Economic Analysis

Governments at times wish to regulate the trade of goods through different means, such as taxes. A more dramatic approach is to **prohibit** the consumption, production, or trade of a good or service [35]. Prohibition itself is often a policy tool used on the supply side of the market, but it can be used to restrict demand if consumption is prohibited, but this is usually much more difficult to control and enforce. Our focus in the economic analysis of prohibition will be to examine the impact of prohibition policies and laws on the supply side of the market, the impact of prohibition type policies on consumption of prohibited goods, and the political economy of prohibition.

2.2.1 Prohibition, Supply and Black Markets

Prohibition is often a supply-side reduction policy, due to the better likelihood of enforcement of the prohibition (e.g. there are usually a much smaller number of producers than consumers in the market) [36]. Prohibition makes the production of the prohibited good illegal, but typically is not able to curtail all the production in the market [35]. That is, a ***black-market*** forms where the product is produced and sometimes consumed illegally. During alcohol prohibition, it was illegal to produce alcohol, but not illegal to consume. Prohibitions are enforced through fines, confiscation of resources used for production, jail terms, etc. These enforcement mechanisms come at a cost to the producer. That is, the cost of production for producers increases, usually dramatically, due to an increase in *transaction costs.* These transaction costs can include paying fines, higher costs for resources to produce the prohibited good, monies for bribes, potential loss of production, etc., all because the production of the good is now illegal. Thus, the prohibition policy acts as a *determinant of supply,* causing the supply curve to shift to the left due to the increase in the cost of production [36]. This shift is illustrated in Figure 1 below.

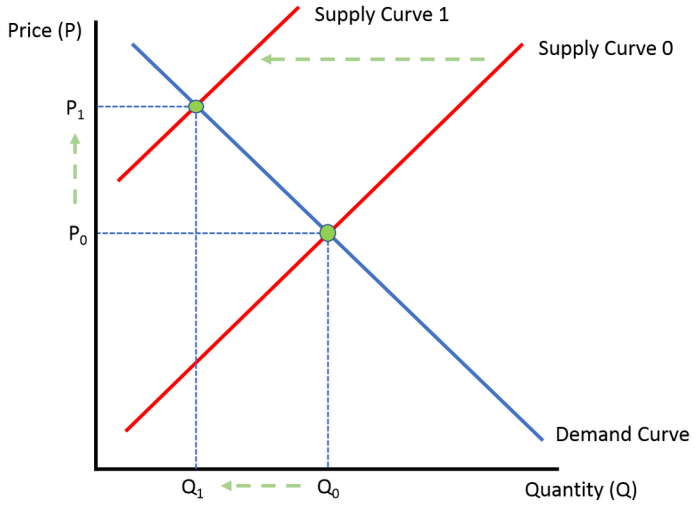


Figure 1: Supply-Side of Prohibition Market Effect

The significant shift in the supply curve from Supply Curve 0 to Supply Curve 1 is due to the high transaction costs. The market equilibrium moves from Q_0, P_0 to Q_1, P_1. This results in a significant increase in the equilibrium price and decrease in the equilibrium quantity in the market for the prohibited good. The *black market* is represented by the shift in the supply curve to the left. That is, the legal market becomes a black market after the shift, as all the production represented by Supply Curve 1 is illegal. In this case, there is no assumed change in the demand for the prohibited good. Overall, under prohibition, both consumers and producers are worse off. Consumers lose utility and must substitute goods that they likely feel may be inferior, while producers lose profit and employment [36].

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2.2.2 Policy Considerations and Demand

As mentioned earlier, prohibition typically fails to eliminate the market for the prohibited good, giving rise to illegal production and potentially illegal consumption. In the U.S., many drugs are illegal to produce and consume. A prohibition-like policy that

could be used to help curb consumption is to place a significant tax on the consumption of the good that you want to prohibit. In this sense, you avoid the direct prohibition of the good but may achieve a significant reduction in the consumption of that good [35]. This result arises from the fact that the tax increases the price of the good to consumers. According to the *Law of Demand,* as the price of a good in the market increases, the consumption of the good (or quantity demanded) will decrease. The tax is further enhanced by another property of demanded goods, the *Law of Diminishing Marginal Utility*. This law states that the more you consume a good, the less satisfaction (or utility) you receive for that good [36]. Thus, the tax may have the effect of essentially "pricing" some people out of the market, providing the same benefit as the prohibition. The tax is a *market-based* policy, in that it does not distort the market, making economic transactions illegal, resulting in a black market like prohibition policies can. The impact of the tax policy will be dependent on how elastic demand is. That is, how much consumption of the good that you want to prohibit (or reduce consumption of) is responsive to price. To see this, let's consider an example.

Assume that the government wants to institute a policy to prohibit the production of textbooks for undergraduates, due to the large use of wood pulp to produce them and their impact on the environment (through say deforestation). Assume that the own price elasticity of demand (η) for these textbooks is $\eta = -0.4$, which is inelastic. Recall, the own price elasticity of demand for textbooks tells us that a 1 % increase in the price of textbooks will decrease the quantity demanded of textbooks by 0.4%. Now assume, the government, in a push to get textbooks off the market, puts a consumption tax on textbooks, which consumers will have to pay when they buy a textbook. The tax comes in the form of an *ad valorem tax*. Assume the tax is 200%. That is, consumers will have to pay the price of a textbook, plus 200% of its value in taxes. If a textbook was $100, the tax would be $200, making the total cost to the consumer $300 for the textbook. What will be the impact of the 200% ad valorem tax on textbook consumption?

To answer the above question, remember the own price elasticity of demand for textbooks tells us what happens if the price of textbooks increases. The imposition of the tax is like a 200% increase in the price of a textbook. Now, recall from past chapters, that $\eta =$ - $\eta =$ -. We can now use this formula to solve for the or percent change in the quantity of textbooks consumed. Using the information provided: \(%△Q^D =η/times{%△P} =−0.4\times 200 = −80\) or an 80% decrease in the consumption of textbooks.

Would you need as large a tax if demand was elastic or responsive to price? Consider the situation now when the own price elasticity of demand for textbooks is $\eta = -2.0$. Use this and the above information to answer the following question about how a lower ad valorem tariff could achieve the same effect in the market if the good is elastic.

Question #8

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2.2.3 Political Economy and other aspects of Prohibition

In this subsection, we want to touch on two other aspects of the economic analysis of prohibition briefly. These two aspects involve the political economy of prohibition and optimal level of enforcement.

Political Economy of Prohibition - In some instances, the prohibition of a good or service is a result of the government's response to strong or influential interest groups. As will be discussed in detail below, the prohibition on margarine in the late 1800s and early 1900s was primarily due to interests groups lobbying government to prohibit the good. The theory underlying why this may occur is the economic theory of regulation proposed by George Stigler [37]. The idea is that politicians are heavily influenced by the interests of the people they represent, their constituents, especially their best-organized constituents. In addition, politicians will likely favor policies that benefit not only their constituents but well-organized and influential interest groups, as it lowers the costs of supporting that policy and can provide political dividends. Policies that only have the support of the general public are usually not as well supported politically, as the political pay-off is not as high as those that are supported by well-organized and influential interest groups [38]. Thus, prohibition policies many times, as seen in the above examples and below, are enacted due to the interests of certain groups, which may not represent what the majority of individuals feel about the policy.

Optimal Enforcement of Prohibition: A significant issue for policymakers to consider when looking to enact a prohibition policy or

law is how to optimally enforce the policy. The government needs to determine at what point the marginal benefit or return from enforcement is equal to the cost of enforcement. Theoretically, at this point, the net gain from enforcement will be maximized. That is, enforcement will achieve the greatest reductions in production and/or consumption of the prohibited good in the most cost-effective manner. The benefits from prohibition include reductions in consumption or production, as well as the value of reductions in harmful impacts that are alleviated due to the consumption or production of the prohibited good. The costs of total enforcement of a prohibition usually far outweigh any benefits achieved [36].

3.0 Case Study – Prohibition of Margarine in the U.S.

We now present a case study to conduct an applied example of the economic assessment of prohibition policies on the market for a good. In this case study we examine the prohibition of margarine in the U.S.

3.1 Historical Background

Margarine was introduced in 1869 by the French chemist Mége-Mouries under Napoleon III. Made from animal fats (as a by-product of the slaughterhouse) or from plant fats (such as cottonseed oil), margarine could be made much cheaper and sold for half the price of conventional butter. The introduction of margarine in the U.S. led dairy interest groups to push for legislation to ban this new product, which would be prohibited in different ways in the U.S. until the mid-twentieth century [39].



Butter [40]

Margarine first arrived in the U.S in the 1870's, much to the dismay of dairy producers. Butter had never had much competition, but the introduction of margarine had the potential to adversely affect dairy producers, reducing the producers' and processors' profits made from producing butter. As a cheap substitute to butter, margarine was readily adopted by consumers across the country, sparking a considerable shift in consumer demand from higher priced butter to lower priced margarine. The market shift to margarine was viewed as being detrimental to the health of the dairy industry and a strong push was made to heavily tax margarine at a discriminatory rate relative to butter. By 1886, 27 states had introduced legislation on margarine production and sale; 20 regulated the labeling and packaging of margarine; and 7 states prohibited its manufacture and sale. [38-39]. Following legislation passed by state governments, the federal government felt the need to step in to help enforcement of state laws. Congress passed the Oleomargarine Bill, imposing a manufacturing tax of 2 cents per pound on margarine and a requirement for annual license fees for all producers in the margarine supply chain. Because of this new legislation, margarine was often sold as butter. Both products were sold in large quantities, and it was very hard to tell the difference between the two by examination. In reaction, the government instituted policies requiring the proper labeling of margarine to be able to identify it clearly and as different from butter. Instead of solving the problem of margarine disguised as butter, it made the situation even more complicated. With further pressure from interest groups, legislation was passed that focused regulation on the color of margarine, which was naturally a white blend and had been artificially died yellow to match the color of butter. By the 20th century, 32 states had passed legislation to prohibit the yellow coloring of margarine, "the most bizarre certainly being Vermont's in 1884, and New

Hampshire's and West Virginia's in 1891 requiring that it be colored pink" [38].



Oleomargarine [41]

By the late 1800s and early 1900s, mounting pressures from interest groups and industry got federal legislation to regulate colored margarine in states where the colored product was still not banned. "The manufacturing tax was raised to 10 cents per pound on colored margarine and lowered to one-fourth cent per pound on the uncolored product" [38-39]. Licensing fees for selling and manufacturing uncolored margarine were also reduced considerably. By 1914, nearly all retailers and wholesalers were selling uncolored margarine [38].

Margarine had been the key focus of lobby and interest groups associated with the dairy industry. The interests of these groups though was up against other significant interest groups, such as those supporting manufactured food products, livestock groups and crop groups (e.g. for cotton) that all shared in the profits from the sale of margarine. Butter was a natural product produced from dairies, while margarine was one of the first manufactured products, but was viewed with suspicion as it was not seen as natural [38-39].

The restriction in the sale of yellow margarine continued until the end of World War 2, when butter prices significantly increased in 1947. The general public and interest groups sought to eliminate the restrictions placed on margarine, a much cheaper substitute during this time. By 1950, the Oleomargarine Bill was repealed. State legislation wasn't far behind in most states, although it wasn't until 1967 when restrictions on colored margarine finally disappeared in the primary dairy states of Minnesota and Wisconsin [38].

3.2 Market Analysis – Supply and Demand in the Margarine and Butter Markets

This section will ask you to examine the potential impacts of margarine prohibition on the market for margarine in the U.S. In

addition, it is important to take into account the impact margarine prohibition had on the market for butter.

Question #9

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Question #10

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Following the introduction of margarine in the United States, dairy producers across the country lobbying for legislation of margarine production; and by 1886, seven states had prohibited the manufacturing or sale of the good, stabilizing the market for butter, with another 20 states regulating the sale of margarine in some way [38-39].

Question #11

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Question #12

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Question #13

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Just as prohibition throughout history has never been entirely successful at eliminating the supply of prohibited goods, the supply of margarine continued to be available, albeit through illegal ways. There are records of trucks carrying margarine across the borders at night into Wisconsin to sell to consumers [35].

Question #14

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3.3 Policy Implications

While it may be a simple economic analysis to look at prohibition in the few states that banned its production outright, this was not the case for much of the United States. In fact, the passing of the Oleomargarine Bill in 1902 was not to completely eliminate the supply of margarine in the U.S. through outright prohibition. Rather, the Oleomargarine Bill was put in place to achieve one particular goal, artificially raising the costs of producing margarine and thus the market price of the good through taxation [38-39].

Question #15

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By imposing a tax on the production of margarine, legislation was created to specifically target the cheaper price of margarine in the market, thus helping to increase the demand for butter. Assume the own price elasticity of colored margarine is $\eta = -0.8$. The tax on margarine set by federal policy increased the price of colored margarine by 50%. Use this information to answer the following question.

Question #16

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By the 1960s much of the legislation passed to prohibit or reduce the consumption of butter was repealed. This had the effect of reducing the price of margarine to the consumer. Now assume that preferences have changed and the own price elasticity of

margarine is now $\eta = -0.4$.

Question #17

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Now assume the cross price elasticity of butter for margarine is equal to $\sigma = 0.7$. Use this information to answer the next question.

Question #18

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4.0 Concluding Remarks

This chapter introduced you to the concept of prohibition, examined its historical and present significance as a policy tool, and the economic impacts that prohibition policies may have. When we think of prohibition, we tend to think of alcohol prohibition, but alcohol prohibition was not the only significant prohibition policy in our country's past. We are still engaged in the "War on Drugs" and we commonly see prohibition of products in the market to protect human safety, just to name a couple of examples. Prohibition will decrease the production and/or consumption of the prohibited good, but it is likely to give rise to black markets and potentially other social and economic hardships. Policymakers have tried to use other market-based tools, such as taxes, to achieve the same effect as prohibition, but try to avoid the other hardships mentioned.

5.0 References

[1] Image courtesy of Wikimedia Commons, within the public domain. (Prohibition Agents destroying barrels of liquor in 1921.)

[2] Black's Law Dictionary Free 2nd Edition and The Law Dictionary. 2018. "What is Prohibit?" Available at: https://thelawdictionary.org/prohibit/.

[3] Image courtesy of Mark Morgan via Flickr, under license CC BY 2.0.

[4] *Historical Statistics of the United States, Colonial Times to 1970* (Washington, DC: Government Printing Office,1975): pp. 689-91

[5] Image courtesy of Wikimedia Commons, within the public domain. (The Drunkards Progress)

[6] Volstead Act. (2018, July 07). Retrieved from https://en.Wikipedia.org/wiki/Volstead_Act

[7] History.com Staff. (2010). 18th and 21st Amendments. Retrieved July 14, 2018, from https://www.history.com/topics/18th-...1st-amendments

[8] Image courtesy of Wikimedia Commons, within the public domain. (Raid at Elk Lake)

[9] The Federal Council of Churches. (n.d.). Available at https://prohibition.osu.edu/american...uncil-churches

[10] Lerner, M. "Unintended Consequences." Public Broadcasting Station (PBS). Available at: http://www.pbs.org/kenburns/prohibit...-consequences/. Accessed on July 29. 2018.

[11] Image courtesy of Wikimedia Commons, within the public domain. (Al Capone Mugshot)

[12] Twenty-first Amendment to the United States Constitution. (2018, May 12). Retrieved from https://en.Wikipedia.org/wiki/Twenty...ion#cite_ref-3

[13] Competitive Enterprise Institute. 2017. "5 Weird Ways Prohibition Still Exists Today." Available at: https://cei.org/content/5-weird-ways...l-exists-today.

[14] U.S. Fish and Wildlife Service. "Endangered Species Act." Available at: https://www.fws.gov/international/la...ecies-act.html. Accessed July 25, 2018.

[15] Wikipedia. 2018. "Endangered Species Act of 1973." Available at: https://en.Wikipedia.org/wiki/Endang...es_Act_of_1973.

[16] Goble, D.D., J.M. Scott and F.W. Davis. 2005. *The Endangered Species Act at Thrity*. Washington DC: Island Press.

[17] Video courtesy of U.S. Fish and Wildlife Service via Youtube, within the public domain.

[18] U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office. 2011. "Northern Spotted Owl: Strix Occidentalis Caurina." Available at: https://www.fws.gov/arcata/es/birds/nso/ns_owl.html.

[19] Dawson, R.W., J.D. Ligon, J.R. Murphy, J.P. Myers, D. Simberloff and J. Verner. 1987. "Report of the Scientific Advisory Panel on the Spotted Owl." *The Condor* 89(1): 205-229.

[20] Bonnett, M. and K. Zimmerman. 1991. "Politics and Preservation: The Endangered Species Act and the Northern Spotted Owl." *Ecology Law Quarterly* 18(1): 105 - 171.

[21] Thomas, J.W., E.D. Forsman, J.B. Lint, E.C. Meslow, B.B. Noon and J. Verner. 1990. "A Conservation Strategy for the Northern Spotted Owl." Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl. U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management, Fish and Wildlife Service and National Park Service. U.S. Goverment Printing Office: 1990-791-171/20026. Available at: https://www.fws.gov/wafwo/species/Fa...20Strategy.pdf.

[22] Oregon State University. 1990. News Release, "Economic Impact of Owl Decision to be Major, Widespread." (June 28, 1990).

[23] Image courtesy of Shane Jeffries, U.S. Fish and Wildlife Service via Flickr, under license CC BY 2.0.

[24] Stwewards of the Sierra National Forest. "Unintended Consequences A Letter by Stan Harger Your LAO SOTSNF." Available at: https://www.sotsnf.org/index.php/new...ger-lao-sotsnf. Accessed: July 25, 2018.

[25] Brueck, H. 2018. "The Real Reason Why So Many Cities and Businesses Are Banning Plastic Straws." Business Insider. Online. Available at: https://www.businessinsider.com/plas...so-many-2018-7.

[26] National Public Radio. "How the Campaign To Ban Plastic Straws Got Its Start." Planet Money. Online. Available at: https://www.npr.org/2018/07/19/63058...-got-its-start.

[27] Gibbens, S. 2018. "How Do Plastic Straw Bans Work?" National Geographic. Online. Available at: https://www.nationalgeographic.com/e...raw-bans-work/.

[28] Image courtesy of Dean Hochman via Flickr, licencsed under CC BY 2.0.

[29] Legal history of cannabis in the United States. (2018, July 25). Available at: https://en.Wikipedia.org/wiki/Legal_..._United_States

[30] Image courtesy of Wikimedia Commons, within the public domain.

[31] History Channel. "Marijuana." Available at: https://www.history.com/topics/history-of-marijuana. Accessed on: July 31, 2018.

[32] Image courtesy of Wikimedia Commons, within the public domain.

[33]The Illegalization of Marijuana: A Brief History | Origins: Current Events in Historical Perspective. (n.d.). Available at: http://origins.osu.edu/article/illeg...-brief-history

[34] Video courtesy of Elaine McMillion Sheldon via Vimeo, licensed under CC BY 3.0.

[35] Bergstrom, T.C. and J.H. Miller. 2000. Experiments with Economic Principles: Microeconomics. 2nd ed. Boston, MA: Irwin McGraw Hill.

[36] Thorton, M. 1991. The Economics of Prohibition. Salt Lake City, Utah: University of Utah Press.

[37] Stigler, G. 1971. "The Theory of Economic Regulation." *Bell Journal of Economics* 2(1): 3 - 21.

[38] Dupré, R. (1999). “If It's Yellow, It Must Be Butter”: Margarine Regulation in North America Since 1886. *The Journal of Economic History, 59*(2), 353-371. doi:10.1017/S0022050700022865

[39] Wilson, T. (2018, January 23). The Butter Wars: When Margarine Was Pink. Available at: https://www.nationalgeographic.com/p...rine-was-pink/

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