The Apple Market

A Sample Chapter from

Experiments with Economics Principles

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Discussion D1

Supply and Demand

In Search of a Theory

We have a mystery on our hands. In the Apple Market, prices seem to be closing in on certain values. But what determines the values to which prices converge?

It would be really nice to have a *theory* that predicts outcomes, not only for the specific market that we observed experimentally, but for a variety of markets under widely varying conditions. We would like a theory that allows us to answer questions like:

- If every supplier's Seller Cost increases by $10, will the market price increase by exactly $10, by less than $10, or by more than $10?
- Suppose that the government decides to pay $10 to every person who buys a bushel of apples. Such a payment is called a **subsidy** to apple consumption. Will suppliers absorb some or all of the subsidy by increasing their prices, or will demanders get all of the benefits from the $10 subsidy?
- If bad weather reduces the quantity of apples that each producer could supply, what will be the effect on the price of apples and what will happen to total revenue of suppliers?

Economists have just such a theory. It is known as **supply and demand theory**, or more formally as **competitive equilibrium theory**. This theory offers answers to the above questions and to many others. These answers are often quite useful and surprising. Of course, a theory that predicts market outcomes will not be much good if these predictions are

badly wrong. Therefore it is important to see whether supply and demand theory does a good job of predicting the outcomes of our experiments. If the theory does well in these experimental environments and continues to do well as we add more elements of realism, then we can put some credence in its predictions for actual markets. If this simple theory does not perform well, then we must look for a better theory.

A Model of Competitive Markets

In our classroom experiment, particularly in the early rounds, some sellers were able to get higher prices for their apples than others. Some sellers were lucky enough to be offered a relatively high price by the first buyer they ran into. Similarly, some buyers were able to find a seller who would sell cheaply and others could only find sellers who insisted on a high price. Every participant in the market would like to get the best deal possible, but different participants will have different ideas about what is possible. To describe all market participants' beliefs about the prices at which they can trade and their luck about whom they meet would be an overwhelmingly complicated task, even for this simple market.

Instead of trying to describe this complex reality in full detail, let's try to make a simplified *model* of competitive markets. The art of good modeling in economics, as in all of science, is to find the "right" simplifications. The model should remove enough complication from the actual situation to allow us to analyze and predict outcomes, without removing so much reality that it seriously distorts our predictions about the way the market will behave. We are looking for a manageable model of markets that makes good predictions of the outcomes that we observe in experimental markets and in actual markets of the commercial world. Specifically, we would like a model that predicts the average price and the number of transactions in a market using the information that we have about the Buyer Values and Seller Costs of the market participants.

An effective way to simplify this problem is to assume that all demanders buy apples at the same price and all suppliers sell apples at the same price. For the first rounds of trading, this assumption is not very accurate, but in later rounds, as traders become better informed about the prices at which they can expect to buy and sell, the differences between prices paid for apples by different people tend to disappear.

If there were just one price for apples, those suppliers who could make a profit at this price would sell apples and those who would make a loss would not sell any apples. Similarly, those demanders who could profit by buying

apples at the prevailing price would buy and those who would lose money would not buy. At this price, it will be possible to satisfy everybody's wishes only if amount of apples that demanders want to buy is *the same* as the amount of apples that suppliers want to sell. At an arbitrarily chosen price, there is no reason to expect that demanders would want to buy the same amount that suppliers would want to sell. But as we will see, there will be *some* price at which the total amount of apples that demanders are willing to buy is equal to the total amount of apples that suppliers are willing to sell. This price, at which "supply equals demand," is known as the **competitive equilibrium price** and the number of units bought and sold at this price is known as the **competitive equilibrium quantity**.

Graphing Supply and Demand

Supply curves and **demand curves** are the main tools that we use to study competitive equilibrium. The supply curve tells us the total amount of a good that suppliers would want to sell at each possible price. We can draw a supply curve if we know each supplier's Seller Cost. In this experiment, since each supplier supplies at most one unit, the number of units that suppliers will be willing to supply at any price P is equal to the number of suppliers whose Seller Costs are less than or equal to P.

The demand curve tells us the total amount of a good that buyers would want to buy at each possible price. We can draw this curve if we know each demander's Buyer Value. In this experiment, each demander buys either one bushel of apples or no apples and thus the total number of bushels that demanders are willing to buy at any price P is equal to the number of demanders whose Buyer Values are greater than or equal to P.

We can show the way that the interaction of suppliers and demanders determines the outcome in a market by drawing the supply and demand curves on the same graph. Competitive equilibrium prices and quantities are found where the supply curve crosses the demand curve.

An Example

We will use a specific example to show how to draw supply and demand curves and find equilibrium prices and quantities. In this example:

- There are 10 high-cost suppliers, who have Seller Costs of 25 dollars a bushel.

- There are 20 low-cost suppliers, who have Seller Costs of 5 dollars a bushel.
- There are 15 high-value demanders, who have Buyer Values of 30 dollars for a bushel of apples.
- There are 15 low-value demanders, who have Buyer Values of 10 dollars for a bushel of apples.

This information is summarized in Table D1.1

Table D1.1: Distribution of Types–Example Market

Type of Agent	Number of Agents	Cost	Value
Low-Cost Supplier	20	5	[redacted]
High-Cost Supplier	10	25	[redacted]
High-Value Demander	15	[redacted]	30
Low-Value Demander	15	[redacted]	10

Making a Supply Table

A **Supply Table** shows the number of bushels of apples that suppliers would offer at each possible price. We can construct a Supply Table for the example market using the information in Table D1.1.

Table D1.2: Supply Table–Example Market

Price Range	Amount Supplied
$P < \$5$	0
$\$5 < P < \$25$	20
$P > \$25$	30

In the example market, low-cost suppliers have a Seller Cost of \$5 a bushel and high-cost suppliers have a Seller Cost of \$25 a bushel. At any price below \$5 a bushel, every supplier who sold a bushel of apples would lose money because it costs every supplier at least \$5 to produce a bushel of apples. Therefore at prices below \$5, nobody would want to supply any apples, so the total number of bushels supplied to the market would be zero. We therefore enter 0 as the amount supplied in the first line of Table D1.2.

If the price, P, is between \$5 and \$25, the 20 low-cost suppliers can each make money by selling a bushel of apples, since their costs are only \$5. But the high-cost suppliers would lose money if they sold apples for any price that is below \$25, since it costs them \$25 to produce a bushel of apples. Therefore at prices between \$5 and \$25, the 20 low-cost suppliers will each sell a bushel of apples, but the high-cost suppliers won't sell any apples. The total quantity of apples supplied at prices between \$5 and \$25 must be 20 bushels, and so we enter 20 as the amount supplied in the second line of the Supply Table.

At prices above \$25, all of the high-cost suppliers *and* all of the low-cost suppliers can make money by selling apples. Since there are 10 high-cost suppliers and 20 low-cost suppliers, the total amount supplied at prices above \$25 is 30 bushels. Therefore we enter 30 as the amount supplied in the last line of the Supply Table.

Making a Demand Table

We can construct a *Demand Table* for this market in much the same way. The Demand Table shows the number of bushels of apples that demanders want to buy at all possible prices.

The highest Buyer Value for a bushel of apples is \$30. If the price is above \$30, no buyer will want to buy any apples. So for all prices above \$30, the number of bushels demanded is 0. We record this fact in the first line of Table D1.3.

Table D1.3: Demand Table–Example Market

Price Range	Amount Demanded
$P >$ \$30	0
\$10 $< P <$ \$30	15
$P <$ \$10	30

If the price of apples is between \$10 and \$30, then all 15 of the high-value demanders can make profits by buying a bushel of apples. But low-value demanders will lose money if they buy apples. So at prices between \$10 and \$30, the total demand for apples is 15 bushels, and we write 15 as the amount demanded in the second line of Table D1.3.

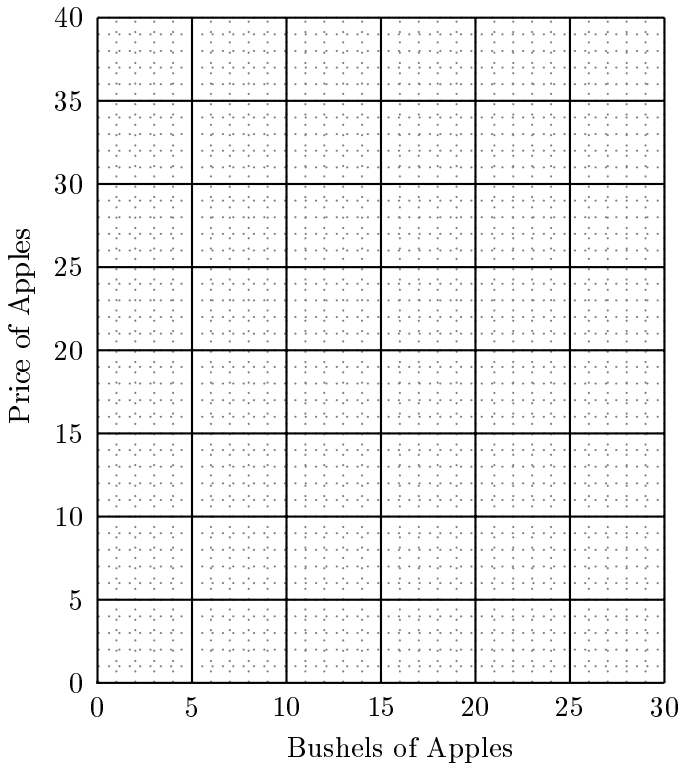
If the price of apples is below \$10, then all of the high-value demanders and all of the low-value demanders can make a profit by buying apples. There are 15 high-value demanders and 15 low-value demanders, so that

total demand for apples at any price below $10 is 30 bushels. Therefore we enter 30 as the amount demanded in the bottom line of Table D1.3.

Drawing Supply and Demand Curves

The supply and demand tables will help you to graph a supply curve and a demand curve. The first step is to draw a pair of axes, with *price of apples* measured on the vertical axis and *quantity of apples* measured on the horizontal axis. This has been done in Figure D1.1 below.

Figure D1.1: Supply and Demand for Apples



Drawing the Supply Curve

A **supply curve** shows the total number of apples that sellers would be willing to sell at each possible price. Price is shown on the vertical axis and quantity (number of units) supplied is shown on the horizontal axis. To determine the quantity that will be supplied at any price, first find the

price on the vertical axis, then move horizontally across the graph until you reach the supply curve, and then read directly downward to find the quantity supplied. We will make a practice of drawing supply curves in red. (Your graphs are will be much easier to read if supply and demand curves are different colors.)

As we see from the Supply Table, at prices below \$5, the amount of apples supplied is 0. Thus the supply curve must show that at these prices no apples will be supplied. This means that the supply curve includes a vertical line that follows the vertical axis from the origin $(0, 0)$ up to the point $(0, 5)$ where price is \$5 and quantity is 0. Draw this line segment.

At any price between \$5 and \$25, the total quantity supplied is 20 bushels. Therefore the supply curve includes a vertical line segment drawn from the point $(20, 5)$ up to the point (20,25). Add this line segment to your graph.

At prices above \$25, we see from the Supply Table that the quantity supplied is 30 bushels. Therefore the supply curve includes a vertical line starting at the point $(30, 25)$ and going straight up to the point (30, one zillion). We don't want you to run out of ink drawing one line, so just draw a line segment from the point $(30, 25)$ to the top of the box.

Your supply curve so far contains three red vertical line segments. But we haven't yet answered the question of what happens at a price of exactly \$5 or of exactly \$25. At a price of \$5, all of the high-cost suppliers would lose money if they sold any apples. At a price of \$5, the low-cost suppliers won't *make* any money by selling apples, but they won't *lose* any money either. They will be *indifferent* between selling and not selling. Since at a price of \$5, each of the 20 low-cost suppliers would be satisfied with supplying any quantity between 0 and 1 bushel, we can say that at a price of \$5, suppliers in total would be willing to supply any quantity of apples between 0 and 20 units. We show this fact by adding a horizontal segment at a price of \$5 on our supply curve. On the graph, this segment is a line from the point $(0, 5)$ to the point $(20, 5)$.

At a price of \$25, all 20 of the low-cost suppliers will want to supply, and the 10 high-cost suppliers would just break even. At this price, each of the 10 high-cost suppliers is willing to supply any amount between zero and one unit. So at a price of \$25, the total quantity supplied can be any amount between 20 and 30 bushels. This implies that the supply curve includes a horizontal segment at a price of \$25. This segment runs from the point $(20, 25)$ to the point $(30, 25)$.

Drawing the Demand Curve

Now that you have drawn a supply curve, it is time to draw a **demand curve.** The demand curve shows the total quantity of apples that demanders would like to buy at each possible price. Like the supply curve, the demand curve consists of vertical and horizontal line segments. You can use the Demand Table to draw the demand curve, much as you used the Supply Table to draw the supply curve. You can probably do this without reading the rest of this section, but in case you get stuck, you will find detailed hints on how to draw the demand curve on the "Lookup Page," which is found on page 20. (We suggest that you try to draw your the supply and demand curves for this example before you peek at the Lookup Page. After you have tried, you can check to see if you got it right.)

Finding Equilibrium Price and Quantity

The **competitive equilibrium price** for a good is the price at which the total amount that suppliers want to sell is equal to the total amount that demanders want to buy. The quantity that is supplied and demanded at the competitive equilibrium price is the **competitive equilibrium quantity**. If you have drawn the supply curve and the demand curve on a graph, how can you find the competitive equilibrium price? Before reading the answer which appears below in small print, see if you can figure it out for yourself.

> **Answer:** Remember that the quantity demanded or supplied at any price is found by locating the price on the vertical axis and reading across until you reach the demand or supply curve. If at some price, supply equals demand, it must be that at this price, the supply curve and the demand curve are touching each other. Thus to find the competitive equilibrium price, simply draw the supply curve and the demand curve and find where they cross. If the two curves intersect at a single point, then you can read across to the vertical axis to find the competitive equilibrium price and down to the horizontal axis to find the competitive equilibrium quantity. (Sometimes the demand curve and supply curve may overlap at more than one point. In this case, there will be more than one competitive equilibrium price and/or quantity.)

If you look at the supply and demand graph that you drew, you can see that at any price higher than the competitive equilibrium price, suppliers want to sell more apples than demanders want to buy. At any price lower than the equilibrium price, demanders want to buy more apples than suppliers are willing to sell. But at the competitive equilibrium price, suppliers want to sell exactly as many apples as demanders want to buy.

■ In this example, if you have drawn your supply and demand curves correctly, they will cross each other at exactly one point. At the point where the two curves cross, the price is $_____ and the quantity is _____ bushels.

Lookup Page for Supply and Demand Curves

Hints on Drawing the Demand Curve.

The highest value that anybody puts on apples is 30, so we know that at prices above 30, nobody is going to want to buy apples. Therefore you can use your green pen to mark a vertical line extending from the point (0,30) to the top of the box. At prices greater than 10 but less than 30, all of the high demanders, who have Buyer Values of 30, will want to buy a bushel of apples, but none of the low demanders, who have Buyer Values of only 10, will want to buy. There are 15 high-value demanders, so total demand at any of these prices is 15. This means that the demand curve includes a vertical segment running from (15,10) to (15,30). At prices below 10, everybody will want to buy one bushel. There are 30 demanders in all, so that total demand will be 30 bushels. The demand curve, therefore, includes a vertical segment running from (0,30) to (10,30).

At a price of exactly 30, the 15 high-value demanders are just indifferent between buying or not. Total demand could be anything between 0 and 15. Therefore the demand curve includes a horizontal segment running from (0,30) to (15,30). At a price of exactly 10, the 15 high-value demanders will all want to buy one unit. The 15 low-value demanders will be just indifferent between buying and not buying, so at this price, demand can be anything between 15 and 30. Therefore the demand curve includes a horizontal segment running from (15,10) to (30,10).

Figure D1.2: Supply and Demand–Example 1