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Chicago Price Theory

An Introduction

THE CHICAGO ECONOMICS TRADITION

A longstanding Chicago tradition treats economics as an empirical subject that measures, explains, and predicts how people behave. Price theory is the analytical toolkit that has been assembled over the years for the purpose of formulating the explanations and predictions, and guiding the measurement.

In the tradition of Chicago's "Economics 301," the purpose of this course is to help you master the tools in the kit so that you can use them to answer practical questions. Studying price theory at Chicago is "a process of immersion in those models so that they bec[o]me so intuitive to one's work that, in combination with new empirical investigation, they open the door to novel evaluations of market organization and government policy."[1]

Because price theory at Chicago has always been tethered to practical questions, this course and the course Jacob Viner taught at Chicago almost 90 years ago (Viner 1930/2013) share some remarkable similarities. The tradition draws heavily on Alfred Marshall (1890) in, among other things, viewing human behavior in the aggregate of an industry, region, or demographic group. Market analysis is essential to price theory because experience has shown that markets enable each person to do things far differently than if he or she lived in isolation. It is no accident that price theory is named after a fundamental market phenomenon: prices.

Price theory is not primarily concerned with individual behavior; models featuring individuals are provided when they offer insight about the

aggregate. None of this is to say that price theory only looks at average or representative agents. Indeed, a primary reason that markets transform human activity is that they encourage the amplification of innate differences among people. Heterogeneity can be important; as we see in the example of comparative advantage below, markets can amplify heterogeneity through returns to specialization.

Price theory has not been static, though. Gary Becker, who taught Economics 301 for many years and gives a couple of the lectures in the video series that accompanies this book, developed human capital analysis and extended price theory to deal with discrimination, crime, the family, and other "noneconomic" behaviors. Becker and Murphy revisited the topic of complementary goods, using it to examine addictions, advertising, and social interactions (Becker 1957, 1968, 1993; Becker and Murphy 1988, 1993, 2003). Most important, people and businesses are in different circumstances today than in Viner's time—as witnessed by the decline of agricultural employment, increased life expectancy, and the rise of information technology.

PRICE THEORY DIFFERS FROM MICROECONOMICS

Although strategic behavior, such as the interactions among sellers in a market where they are few in number, has been treated with price theory (Weyl 2018), the introductory Chicago price theory course has not emphasized it. Competition, by which we mean that buyers and sellers take prices as given and the marginal entrant earns zero profit, is emphasized in large part because for most purposes, it is a reasonable description of most markets (Pashigian and Self 2007). Moreover, the competitive framework is simple enough to make room for us to master additional aspects of tastes and technology—such as product quality, habit formation, social interactions, durable production inputs, and complementarities—that are important for practical problems. Monopoly models are used on those occasions when price-setting behavior is relevant (Friedman 1966, 34–35; Stigler 1972; Demsetz 1993, 799). More generally, price theory is stingy as to the number of variables that are declared to be important in any given application.

In emphasizing markets and competition, price theory is different from microeconomics. Both typically begin with the consumer or household, but price theory stresses how consumers react to prices, many times without reference to utility or even "rationality"; whereas microeconomics

takes care to lay down an axiomatic foundation of the utility function and individual demand functions. Price theory then quickly gets to market equilibrium, treating related subjects such as compensating differences, tax incidence, and price controls.

Microeconomics makes more intensive use of game theory, which traditionally puts somewhat more emphasis on rationality and optimizing agents. Both price and game theory model behavior as an equilibrium, but the latter typically focuses on interactions among small numbers of agents and strives to make separate predictions for each one. The rest of the market is treated as a constant.

The typical auction model of price (Klemperer 2004) is an example of the game-theoretic approach. That model has a fixed number of goods for sale in the auction, with little attention to how the goods were produced or how they would be used if not sold in the auction. The model has a fixed number of buyers and predicts how each buyer separately makes bids on the items for sale. Understanding why there are, say, two buyers rather than some other number, or what determines the seller's reservation price, is considered to be an advanced topic. With its emphasis on competitive market equilibrium, basic price theory is not concerned with bid prices but rather the ultimate transaction price, aggregate quantities produced and sold, and how they are connected with costs of various kinds, as well as how the good is situated in the consumer demand system.

The market-equilibrium approach says that the most important effects of policy, technical change, and other events are not necessarily found in the immediate proximity of the event. An ethanol subsidy example, discussed below, features a subsidy that is paid only in the market for fuel, which uses just a fraction of total corn production but has more price-sensitive demand. The market for animal feed is unsubsidized, but corn farmers' opportunity cost for selling animal feed is linked to the subsidized fuel market, so much of their gain from the subsidy comes from the increase in the equilibrium price of animal feed.

Real-life situations involve an element of strategic interaction where the players in a small-scale game understand the outside options available to them in a larger market. One approach would be to simultaneously model both the strategies and market prices. Auction models could, in principle, have endogenous production, entry, and reservation values that reflect economic activity outside the auction. But the point of theory in economics or any other field is to focus on important

variables and leave the others to the side. As noted above, a great many markets have many buyers and many sellers, and have complementarities, taxes, habits, and other variables that need attention before getting into the strategic details for specific buyers or sellers. These are the situations in which price theory is needed.

The ethanol subsidy example also demonstrates how price theory guides measurement. Empirical studies of markets over time, or comparisons across countries or industries, must consider how to summarize a seemingly complicated reality behind each observation. Price theory shows how the appropriate approach to measurement depends on the question at hand.

Putting practical questions in a market context changes the answer. Trained economists are generally aware that market analysis is why the economic incidence of, say, a tax is different from the legal liability for paying the tax. But without price theory, economics training has too little practice in market analysis and results in policy investigations that too quickly presume that, say, the corporate income tax primarily harms corporations or an earned income tax credit primarily benefits workers.

USING *CHICAGO PRICE THEORY* TO LEARN ECONOMICS

Graduate microeconomics texts often devote more pages to game theory than competitive equilibrium, and part of their competitive analysis is dedicated to confirming that an equilibrium exists as a mathematical object. To the price theorist, the toolkit's mathematical foundations and possible abstract generalizations are an interesting subject for specialists, whereas a general economics education requires seeing how the tools have been successfully applied in the past and preparing to nimbly apply them to the next practical question that we encounter. Completing a mathematical microeconomics course will not make you good at price theory; price theory skills are obtained by practicing applications of the toolkit.

Whereas many economics courses help you master models, and leave application of those models as an advanced topic, price theory immediately engages the student with applications. The book and video series (available at https://press.princeton.edu/titles/30205.html or ChicagoPriceTheory.com) together provide three or four methods of practicing applications. First, both book and videos contain

chapter-length examples such as addictive goods, urban property pricing, learning-by-doing, the consequences of prohibition, the value of a statistical life, and occupational choice. These chapters are instances of applications of price theory that were advanced by important research papers, and sometimes spawned an entire subfield of research activity, with novel and counterintuitive results.

At Chicago, both the students and instructors over the years have gotten better at price theory as a result of engaging with the homework. If you want a formula that makes you good at price theory, this is it: practice. Know what tools are available to study markets, and with repetition notice the types of questions to which each tool is best suited, in the sense of offering a simple analysis with predictions in accordance with observation.

The Chicago homework problems are not paired with specific lectures because part of excelling at real-world applications is knowing which price-theoretic tool is the best one to use for a particular practical problem. This book therefore provides a number of sample homework questions, but only at the end of one of the three parts of the book. The video series includes about a dozen of Professor Murphy's impromptu answers to student questions about current market events.

Becker and Murphy's course has always been intensive in solving applied problems, with considerable time of the instructors and advanced star graduate students devoted to formulating and helping students solve homework questions. The drafts of the book and video are now being used at Chicago to further "flip" the Price Theory classroom so that more of the student interactions with Murphy address applied problems.[2] Price theory instructors not at Chicago also have the opportunity to reallocate their time away from lecturing—let this book and video series help with that—and toward developing and discussing relevant and challenging applied homework questions.

Another way to practice applications is to do some homework before you begin the course and return to them afterwards. You will be amazed at how differently you think at the end! The six questions below are good examples:

1. Is learning by working on the job cheaper than formal schooling? (See chapter 9.)
2. What is the difference between prohibiting marijuana sales and subjecting its sales to a high tax? (See chapter 12.)

3. A great many manufacturers use machines and labor in fixed proportions. Does that mean that the wage rate has little effect on the amount of labor used in manufacturing? (See chapter 7.)
4. Does the availability of e-books reduce the sales of physical books? (See chapter 11.)
5. When housing prices are above their long-run values and continue to rise, is that good evidence that home buyers or builders have unrealistic expectations about the future? (See chapter 15.)
6. Could a billion dollars in federal subsidies to farmers increase farm incomes by more than one billion? (This chapter.)

As you work through the homework questions and the applied chapters, you will practice identifying and applying the tools of price theory. But the tools are just a means to an end, which is to understand human behavior. Most of the homework questions and applied chapters in price theory are therefore real-world questions about human behavior, of the same kind that are addressed by professional economists every day at central banks, major corporations like amazon.com, and regulatory agencies like the Food and Drug Administration.

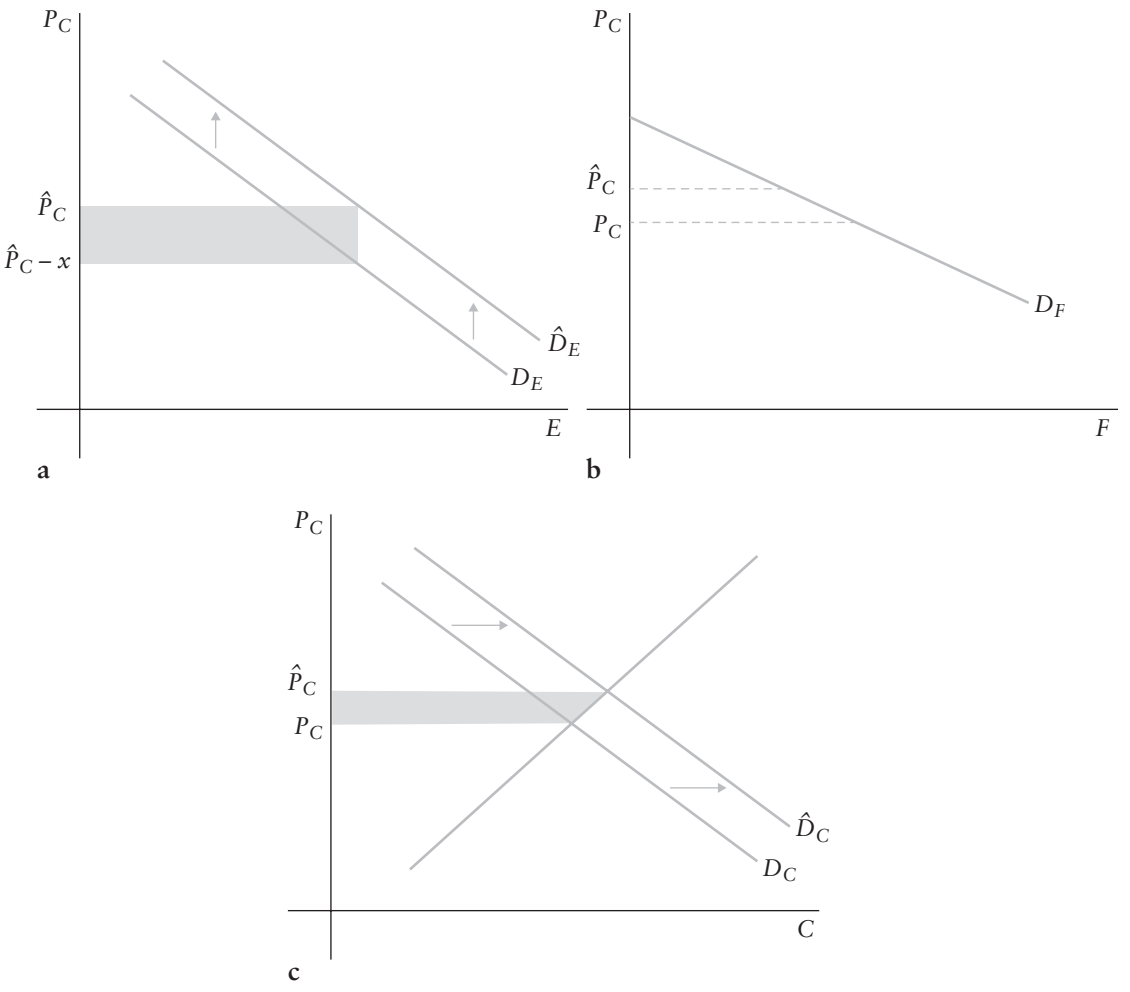
Because it is useful, price theory gets applied to a large number of practical questions. Each practitioner of price theory thereby builds a wealth of experience that pays dividends in subsequent applications. New problems are recognized for their relation to problems already solved. Perhaps this is why price theory is sometimes called "intuitive."[3]

EXAMPLE: ETHANOL FUEL SUBSIDIES

A Market "Multiplier"

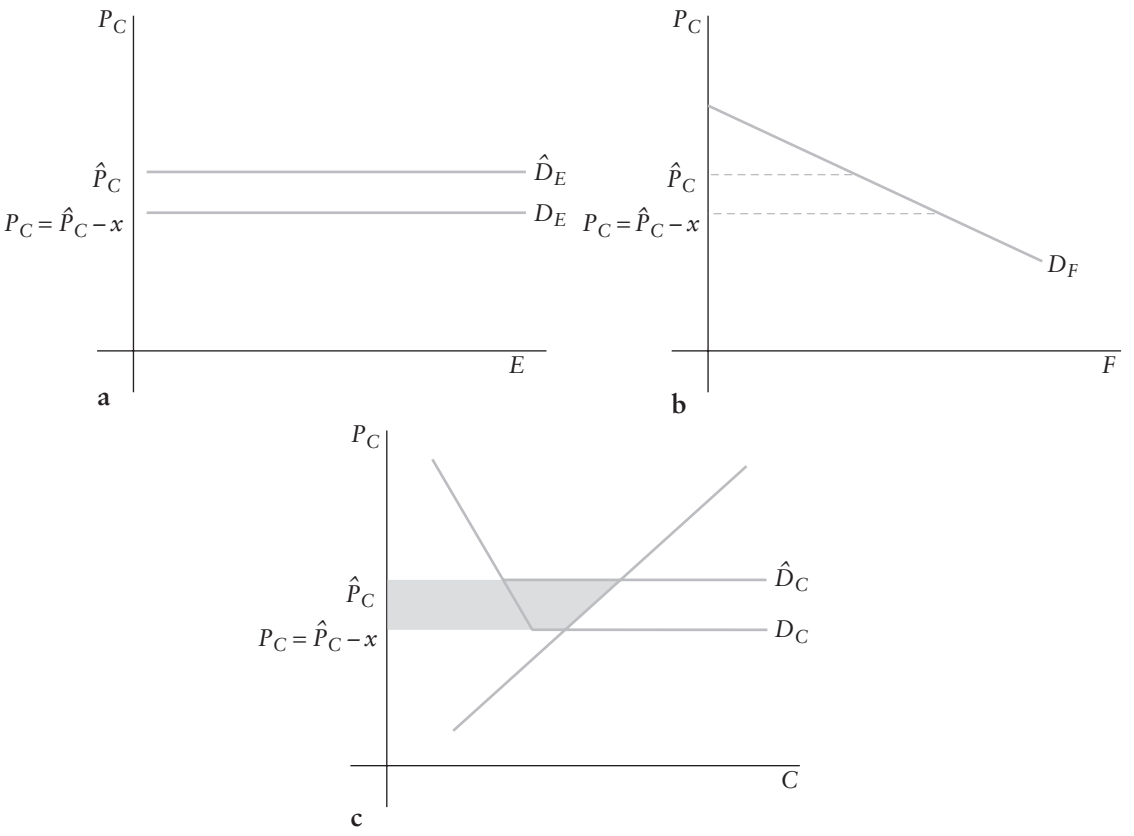
The federal government has been supporting the production of ethanol fuel with a variety of tax credits, subsidies, guarantees, and so forth. When the U.S. government started subsidizing ethanol fuel, the price of land used to grow corn—the primary ingredient in U.S. ethanol production—increased, regardless of whether the corn grown on that land actually ended up in the fuel.

Given that U.S. ethanol is primarily produced with corn, is it possible that corn farmers benefit by more than $1 billion for each $1 billion that the federal treasury spends on that support? In other words, let's use price theory to examine the incidence of ethanol fuel subsidies.



Figures I-1a, I-1b, and I-1c: Can farmers gain more from an ethanol subsidy than the amount the government pays?

Take a simple model in which corn, C, is used to make either ethanol fuel, E, or animal feed, F. We will consider demand curves D_E, D_F, and D_C, shown in Figures I-1a, I-1b, and I-1c, respectively; D_C, the market demand curve for corn, is found by adding the demands for ethanol and animal feed. A subsidy of the amount x per unit corn used in ethanol serves to increase the demand for ethanol by x units in the price dimension to $\hat{D}_E$. Horizontally adding the new ethanol demand curve with the stable feed demand curve, we get a new overall corn demand curve $\hat{D}_C$. Supply and demand for corn determine the equilibrium price of corn, which is the same regardless of how it is used. An example of our market is shown in Figures I-1a–c.

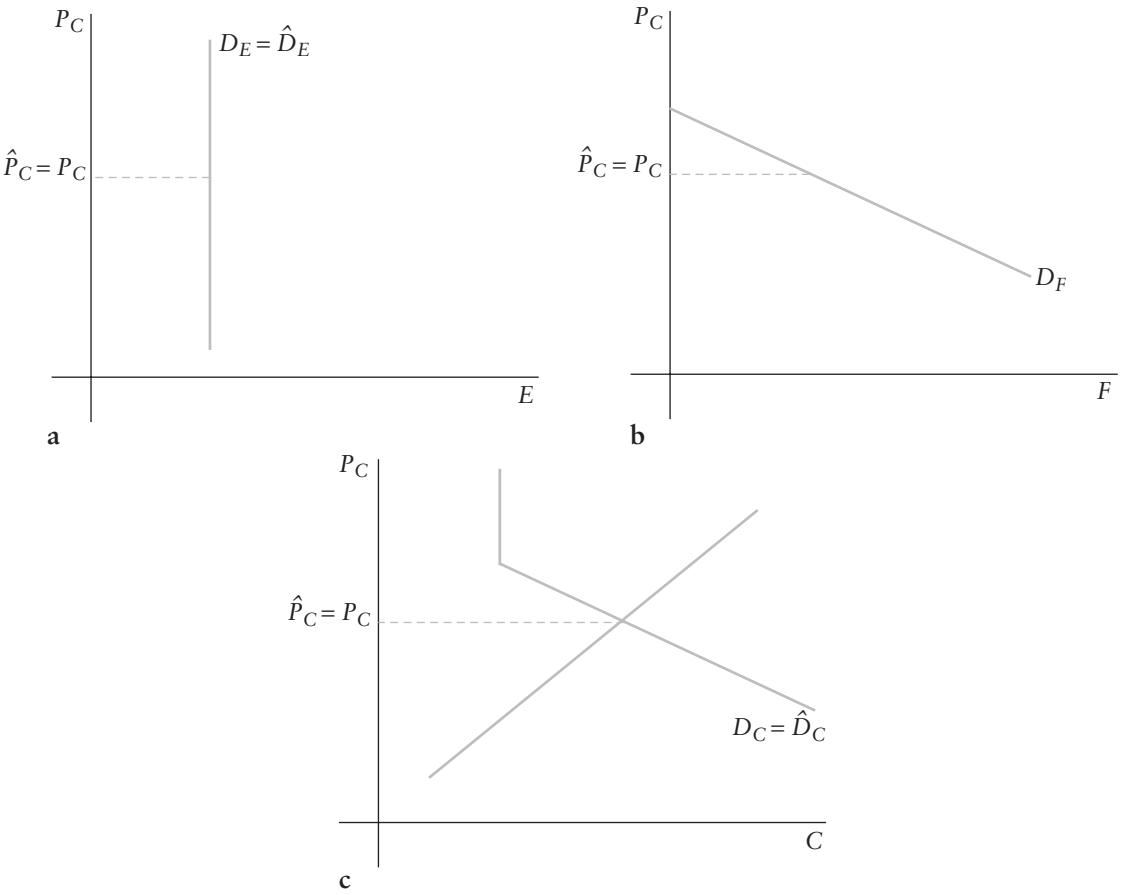


Figures I-2a, I-2b, and I-2c: In a market where demand for ethanol is more elastic than the demand for feed, the benefit of the ethanol subsidy to corn farmers can exceed the amount the government spends on the subsidy.

The result of the subsidy is that more corn is sold overall, and for a higher price ($\hat{P}_C$ rather than P_C). Less corn is sold for animal feed, because that demand curve is stable and the price is higher. The extra corn sales go to ethanol because the subsidy amount x more than offsets the price increase.

Our question, posed from the perspective of the figure, is whether the producer-surplus trapezoid in the market for corn (see Figure I-1c) can be larger than the subsidy-expenditure rectangle in the market for ethanol (see Figure I-1a).

Consider a case in which the demand for ethanol fuel is perfectly elastic (Figure I-2a) and the demand for feed is strictly decreasing (Figure I-2b). The overall demand curve is flat when the price is below what the ethanol market will bear (Figure I-2c). At prices above that, all corn is sold for



Figures I-3a, I-3b, and I-3c: In a market where demand for ethanol is more inelastic than the demand for feed, the benefit of the ethanol subsidy to farmers cannot exceed the amount the government spends on the subsidy. The ethanol demand shown above is perfectly inelastic, so the subsidy has no price impact.

animal feed and none for ethanol. Putting the two together, we have an overall demand curve with a hockey-stick shape, as shown below when we adapt the previous graphs to this new setting, as shown in Figures I-2a–c.

Suppose the subsidy is $0.10 per gallon. Then, in this market, the $0.10 gap created between the buyer and seller price per gallon in the ethanol market gets carried over in full to the aggregate market for corn.[4] If the subsidy is small enough, the gain to corn farmers is larger than the amount the government is paying.[5] Why? Not only do corn farmers get $0.10 more for the corn going to ethanol, which the government pays; they also get $0.10 more for the corn going to feed, which the animal-feed buyers pay. Maybe this also helps explain why the federal

government assists corn farmers with an ethanol subsidy rather than paying the farmers cash directly.

Now consider a case in which the demand for ethanol fuel is perfectly inelastic. We leave the demand for feed unchanged.

Figure I-3a shows ethanol corn demand as perfectly inelastic, which means that, given any price, people demand the same amount. Thus an ethanol subsidy, which reduces the price that the ethanol corn buyers see, has no effect on their demand. Because the market demand curve is just the sum of the demand curves in the ethanol and feed markets, as shown in Figure I-3c, there is likewise no effect on market demand. The corn farmers, in this case, get no surplus from the subsidy despite what the government spends on it.

In general, corn farmers can benefit more than the amount the government spends on the subsidy only if the demand for ethanol is more elastic than the demand for feed. This is the empirically likely case, given that there are corn-free ways to make fuel that is essentially the same from the fuel consumer's perspective, but it is not as easy to switch to alternative animal feeds. Moreover, the supply of land for growing corn may be inelastic in the short run (but probably elastic in the long run).

How can we think about this intuitively? Think about price discrimination. Normally, we want to charge the low price to the people with elastic demand and the high price to people with the relatively inelastic demand. The ethanol subsidy looks like price discrimination precisely when the demand for ethanol is price elastic relative to feed because it pushes the ethanol price down relative to the feed price. Corn farmers can gain substantially in this scenario relative to spreading the same subsidy dollars across all corn sales.

We can also look at the equilibrium from the feed market perspective. Possible feed demand curves are already drawn in Figures I-1b, I-2b, and I-3b. The feed supply curve is a residual supply curve: the horizontal difference between the overall corn supply curve and the ethanol demand curve. The more elastic is ethanol demand, the more elastic the residual supply. In the perfectly elastic case introduced in Figure I-2, nothing is supplied to the feed market when prices are below the ethanol demand curve (all of the corn goes to ethanol)—and coincides with the overall supply curve at prices above that (no corn goes to ethanol). Figure I-4 therefore draws a supply curve that is horizontal at quantities in between the price axis and the overall supply curve.

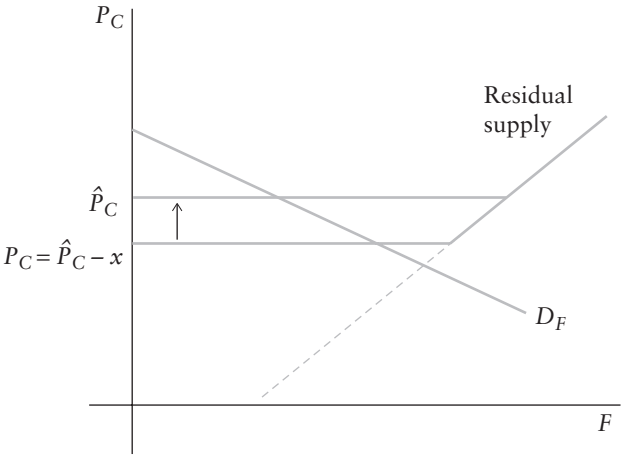


Figure I-4: The supply of corn to feed usage is a residual supply curve. It is shifted up by the subsidy in the ethanol market. The case shown here corresponds to horizontal ethanol demand.

The ethanol subsidy x shifts up the residual supply curve by the amount x and raises the price that feed buyers pay for corn by x. The revenue that corn farmers gain in the feed market could easily exceed the revenue they gain in the subsidized market (ethanol) because (i) ethanol gets a minority of corn production and (ii) more important, ethanol demand is much more price sensitive than feed-corn demand.

The main idea here is that because we have a market, the subsidy on ethanol has an effect broader than its initial amount. The price of corn going into animal feed will also increase.

Price Theory Guides Measurement

In many labor, health, and other markets with large amounts of subsidies or taxes, there is a big difference between the price paid by buyers and the price received by sellers because one of the parties is paying a tax or receiving a subsidy. In these cases, price theory makes it obvious that the proper measurement of price depends on whether buyer or seller behavior is to be explained.

In our ethanol subsidy example, some buyers pay less than others. The use of the various prices for empirical analysis depends on the question at hand. For the purposes of predicting the amount of government revenue to subsidize corn sales, what matters is the quantity-weighted average subsidy

in the market. That is the average of zero on feed corn and the subsidy rate on ethanol corn, weighted by the quantity of corn going to each use.

For the purposes of measuring the price impact, the quantity weights need to be adjusted for the price sensitivity of the buyers. In the neighborhood of no subsidy, the price impact formula is the product of three terms:[6]

$$\frac{dP_C}{dx} = \theta \, \frac{E}{C} \, \frac{P_C D'_E / E}{P_C D'_C / C} \, , \; \theta = \frac{D'_C}{D'_C - S'}$$

where x is the subsidy rate, S' is the slope of the supply curve and θ is the usual incidence parameter indicating how each unit of a uniform subsidy would raise the price received by sellers. As a matter of algebra, we could further simplify the formula, but we keep the three terms separate in order to discuss their economic interpretation. The second term in the price impact formula is the quantity-weight term and recognizes that only a fraction (E/C) of the corn supplied goes to ethanol. The third term, with a price elasticity for both its numerator and denominator, adjusts for any difference between the ethanol demand elasticity and the overall demand elasticity. The third term ranges from zero when ethanol demand is completely inelastic (Figure I-3) to $C/E > 1$ when ethanol demand is infinitely elastic (Figure I-2); it would be one if both types of buyers were equally price elastic.[7]

In other words, the units sold to more-price-elastic buyers count more than the units sold to less-price-elastic buyers. In our example, with one type of buyer that is subsidized and the less price-sensitive type of buyer that is not, the price-sensitivity-adjusted weighted average subsidy exceeds the pure quantity-weighted average, which is why the corn farmers can gain more than the Treasury spends on the subsidy.

The analysis above refers to a subsidy rate that is small in comparison with the price. With larger subsidies we need to consider, for example, that the three terms in the formula vary with the level of the subsidy, which is essentially the price-index problem whose solutions are discussed in chapter 4.

EXAMPLE: ACQUIRED COMPARATIVE ADVANTAGE

With its emphasis on markets, price theory frequently highlights comparative advantage, which is about economic progress obtained through specialization and trade. The specialization made possible by markets

helps explain where people live and work (Becker and Murphy 1992); why economies grow (Smith 1776/1904, Book I, Chapter I); why men are different from women (Becker 1985), but less so recently (Mulligan and Rubinstein 2008); and much more.

We examine the acquisition of comparative advantage in a simple market setup with two tasks, A and B. An individual has human capital for those tasks H_A and H_B. Whichever task is picked, a wage per unit of human capital is paid: w_A or w_B, as appropriate. This will mean total income for an individual from task A is $Y_A = w_A H_A$ and from task B is $Y_B = w_B H_B$. The maximum income that the individual can earn is

$$Y = \max\{w_A H_A, w_B H_B\},$$

which is obtained by picking task A if $w_A H_A > w_B H_B \Leftrightarrow \frac{w_A}{w_B} > \frac{H_B}{H_A}$, picking task B if $\frac{w_A}{w_B} < \frac{H_B}{H_A}$ and picking either task if the two ratios are equal. This is comparative advantage because the choice of task depends on the relative amounts of human capital held, not the absolute amount.

Figure I-5 illustrates the choice in the $[H_A, H_B]$ plane by drawing a solid task-indifference ray showing all of the configurations of human capital that someone could have and be indifferent toward the two tasks.

There is demand for tasks A and B, which in equilibrium has to match up with the available human capital and the aforementioned incentives for workers to choose one task rather than the other. This happens with wage adjustments. If there were a lot of demand for A, then Figure I-5's task-indifference ray has to be steep so that lots of workers choose task A and few choose B. In other words, w_A / w_B would be greater than 1.

Now, assume we have reached the equilibrium, so that w_A / w_B reflects market supply and demand. Then for any point on the line, every person directly below and directly left must be earning the same income. See the dashed lines in Figure I-5. This is because each person on the dashed line above the task-indifference ray has the same level of H_B and his or her H_A does not matter because it is not used. Each person on the dashed line below the task-indifference ray has the same level of H_A and H_B does not matter because he or she does not use it. Let's call the union of the two dashed lines an indifference curve for the worker.

Now, let's allow each agent to choose their human capital. For example, the agent is considering whether to be a good plumber versus being a good

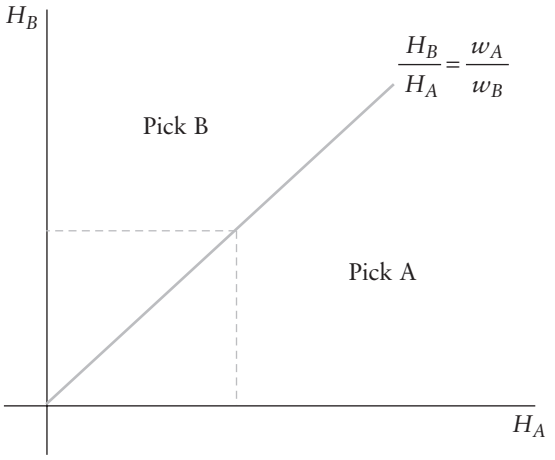


Figure I-5: Supply and demand will rotate the task-indifference ray until the right number of workers is in each task.

carpenter. The opportunity set for human capital could have an interesting shape, as depicted in Figure I-6. Consider the point associated with the maximum level of H_B. As it is depicted, this person will have some positive level of H_A. This reflects an underlying story that tasks *A* and *B* require some of the same abilities. Thus, if I choose to be a good plumber, that doesn't mean that I end up with zero human capital as a carpenter.

Note further that in this graph, the economically relevant region of the opportunity set lies between the two points, and we can erase the parts of the curve close to the axes because no one would choose a human capital pairing left of the top point or below the right point. On the erased regions, the agent could be better at both tasks!

Now let's put the opportunity set together with the worker's indifference curves, as in Figure I-7. We can even have everyone identical in the sense that they all have the same opportunity curve to choose from. Nevertheless, specialization is optimal behavior. Being equally good at tasks *A* and *B* is worse than being very good at just one task because you have acquired a lot of human capital that you do not use.

We started this picture by indicating the types of workers (that is, configurations of human capital) who are indifferent between the two tasks. But now we have shown that people will not choose to be those types of workers. Because human capital is acquired, indifference toward the two tasks does not occur in equilibrium.[8]

The equilibrium requires that both tasks are performed, so some people specialize in *A* and others in *B*. People who are identical, in the

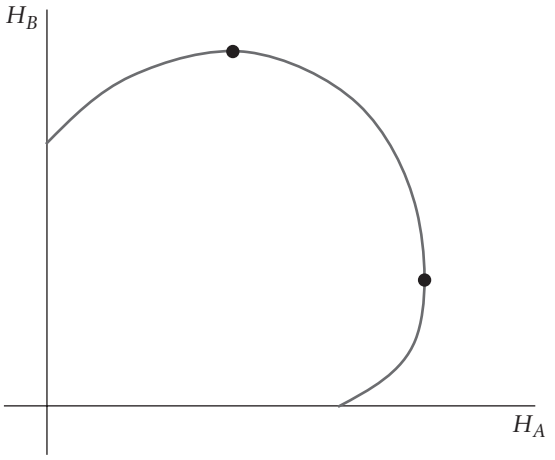


Figure I-6: The opportunity set for selecting human capital. The agent with maximum human capital for task *A* still has positive human capital for task *B*.

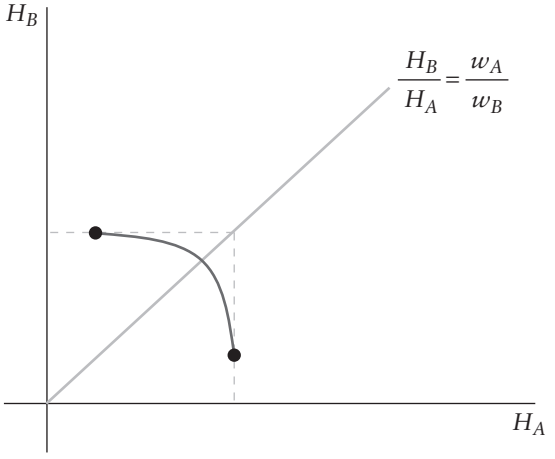


Figure I-7: Specialization. Agents maximize their human capital at task *A* or task *B*.

sense of having the same opportunities open to them, end up being different.

You might say that it is a coin flip as to exactly who goes toward task *A* and who toward task *B*, and we would agree if people were precisely identical. But in reality, people have somewhat different opportunities open to them: in Figures I-6 and I-7, that means somewhat different opportunity curves. Some of the opportunity curves may be relatively steep and others relatively flat. Then just a small difference among people

in the slope of the curve will decide who specializes in what. Specialization in the marketplace turns small differences into large ones.

OUTLINE OF THE COURSE

Three economic themes are repeatedly encountered when human behaviors are viewed through the lens of economic theory: substitution effects, market equilibrium, and durable goods. Each of these is a part of the course presenting the classic model and then going through some important applications such as price indices, learning by doing, and house prices.

Part I, on prices and substitution effects, is written from the perspective of consumer theory. We see little need to explicitly treat firms here, merely for the sake of repetition. The theory of substitution effects is the foundation of price and quantity indices (chapter 4), which are among the most widely used tools for economic measurement. Chapter 5 looks at a bit of "behavioral economics" from the perspective of the Marshallian demand curve. The distinction between short- and long-run demand, examined in chapter 6, has a number of immediate and nontrivial applications such as habits and addictions.

Once we have consumers, the purpose of bringing in firms is to have markets (Part II), which are the primary emphasis of the course. Here we begin with Adam Smith's (1776/1904) compensating differences, as further developed by Sherwin Rosen (1986) in his publications and teaching price theory at Chicago. Without saying much yet about production, this allows us to obtain results for urban economics and the accumulation of human capital.

One of the lessons of compensating differences is to be wary of purported "free lunches." The learning-by-doing application is of significant intrinsic interest but was also one of Becker's and Rosen's favorite demonstrations of a consequence of market competition, which reappears in a great many applications, ranging from health insurance to industrial organization to taxation.

Firms are carefully examined toward the end of Part II. This completes the foundation of the "industry model" (aka supply and demand), thereby opening up a huge range of applications. One application with particularly surprising results is the consequence of prohibiting trade in specific goods such as illegal narcotics, which is the subject of chapter 12. Exclusive dealing, quantity discounts, and other pricing practices are also

readily examined once we have consumers and firms together, as we show in chapter 13. The final chapter of Part II extends the industry model to more than two production factors, which is helpful for examining durable goods (as in Part III).

Part III looks at changes over time. It begins by defining durable goods and extending the industry model to include both a capital-rental market and a capital-purchase market (chapters 15 and 16). This brings us pretty close to the adjustment-cost model of investment and the neoclassical growth model (chapter 17). These are usually considered "macroeconomics" topics but, as factor supply and demand repeat over time, the two models should not be omitted from price theory. Most important, price theory treats durable goods because durability is an important feature in many practical questions.

The final three chapters look at important applications of the durable goods models—such as capital-income tax incidence, the determination of labor's share of national income, and investments in health.

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