SIMPLIFYING THE PRICE ELASTICITY OF DEMAND

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Abstract

Ockham's Razor is a reminder to keep things simple, but this principle is often ignored in the elasticity chapters of many economics textbooks. Many texts invoke slope unnecessarily and in contradictory ways. Discussions of the determinants of the price elasticity of demand have the potential to further confuse students, as do elasticity estimates that are dated and inappropriate. Principles instructors could better explain the price elasticity of demand by concentrating on the price-quantity point on a demand curve and the mid-point formula, while avoiding rotating demand curves and relying less on simplistic determinants and outdated estimates.

Key Words: elasticity of demand, price elasticity, demand

JEL Classification: A1, A2

"One should not increase, beyond what is necessary, the number of entities required to explain anything." - Ockham's Razor

Introduction

Several years ago on the heels of a standard lecture on elasticity, I asked the class the following question: "Is the demand for movie theater popcorn price elastic or inelastic at the current price?" The students began an enthusiastic debate based on four characteristics of price elasticity of demand (number of substitutes, percentage of income, necessity versus luxury, and time) and the two graphs shown in Figure 1.

The class finally decided the demand was "price inelastic" because movie popcorn comprises a small percentage of income and lacks a good substitute. By the end of the discussion, we were all convinced we were right, and that surely the demand curve for popcorn would be relatively steep.

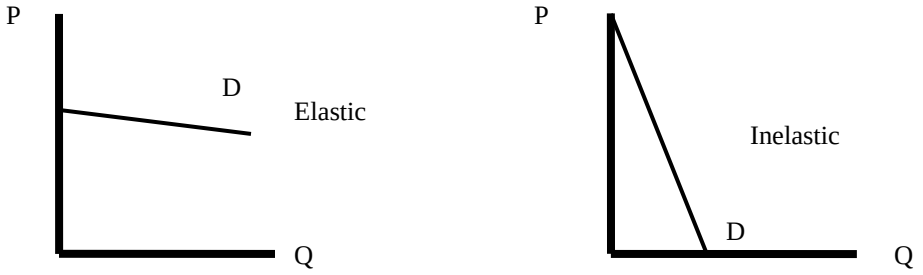

FIGURE 1. Misleading demand elasticity diagrams

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Later, I realized my somewhat obvious mistake: the demand for movie popcorn had to be price *elastic*, not inelastic. Five dollars for a container of popcorn is a raw display of monopoly power, and profit maximizing monopolies operate in the price elastic portion of the demand curve. It turns out that I had been misled by my own principles text and a failure to abide by Ockham's razor. Consideration of the slope and the determinants of price elasticity of demand had led to an incorrect conclusion.

It can be argued, at least theoretically, that if goods are sold by firms with some degree of monopoly power, then those goods probably have prices that place them in the price elastic part of their demand curves. That relatively minor insight is enough to expose a host of problems with the way we still teach price elasticity of demand.

Perhaps, some economists have forgotten Nieswiadomy's (1986) succinct demonstration in the *Journal of Economic Education* that used simple mathematics to show that for linear demand curves, price elasticity depends on the price of the good and the price intercept, but not the slope. For:

$$P = c - dQ \tag{1}$$

the price elasticity of demand is:

$$E = \frac{P}{c - P} \tag{2}$$

The slope term (d) does not appear in Equation 2 and is, therefore, not a determinant of price elasticity of demand. Yet, many principles of economics authors in one manner or another still imply that slope is a determinant of the price elasticity of demand.[2]

Principles textbooks have tended to confuse students with respect to price elasticity of demand in three ways. First, textbook authors often use graphs that lead students to confuse slope with the price elasticity of demand. Second, textbook authors over-rely on specific factors in determining price elasticity of demand. Lastly, some authors include tables of outdated price elasticity numbers that could lead students to believe that price elasticity of demand is constant over time regardless of changes in many significant factors.

Where We're Going Wrong

How elasticity and slope are confused

A number of Microeconomics principles texts (Bade & Parkin, 2009; Hubbard & O'Brien, 2008; Mankiew, 2004; McConnell, Brue, & Flynn, 2009; J. Miller, 2009) continue to include figures that use a relatively flat curve to illustrate a relatively price elastic demand curve and a relatively steep curve to illustrate a relatively price inelastic demand curve. For instance, authors sometimes use a figure like Figure 2 to claim that the relatively steep demand curve for cigarettes is illustrative of a product facing price inelasticity of demand. Such a figure contributes to the confusion that persists between price elasticity of demand and the slope of the demand curve. The demand curve in Figure 2, like any linear demand curve, has a portion over which the demand is price inelastic and a portion over which the demand is price elastic.

[2] Karl Case's comments on the Nieswiadomy article and his textbook coauthored with Ray Fair and Sharon M. Oster (2008) are notable exceptions.

Consequently, figures like Figure 2 have the potential to mislead the reader into thinking that all points along a relatively steep demand curve are points of price inelasticity.

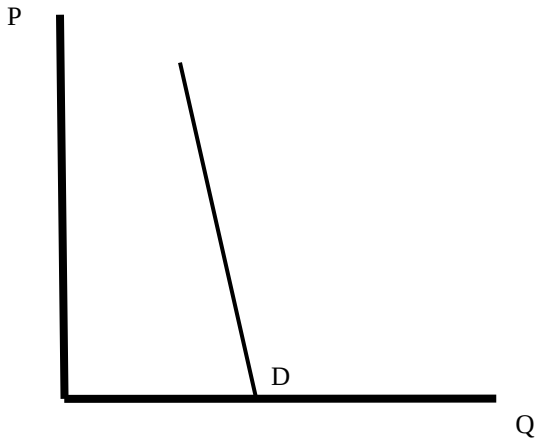

FIGURE 2. Common, but misleading, inelastic demand diagram

The entire demand curve, which is truncated in Figure 2, is shown in Figure 3. Students should understand that, given a sufficiently high price, the demand in Figure 2 might well be price elastic.

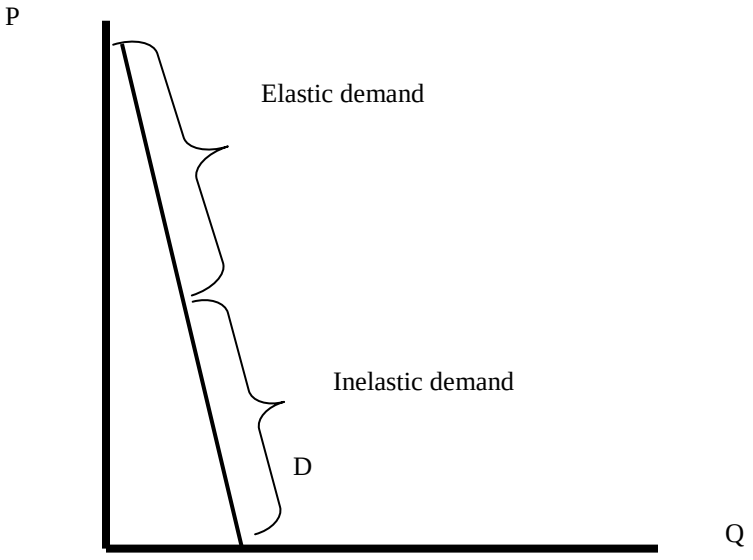

FIGURE 3. Steep demand curve

Portraying steep or flat demand curves as either price inelastic or elastic, respectively, is in direct conflict with Figure 3 which is also included in most principles texts. As shown in Figure 3, the price elasticity of demand changes along a linear demand curve. Because many texts include some diagrams showing that position on a demand curve determines price elasticity and other diagrams that imply slope determines price elasticity, students become confused.

Confusion between slope and the price elasticity of demand might also be related to the price elasticity formula itself:

$$E = \frac{P}{Q} * \frac{\Delta Q}{\Delta P} \quad (3)$$

It is obvious from Equation 3 that a product's price elasticity of demand is related to the slope since $\Delta Q/\Delta P = 1/\text{slope}$. It is also clear from the equation that for a given price-quantity combination a different slope will lead to a different price elasticity of demand. However, using a formula that invokes slope has the potential to mislead students into thinking that the slope of a linear demand function determines elasticity rather than a combination of position and slope. Luckily for students, only one principles textbook (Frank & Bernanke, 2009) of the 17 textbooks examined uses a price elasticity of demand formula that explicitly includes the inverse of the slope such that the elasticity = (P/Q) x (1/slope).

Comparing and rotating demand curves

Principles textbooks need to continue to strengthen the qualifier "*for a given price-quantity combination.*" The qualifier means that care must be taken when comparing the demand curves for two goods because they may not have similar price and units of quantity. Even if the price and quantity are nominally the same, the units for quantity may still make the slopes logically incomparable. A classic example of this misunderstanding was shown in the second edition of Samuelson's *Economics* (1951). Samuelson compared the demand for wheat and automobiles by overlaying the two demand curves using what the author calls "a careful juxtaposition of scales." Samuelson's figure is reproduced in Figure 4 and is used in the 1951 text to reinforce the notion that the demand for wheat is more price inelastic than that facing automobiles. Unfortunately, it is difficult to conjure an actual scale that would make the comparison meaningful.

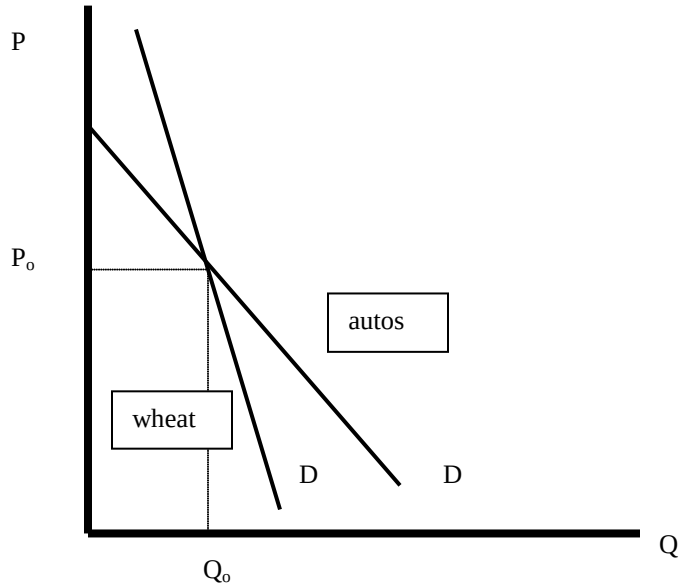

FIGURE 4. Comparing slopes for different goods

In other words, it makes little sense to compare the slope of the demand for cars with the slope of the demand for wheat as any contrast in slopes could easily be reversed by redefinition of units (bushels, tons, etc.). In fact, the problem associated with the arbitrary definition of units

is often cited in principles texts as one of the primary reasons for using price elasticity as a measure of demand sensitivity instead of slope. Despite that, many principles textbooks still place the demand curves for two different products side-by-side to illustrate how the steeper demand curve indicates a greater price inelasticity of demand regardless of how the products' units are measured.

In some principles textbooks there is a graph that shows two different demand curves for the same good. As shown in Figure 5 one demand curve is sometimes superimposed on the other demand curve. At the point of intersection, the curves share the same price and quantity combination, but the slopes differ. In this situation, the flatter curve shows a good facing a greater price elasticity of demand at the common price-quantity combination, but it should be noted that both curves still have elastic and inelastic ranges. The price (P_o) is merely closer to the top of the more "elastic" demand curve.

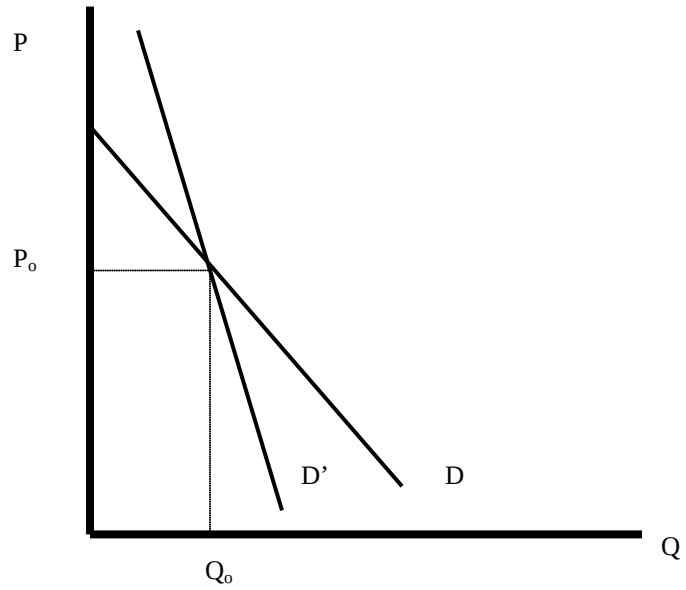

FIGURE 5. Changing slopes for the same good

The "rotating" demand curve shown in Figure 5 which changes both slope and intercept for the same good is difficult to explain to principles students. Most principles students have previously been taught that non-price determinants shift the demand curve rather than rotate it. So, what could cause such a change in slope? Although some factors clearly rotate the curve, these are generally not cases that can be effectively introduced at the principles level and certainly not in the elasticity chapter. For example, some forms of advertising rotate the demand curve while other forms of advertising are more likely to shift the demand curve outwards. According to Johnson and Myatt (2006) and Meyerhoefer and Zuvekas (2008), rotation is more likely to occur when advertising contains real information about a specialized product, while a demand shift is more likely to occur when the advertising makes consumers aware of the existence of a non-specialized product thereby stimulating demand among a large fraction of the mass market. Of the 17 microeconomic principles texts reviewed, only two (Schiller, 2008; Slavin, 2009) contain figures in the elasticity chapters that show a rotation in the demand curve

due to advertising. This case of rotating demand curves is probably something best introduced later in the course or in an intermediate level microeconomics class.

While the rotational aspect of advertising is not something we would expect principles students to comprehend, the difference between short-run and long-run is something that can be taught at the introductory level. Figure 5 can be used to show the effect of time on the price elasticity of demand such that the steeper curve, D', shows the short-run demand curve and the flatter curve, D, shows the demand curve for the same good in the long-run. *At any given price*, the price elasticity of demand for a good in the long-run will be more elastic than the price elasticity of demand for the same good in the short-run.

Changes in other common determinants of price elasticity (besides time) could also change the slope of the demand curve for a specific good. And, while it is true, that at any given price the flatter demand curve will be more price elastic than the steeper demand curve, it is also true, that a good initially facing an inelastic demand might still be facing an inelastic demand if both points are in the lower half of both curves. A change in the slope of a demand curve does not necessarily mean that the price elasticity of demand for that good has changed from being inelastic to elastic or vice-versa.

Comparisons of demand curves for different products and rotating demand curves for a single product have the potential to distract students from the fact that price elasticity of demand is determined by the price-quantity combination chosen on a linear demand curve irrespective of the slope. In short, graphically introducing a slope change (or rotation) in a principles discussion must be carefully done and restricted to the time factor so as not to add an unnecessary layer of complexity that would not survive Ockham's razor.

Determinants of price elasticity of demand can be misleading

Almost all microeconomics textbooks contain a section on the factors or determinants that affect price elasticity of demand. Products that are price inelastic are typically described as necessities with few substitutes that absorb a small fraction of income. Conversely, products that are price elastic tend to be luxuries with many substitutes that absorb a large amount of income. These factors are generally introduced to help students distinguish between price elastic and price inelastic products and, although they have an intuitive appeal and some logical basis, they also have the potential to confuse and mislead students. (The textbooks by Case, Fair & Oster (2008) and Frank & Bernanke (2009) are examples of a few principles textbooks that no longer include "luxury versus necessity" as a determinant of the price elasticity of demand.)

These factors can sometimes obscure the fact that the ultimate determinant of a product's price elasticity of demand is its price-quantity combination or position on the demand curve. Thus, the price elasticity of demand for luxuries that consume substantial income with many substitutes may still be price inelastic if the price falls low enough on a linear demand curve. Conversely, if necessary goods consuming a small fraction of income with few substitutes have prices that are high enough, demand will be price elastic. The intuition from slope to price elasticity only works if products in the first "elastic" category tend to have prices in the upper half of their demand curves, while goods in the second category tend to have prices in the lower half of demand. Although luxuries are generally more expensive, they are not always so.

While the determinants may be easily applied to some products, there are many products that elude categorization based on these common factors. An example of the confusion related to these factors can be drawn from the demand for cigarettes. The standard "intuition" is that cigarettes meet all the requirements for price inelastic demand. While this intuition might

provide valuable insight into price elasticity when cigarettes are $1.50 per pack, as they were in 2002 in New York City, tax hikes have pushed the prices to $8 per pack and consumption has fallen (*New York Times*, May 7, 2004). What was true of price elasticity of demand at $1.50 is not as obviously true at $8. From a policy perspective, the inferences we can make about the slope of demand using the determinants might be misleading regarding the price elasticity of demand.

In another example, is the demand for latte price elastic or price inelastic? Although some students might assume its demand is price elastic because it is a luxury, others might conclude its demand is price inelastic because it consumes a small portion of a consumer's income. Others might believe that latte faces many close substitutes in cappuccino, coffee, etc. and, therefore, conclude that the demand for latte is price elastic. Obviously, the determinants of price elasticity of demand do not necessarily contribute to a student's understanding of the price elasticity of demand for lattes.

Although many textbooks select goods and/or services that can be easily categorized by using the determinants, instructors need to recognize the limitations of using these factors to determine a product's price elasticity of demand.

Misleading Historical Elasticities' Tables

Some textbooks include tables that list goods and services with one number reflecting each good's price elasticity of demand. Typical lists include goods such as: ***salt, matches, toothpicks, short-run airline travel, gasoline, residential natural gas, coffee, fish, tobacco, legal services, physician services, beer, shoes, taxi service, and automobiles.***

These numbers are sometimes based on dated studies. Some textbooks still use Houthakker and Taylor's (1970) severely outdated estimates of price elasticities of demand from misspecified equations. See Appendix A for a discussion of what their numbers actually represent. By presenting them, authors ignore the possibility that changes in the real prices of these goods as well as changes in the goods themselves, consumer tastes, technology, and their markets may have significantly altered their price elasticities of demand since the studies were done. In the 4th edition of Frank and Bernanke's Principles of Microeconomics book (2009) the table on p. 101 uses elasticity estimates from sources dated 1970, 1975, 1977, and 1996. Although the price elasticities of demand may have been correct when they were computed, these tables give students the illusion that price elasticities are constant and unchangeable over time.

Appendix B shows which microeconomic principles books in a sample of 17 textbooks include misleading slope diagrams and outdated historical elasticities tables.

Solutions

Concentrate on position on the demand curve and the formula

The discussion of price elasticity of demand can be improved by placing emphasis where it belongs: on the relative price level. To put it simply, if the price of a product is in the upper half of a linear demand curve, then demand is price elastic; otherwise it is price inelastic. Samuelson and Nordhaus (2010) suggest a "trick" for calculating the price elasticity of demand. The elasticity of a linear demand curve is the ratio of the length of the curve below the price to the length above. While the calculations of the length of line segments are not particularly simple, the intuition is helpful. If there is more line above the price than below, the demand is

price inelastic. The point of the exercise is clear. Slope does not matter. What matters is where the price resides on a linear demand curve.

Further, although it is typically true that a firm mass producing a low cost good with little or no control over price is likely to operate in the price inelastic part of its demand curve, while a firm that is producing a high cost good in a monopolistic or monopoly market is likely to operate in the price elastic part of its demand curve, instructors cannot use these determinants to motivate a principles discussion of price elasticity of demand. After all, price elasticity of demand is covered in the first half of the semester while cost curves and market structure are covered in the second half of the semester. As a consequence, instructors must use the price-quantity combination on the linear demand curve regardless of a firm's cost curves and market structure to provide the basis for distinguishing between a demand that is price inelastic or price elastic.

The mid-point formula (Formula 4), which is the most common approach used by principles textbooks, shows students how to quantify the price elasticity of demand without reference to the slope of the demand curve. This formula reinforces the notion that slope is not relevant in determining the price elasticity of demand.

$$E_D = \left(\frac{\Delta Q}{(\Delta Q_1 + \Delta Q_2) \div 2} \right) \div \left(\frac{\Delta P}{(P_1 - P_2) \div 2} \right) \quad (4)$$

Price elasticity of demand formulas that explicitly incorporate slope (Frank and Bernanke, 2009) should be avoided in principles textbooks since they may lead to confusion on the part of students.

Use two demand curves to show different elasticities without changing slope

When students are being introduced to the elasticity concept, a rotated demand curve should be limited to discussions of the effect of time on demand. Instead of rotating a demand curve or showing demand curves with different slopes, differences in price elasticity or changes in elasticity due to a non-price determinant can be shown using two separate demand curves with the same slope. This helps students understand that it is a product's position on its demand curve, and not the slope of the curve, that determines the price elasticity of demand. For example, in the case of market segmentation and price discrimination, two different markets for the same product can be shown using two demand curves with the same slope. Although it is true that the slope of the demand curve may differ for two groups of consumers, it is less likely for students to confuse slope with the concept of price elasticity when both demand curves have the same slope.

To illustrate, consider the U.S. market for cigarettes. Smoking studies have shown that children have a higher price elasticity of demand for cigarettes than adults. Assuming children have lower income than adults and that cigarettes are a normal good, the U.S. cigarette market can be shown as two separate demand curves with similar slopes. In Figure 6, adolescents have the inside demand curve (D_1) and adults have the outside demand curve (D_2). If one assumes that price is as shown in Figure 6, the demand for cigarettes is price elastic for adolescents (D_1) and price inelastic for adults (D_2).

Because the two demand curves show differences in the willingness to pay, this approach illustrates how a market can be segmented and each group of consumers charged a different price. At a uniform price, the outside curve will be more inelastic (the price is closer to the bottom of the curve), so raising the price in that market will increase total revenue. In contrast,

an increase in price in the other market which is price elastic would cause a decrease in total revenue.

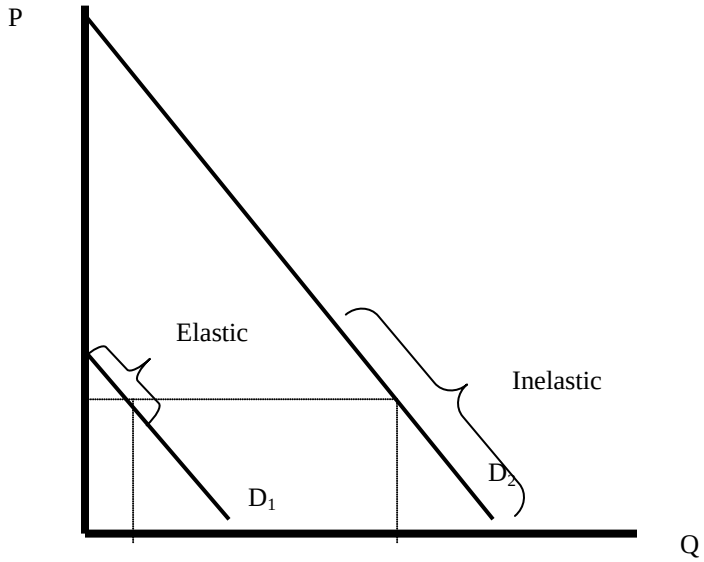

FIGURE 6. Market segmentation and different elasticities for cigarettes using two demand curves with the same slope.

Figure 6 can also be used to show students how a shift in a demand curve due to a change in any of the demand shifters, can change elasticity without necessitating a change in the slope of that demand curve. When principles students study the elasticity chapter, they have already covered demand shifters such as changes in income, the price of another good, population, etc. An instructor can use Figure 6 to show how a shift in the demand curve can change the price elasticity of demand at a given price.

The topic of price discrimination is often presented during a discussion of imperfect markets. At that point in the course, principles students are less likely to confuse slope with elasticity and are better able to handle two groups of consumers with demand curves that differ in slope. However, in the textbook chapter covering elasticity, which occurs early in the course, the juxtaposing of two demand curves with different slopes should be avoided.

Other Suggestions

Principles textbooks have used four non-price factors to explain the price elasticity of demand. While time is an important determinant, the other three commonly used factors (number of substitutes, percentage of budget or income, and necessity versus luxury) can sometimes lead to more, rather than less, confusion among students. Instructors should caution students about applying these sometimes ambiguous determinants. Discussing the determinants has the potential to divert principles student from understanding that the most important and unambiguous determinant of the price elasticity of demand is the price-quantity position on the linear demand curve.

Finally, the continued usage of dated estimates - some from the Houthakker and Taylor studies (1970) - of price elasticity has the potential to mislead students into believing that price

elasticity of demand is constant despite changes in many other factors such as technology, advertising, tastes, relative prices, and market structure. Rather than rely on outdated price elasticities of demand, professors might refer students to the United States Department of Agriculture website (USDA) to obtain more current price elasticities of demand for various agricultural products in many different countries. The website ***www.ers.usda.gov/Data/Elasticities/query.aspx*** provides price elasticities of demand across countries and within countries. For instance, a professor can ask students to compare the price elasticity of demand for rice in China (urban versus rural consumers) and the United States. An instructor might then ask students why the demand for rice may have become more price elastic in China since the 1990s. This analysis also shows students how estimates of price elasticity of demand can differ fairly dramatically according to when the estimate is calculated, the group of consumers, and the research method.

Conclusion

The position along a linear demand curve is the most important determinant of the price elasticity of demand for a product. Following Ockham's razor, the instructor should emphasize this simple and unambiguous fact. Authors of principles textbooks could improve their presentation of the price elasticity of demand by avoiding diagrams that appear to confuse slope and elasticity; avoiding rotating demand curves, except in the case of time; and applying non-price determinants with greater caution.

Instructors can provide students with greater clarity by continuing to utilize the mid-point formula, by providing a graph that clearly shows how elasticity changes along a linear demand curve, and by discussing more current price elasticities of demand. Since the concept of elasticity is often introduced early in a microeconomics course, it is also suggested that changes or differences in the price elasticity of demand for one product be shown without changing the slope of the demand curve. In other words, the market demand curve can be shifted or segmented while keeping the slope the same.

During the last few years there has been some improvement in the way principles textbooks approach the price elasticity of demand, but more can be done. Hopefully, this article will encourage authors and instructors to embrace greater simplicity with more emphasis on price and position, and less emphasis on rotating demand curves, ambiguous determinants, and dated elasticities.

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Appendix A: Reporting Elasticity Estimates

Many microeconomics principles textbooks devote some time to reporting price elasticity of demand estimates in a table. One widely cited report on price elasticity is the work by Houthakker and Taylor (1970) on consumer demand in the United States. Estimates from this source have become so common in principles texts that they sometimes do not even get a full citation. What the authors fail to note is the context of these estimates.

These estimates were published in 1970 based on results completed in 1967 using annual data from 1929 to 1964 excluding the war years. The purpose of the work was to project personal consumption expenditures for 1970. The forty year difference aside, the price elasticities of demand reported in that study are not true price elasticities of demand as defined in Equation A. For example, one commonly reported estimate is for restaurant meals which has an elasticity of -2.27. This estimate is found on page 63 of the second edition of the Houthakker and Taylor book and is based on the following equation:

$$q_t = -.9741 q_{t-1} + .0668 \Delta x_t - 1.3682 \Delta p_t \qquad \text{(A)}$$

where q is per capita personal consumption expenditures on purchased meals in current dollars and x is total per capita personal consumption expenditures and p is a relative price index. The elasticity calculated from this equation is more accurately a spending elasticity rather than a price elasticity of demand (i.e. q translates to p*q). Also, note the lack of substitute prices or other structural variables in Equation A. This point is not meant to criticize the original study for its purpose was not to estimate a structurally accurate demand equation but rather to forecast consumption expenditures. However, economists should be taken to task for misrepresenting the results of that study to principles students for nearly four decades. McConnell and Brue (18th edition, 2009) still reports telephone service demand as being inelastic (.26) based on the Houthakker-Taylor study. An estimate of telephone service expenditures from the first half of the twentieth century is certainly of questionable relevance today.

Appendix B: Selected Textbook Overview

Column 4 in the table below indicates which textbooks have slope diagrams that refer to steeper demand curves and less steep demand curves as relatively price inelastic and price elastic, respectively. The last column indicates textbooks that show Houthakker-Taylor price elasticities of demand or other dated elasticity estimates. All of the textbooks below use some determinants of the price elasticity of demand to explain elasticity.

Author	Title	Ed./year	Misleading slope diagrams	Dated elasticity estimates (HT indicates usage of Houthakker-Taylor elasticities)
Bade & Parkin	*Foundations of Microeconomics*	4th/2009	yes	Elasticity esimates are fairly current.
Baumol & Blinder	*Microeconomics: Principles & Policies*	10th/2006	yes	Elasticity estimates are dated (HT).
Boyes & Melvin	*Microeconomics*	6th/2005	no	No table
Case, Fair & Oster	*Principles of Microeconomics*	9th/2008	no	No table
Colander	*Microeconomics*	7th/2008	no	Some elasticity estimates are dated (HT); others more current.
Frank & Bernanke	*Principles of Microeconomics*	4th/2009	no	Some elasticity estimates are dated (HT); others more current.
Hubbard & O'Brien	*Microeconomics*	2nd/2008	yes	No table
Mankiw	*Principles of Microeconomics*	3rd/2004	yes	No table
McConnell, Brue & Flynn	*Microeconomics*	18th/2009	yes	Dates and sources of elasticities are unclear.
Miller, J.D.	*Principles of Microeconomics*	1st/2009	yes	Elasticity estimates are fairly current.
Miller, R.L.	*Economics Today the Micro View*	13th/2006	no	Dates and sources of elasticities are unclear.

Rittenberg & Tregarthen	*Principles of Economics*	1st/2009	no	Uses current elasticity estimates for crude oil demand across countries.
Samuelson & Nordhaus	*Microeconomics*	19th/2010	yes	No table
Schiller	*The Microeconomy Today*	11th/2008	no	Some elasticity estimates are dated (HT); others more current.
Stiglitz & Walsh	*Principles of Microeconomics*	4th/2006	yes	No table
Taylor & Weerapana	*Principles of Microeconomics*	6th/2009	no	Dates and sources of elasticities are unclear.
Slavin	*Microeconomics*	9th/2009	yes	Dates and sources of elasticities are unclear.