CHAPTER 4

The Elasticity of the Demand for Farm Products

In most cases in economics, it is difficult to draw a sharp line between the long run and the short run. In agricultural economics, however, one kind of short run is clearly marked off. Most crops are produced once a year, and the yield per acre is determined chiefly by the weather. Variations in the weather from year to year are almost entirely random in character. A tendency toward cyclic variations has been "discovered" by a number of different investigators, but the length of the cycles differs so much among the different investigators that there is a real question whether there actually are any cycles at all. Crop production series show almost completely random variations from year to year. Each crop is like a flip of a coin or a roll of the dice—a new item, practically independent of the other items in the series. Crop production series, and other series closely associated with them (such as crop price series in times of stable demand, or independent of variations in demand), therefore lend themselves well to statistical analysis.

RELATIONS AMONG PRODUCTION, PRICE, AND INCOME

Each year farmers plant their crops, not knowing whether the weather will be good, bad, or indifferent; their crops accordingly large, small or average; and their prices accordingly low, high, or average.

Large crops bring low prices, and small crops, high prices. But will large crops bring high incomes, or low incomes?

The answer depends upon the extent to which prices vary (inversely) with variations in production. In the case of some crops, an increase in production of 10 per cent decreases price 20 per cent. The price falls twice as far as the size of the crop increases. In this case, a large crop brings a lower income than an average crop. In other cases, the price falls less than the size of the crop increases; a large crop then is worth more than an average crop.

This relation between the extent of the change in the size of the crop and the extent of the change in price is called the price elasticity of the demand. Each crop has its own price elasticity of demand, differing from the elasticity for other crops. It is important to measure this elasticity for each crop. In a free-market economy, it is important to know how much, and in which direction, variations in the size of the crop affect income as well as price. This knowledge is still more important in a controlled economy or sector of an economy, such as a price or income stabilization program.

THE MEASUREMENT OF THE ELASTICITY OF DEMAND

The concept of elasticity is basically simple. People will buy more carrots, for example, when they are cheap than when they are high-priced. A reduction in the price of almost anything ordinarily increases the amount of the thing that can be sold. This responsiveness of quantity to price is called the elasticity of the good in question.[1]

With some goods, for example peaches, a change in the price will result in a large change in the amount that can be sold. With other goods, for example, salt, the same change in the price has only a small effect on the amount that can be sold. In practically no case is the quantity of a good completely unresponsive to a change in price; that is, the demand is very seldom completely inelastic. With most goods a change in price has an appreciable effect upon the quantity that can be sold—a small effect in the case of some goods, a large effect in the case of some others.

This definition of elasticity of demand is phrased in terms of the change in quantity per unit change in price. This does not mean that the change in price is regarded as the cause, and the change in quantity as the effect. In many cases the line of causation runs the other way; in agriculture, farmers determine the acreage and the weather determines the yield of the crop, and the quantity produced "sets the price." But the term elasticity here as elsewhere refers to the change in quantity, neither causing nor caused by, but *associated with* a given change in price.

[1] The term elasticity is not very clear. Frank Knight believes that the term "responsiveness of consumption" expresses the concept better. (Frank H. Knight, "Demand," *Encyclopaedia of the Social Sciences,* Vol. V, 1931, p. 70.) It makes clear that elasticity refers to the responsiveness of quantity to price, not vice versa (which Moore has called the "flexibility of prices"). Knight's term, "responsiveness of consumption," is clearer or at least more self-explanatory than "elasticity of demand"; but it has one shortcoming, namely that it cannot, strictly speaking, be applied to the purchases of dealers who do not consume the product, whereas "elasticity of demand" can be thus applied. The term "elasticity of purchases" would meet this objection, but it is not so clear as the other. In any case, "elasticity of demand" has become so well established in use that it probably will remain in use (like the established width of railroad tracks, even though a greater width would be better suited to present needs).

The concept of elasticity has been familiar to economists for generations. Gregory King two or three centuries ago attempted to measure the elasticity of the demand for wheat in quantitative terms,[2] but nothing much else was done until Moore in 1914 published his empirical studies of the elasticity of the demand for corn, hay, and potatoes.[3] After World War I, a great increase took place in the quantity of statistical data available concerning production, prices, demand, and supply, and analytical statistical methods were applied to economic data on an extensive scale. Many studies of the elasticities of demand for different products have been published, and one of the first things a student of price analysis should be able to do is to measure the elasticity of the demand for a given product and interpret his results properly.

MEASURING ELASTICITY

Let us take a concrete example. The price and production data for potatoes for the years 1929–39 are given in Table 4. They are plotted in scatter-diagram form in Figure 21. The prices are the average United States farm prices December 15 each year, adjusted for changes in the general price level.[4] The production figures show the total production of potatoes in the United States.

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[2] "We take it, that a defect in the harvest may raise the price of corn in the following proportions:

Defect		*Above the Common Rate*
1 Tenth		3 Tenths
2 Tenths	*Raises the*	8 Tenths
3 Tenths	*price*	16 Tenths
4 Tenths		28 Tenths
5 Tenths		45 Tenths

so that when corn rises to treble the common rate, it may be presumed that we want above 1/3rd (one-third) of the common produce; and if we should want 5/10ths, or half the common produce, the price would rise to near five times the common rates." C. D'Avenant, *Political and Commercial Works*, Vol. II, 1771, p. 224, quoted in *Farm Economics*, Cornell Univ., May, 1939, p. 2758.

[3] Henry L. Moore, *Economic Cycles, Their Law and Cause*, Macmillan, 1914.

[4] December prices are used here rather than the season average price used in Table 3, because they reflect the size of the crop just produced more accurately than the season average price. The season average price is affected by other events occurring later in the season.

The adjustment for changes in the general price level here consists in dividing the price data by the corresponding Bureau of Labor Statistics all-commodity wholesale price index inflated by 50 per cent (because the relation between the two is not 1 to 1 but 1 to 1.5). This procedure, probably not clear to the reader at this point, is explained in detail in Chapter 8, along with a general discussion of the adjustment of prices to take care of the effect of changes in demand.

The simple analytical methods used have resulted in the straight-line demand curve shown. More complicated and accurate analyses show that the demand curve has a concave curvature at the lower end.

TABLE 4

POTATOES: UNITED STATES PRODUCTION AND AVERAGE FARM PRICE, DECEMBER 15, 1929–39*

Year	(1) Potatoes (000 bushels)	(2) Potatoes Average Price per Bushel December 15 (cents)	(3) Wholesale Price Index, All Commodities Dec. 1926=100	(4) [(3)x1.50−50]	(5) (2) ÷ (4)	Data in (1) and (5) Expressed in Percentages of Average	
						Production	Deflated Prices
1929........	322,204	134.6	93.3	89.95	149.6	88.1	144.5
1930........	340,572	89.8	79.6	69.40	129.4	93.1	125.0
1931........	384,125	45.0	68.6	52.90	85.1	105.0	82.2
1932........	376,425	36.8	62.6	43.90	83.8	102.9	81.0
1933........	342,306	69.2	70.8	56.20	123.1	93.6	118.9
1934........	406,105	44.9	76.9	65.35	68.7	111.0	66.4
1935........	386,380	63.7	80.9	71.35	89.3	105.6	86.2
1936........	331,918	106.3	84.0	76.0	139.9	90.7	135.2
1937........	395,294	53.0	81.7	72.55	73.1	108.1	70.6
1938........	374,163	61.3	77.0	65.5	93.6	102.3	90.4
1939........	364,016	70.8	79.0	68.5	103.4	99.5	99.9

* Sources of data: (1) and (2) *Agricultural Statistics*, 1940, pp. 262, 269; *Crops and Markets* (monthly); current data from *Wholesale Prices* (monthly). (3) *Mimeo. 4313*, Bureau of Labor Statistics, U. S. Department of Labor.

The dots in Figure 21 fall closely around a sloping line, which can be fitted to the data mathematically by the method of least squares, or simply drawn in freehand. In either case, the investigator must decide whether to use a straight line or a curved line to fit the dots. The decision must be based on (1) the appearance of the data, (2) the investigator's knowledge of the particular product,

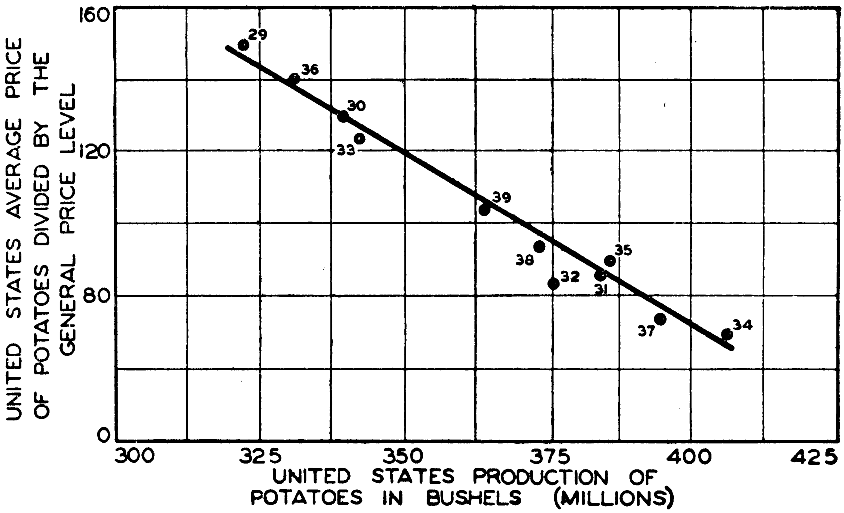

FIG. 21.—Potatoes: United States average farm price, December 1, and total production, 1929–39.

and (3) his grasp of economic theory. That is, the line chosen should be a reasonable one from all three of these points of view. In Figure 21 the dots fall about a straight line, and in the absence of any reason for using a curved line, a straight line is chosen. The line in this case is drawn in freehand. It does not necessarily go through any of the dots, but merely represents the average relationship between production and price shown by the data. The line should not be extrapolated (extended) beyond the dots.

The job now is to measure the elasticity of the demand represented by this line—that is, to measure the change in quantity associated with a unit change in price.[5] Inspection of the chart

[5] The computation of the elasticity of the demand should be based upon two points on the line rather than upon two actual data dots, because a line joining and two dots (1938 and 1939, for example, or still more obviously, 1931 and 1932) may have a different slope from the line representing the average rela-

shows that a change in quantity from 325 million bushels to 400 million bushels (using round numbers near the ends of the line) is associated with a change in price in the opposite direction, from 144 to 70 cents per bushel. That is, a change in quantity of 75 million bushels is associated with an opposite change in price of 74 cents; the change in quantity per unit change in price is $\frac{75}{-74} = -1.01$. But this is not the elasticity of the demand for potatoes, for it is evident that the result is determined largely by the particular units in which the quantity and price changes are measured. If the quantity had been measured in bushels, for example, instead of millions of bushels, the answer obtained by the formula above would have been —1,013,389, clearly an absurd answer. Or if the price had been measured in English money, the change in price would have been about 3 shillings instead of 75 cents; and this again would have given a different answer. The basic situation remains unchanged when different units of computation are used, but the numerical results obtained above are quite different. This is not as it should be. What is needed is a measure of elasticity that will be unaffected by the units of measurement chosen—a coefficient of elasticity.

THE COEFFICIENT OF ELASTICITY

One good way to compute such a coefficient of elasticity is to divide the observed change in quantity by the average of the two quantities (i. e., to divide $400 - 325 = 75$ by $\frac{400 + 325}{2} = 367.5$).

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tionship of all the dots, and it is the average relationship that is being measured. Furthermore, two points at the ends of the line shown in Figure 21 should be used, rather than two anywhere along the line, since it is the elasticity of the line as a whole that is to be measured, not just the elasticity of a part of it.

This concept of the elasticity of the line as a whole, or of a part of it, may be referred to as the average elasticity in much the same way that reference is made to one's average speed, say 50 miles an hour, on a trip. It is contrasted with point elasticity, as in physics the empirical concept of average speed is contrasted with the limiting concept of velocity. Point elasticity is taken up in the next chapter.

For a full discussion of the measurement of elasticity, *see* A. P. Lerner, "The Diagrammatical Representation of Elasticity of Demand," *Review of Economic Studies*, I, No. 1, 1933–34, pp. 39–44, and R. G. D. Allen, "The Concept of Arc Elasticity of Demand," same volume, pp. 226–29, and the accompanying note by Lerner.

The same thing can be done with the prices. The formula thus becomes a complex fraction,

$$\cfrac{\cfrac{\textit{change in quantity}}{\textit{average quantity}}}{\cfrac{\textit{change in price}}{\textit{average price}}}$$

Now the average is simply the total sum divided by the number of items. The number of quantity items is the same as the number of price items (in this case two) so the result will be the same if the sum of the quantities and the sum of the prices is used instead of the average prices and quantities (the 2's in the numerator and denominator cancel out). This will save some computation. The formula may then be expressed:

$$\cfrac{\cfrac{q_1 - q_2}{q_1 + q_2}}{\cfrac{p_1 - p_2}{p_1 + p_2}}$$

The same formula can also be written in the form

$$\frac{q_1 - q_2}{p_1 - p_2} \cdot \frac{p_1 + p_2}{q_1 + q_2}$$

This was substantially the form which Marshall used,[6] although he restricted the concept to infinitesimally small changes, in which case the change is represented by "*d*," and there is no need to use the average or the sum of the quantities and prices. His formula was merely $\frac{dq}{dp} \cdot \frac{p}{q}$. The complex-fraction formula is clumsier in appearance than the Marshallian form of the formula; it is superior to the other form for introductory expository purposes, because it shows more clearly just what elasticity is, but Marshall's form of the formula is standard and we will use it henceforth.

The data for potatoes substituted in this formula yield the following coefficient of elasticity:

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[6] Marshall, *Principles of Economics,* 8th edition, Mathematical Appendix, Note III, p. 103 n.

$$\frac{400 - 325}{70 - 144} \cdot \frac{70 + 144}{400 + 325} = \frac{75}{-74} \cdot \frac{214}{725} = \frac{1605}{-5365} = -0.299$$

Exactly the same result is obtained when the original quantity data are expressed in tons instead of bushels. The figures then become

$$\frac{12 - 9.75}{70 - 144} \cdot \frac{70 + 144}{12 + 9.75} = \frac{2.25}{-74} \cdot \frac{214}{21.75} = \frac{481.5}{1609.5} = -0.299$$

The same thing is obviously true if the prices are expressed in some other units.

We can now refine our definition of elasticity and make it more precise and definite, thus: Elasticity is the proportional change in quantity associated with a proportional change in price. The strict mathematical definition runs in terms of infinitesimals, but for students without mathematical training, the concept can be expressed in terms of percentages. The definition in that case is: Elasticity is the percentage change in quantity associated with a 1 per cent change in price (other things remaining constant). The computation for potatoes given above shows that a change in quantity of 0.299 per cent (roughly, 0.3 per cent) is associated with a 1 per cent change in price. That is, the elasticity of the demand for potatoes is — 0.3.

EFFECT OF CROP SIZE ON TOTAL INCOME

The chart discussed in the preceding pages shows the effect of the size of the potato crop upon the price of potatoes. Another question now arises. What is the effect of the size of the potato crop upon the *total revenue* from the crop? Does a large crop depress prices so much that the low price per bushel more than offsets the large number of bushels sold, or not?

It takes only a moment to answer this question. The smallest crop shown in Figure 21 was 322 million bushels; it sold at a price of $1.50 per bushel; the total revenue, therefore, was 322 million × $1.50, or *$483 million.* The largest crop was 406 million bushels; it sold at a price of 69 cents per bushel; the total revenue therefore was 406 million × $.69, or *$289 million.* The small crop was worth more than the large crop. The larger the crop, the smaller the total income. The demand in this case is said to be inelastic. In the case of some goods, a small reduction in price results in a larger increase, proportionally, in sales, and the larger the crop, the *larger* the total revenue. The demand in this case is referred to as elastic.

What these terms elastic and inelastic really mean is "relatively elastic" and "relatively inelastic." The term "relatively" is dropped only for brevity; it really belongs in. "Relatively" here means relative to *unit elasticity,* the borderline case between relatively elastic and relatively inelastic. If the elasticity of demand for a good were such that any percentage increase in supply depressed the price by an equal percentage, then the total value of a large crop would be the same as that of a small crop.[7] In fact, no matter what the size of the crop, it would be offset by an opposite change in price, so that the total value of the crop would be constant no matter what its size. In this case, in the formula presented a few paragraphs back, a 10 per cent (or any other) change would yield the following results:

$$\frac{10}{-10} \cdot \frac{100}{100} = \frac{1000}{-1000} = -1.0$$

This is called unit elasticity. It is the dividing line or borderline case between elastic demand and inelastic demand. If the elasticity is less than 1 it is called inelastic; if it is more than 1 it is called elastic. For technical accuracy, the terms, "relatively inelastic" (that is, less elastic than unity, inelastic relative to unit elasticity) and "relatively elastic" (more elastic than unity) should be used. But the word "relatively" is understood, and may be omitted in ordinary discussion.

In the illustration just given, an increase in quantity, a plus, is associated with a decrease in price, a minus. The measure of elasticity, therefore, carries a minus sign, as shown. Curves of this sort, with minus signs, all slope downward to the right, that is, from northwest to southeast. Practically all demand curves are of this character. If a case were found where increases in quantities were associated with *increases* in prices, the numerical expression of elasticity would have a positive sign and the curve would slope upwards to the right.

ELASTICITY GRAPHICALLY REPRESENTED

Elasticity can be represented graphically, but proper attention must be given to the scales of the charts. One might think that a

[7] Strictly speaking, this is true only when the percentage changes involved are infinitesimally small. Large changes introduce slight arithmetic discrepancies. For example, if the crop increased 10 per cent and the price decreased 10 per cent, the total value would be 90 × 110 = 9,900, not 10,000. This question is discussed fully in the next chapter.

demand curve of unit elasticity would be the hypotenuse of a right-angled triangle lying on one side, and that the slope of the curve would therefore be 45°; and, further, one might conclude that all curves that were more steeply sloped than 45°—say 50°, 60°, or 70°—would be inelastic, and all curves less steeply sloped than 45° would be elastic.

Reference back to Figure 21, however, shows that the demand curve for potatoes shown in that figure has a slope that is definitely less than 45°. It is about 30°. This would seem to place it in the elastic category. Yet the numerical computations a few pages back showed that the elasticity was —0.3°. This is clearly inelastic. Which is wrong, our graphics or our arithmetic?

A moment's reflection shows that it is our graphics that is at fault. The scales in Figure 21 are laid out in absolute, not percentage, terms. But elasticity is a proportional concept. The scales in the graph should run in percentage terms, and 10 per cent on the quantity scale should cover as much distance as 10 per cent on the price scale. If this procedure is followed, the chart will show elasticity correctly; the category into which the curve falls—inelastic or elastic—can then be determined directly from the chart by observing whether its slope is steeper or flatter than 45°.

The data, expressed in percentage terms and plotted on a properly scaled chart, are shown in the left hand section of Figure 22. The curve in this chart is much steeper than the one in Figure 21. It is clearly in the inelastic category. The proper arrangement of scales for representing elasticity directly is that which is used in Figure 22, with the data expressed as percentages and the horizontal and vertical scales equal, so that 10 per cent on one scale equals the same distance as 10 per cent on the other.

It is not the conversion of the original data into percentage form alone that enables elasticity to be read directly from the slope of the line on a chart with arithmetic scales. It is this, plus the setting of the horizontal and vertical scales so that 10 per cent on the one scale is represented by the same distance as 10 per cent on the other scale, that does the trick.

This could be accomplished just as well by plotting the data in their original form, on a chart with the horizontal and vertical scales set so that the average price equals (say) 5 inches on the vertical scale, and the average production equals the same distance, 5 inches, on the horizontal scale. The elasticity could then be read directly from the slope of the line on a chart with arithmetic scales, regardless of what units the original data were expressed in. This sounds easier than converting the data into index form. But, as a matter of fact, it turns out that it is more trouble to do this than to convert

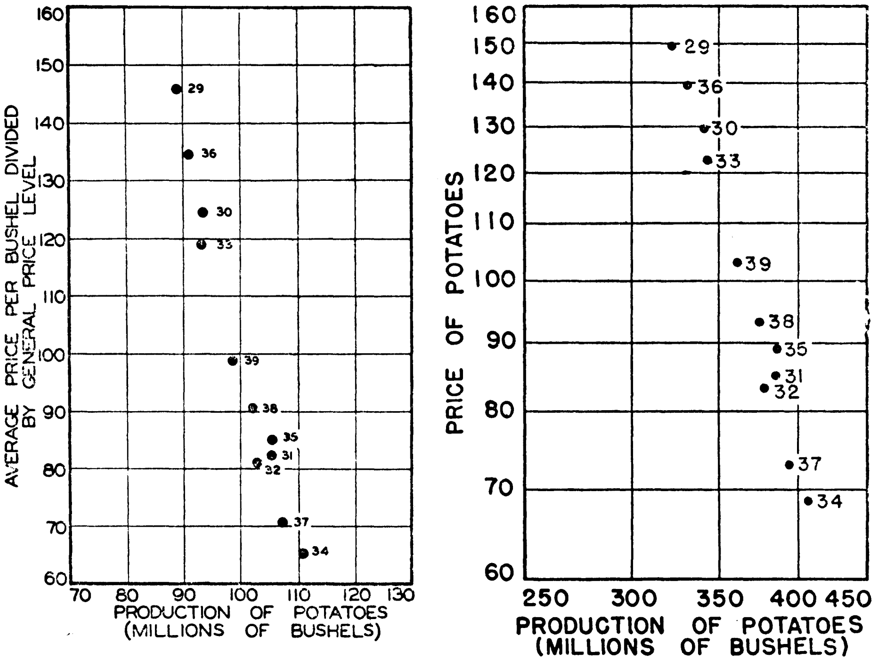

FIG. 22.—Potatoes: United States average farm price, December 1, and total production, 1929–39. (A) Data in percentage terms; arithmetic scales. (B) Data in original form; logarithmic scales.

the data into index form and plot them in that form. For suppose that the average price comes out to be 77 cents, or some other figure that is not an easy multiple of 5; the resulting scale is very awkward to plot, especially when the production scale is probably awkward too. It is easier after all to convert the data into index form (i. e., into percentages) and set the scales so that 100 per cent equals 5 or 10 inches, or some other easy divisor of 100.

Elasticity can also be shown graphically by plotting the data in their original form on double logarithmic paper, that is, paper in which both the horizontal and vertical scales are logarithmic. No matter what units the original data are expressed in—dollars, francs, pounds, ounces, etc.—when they are plotted on double logarithmic scales, the slope of the line shows the elasticity directly.[8] The data plotted in this manner are shown in the right hand section of Figure 22. The slope of the curve here is identical with the slope of the curve in the left hand section of Figure 22. This is really the simplest way to show the relation between price and production data; but most people are not familiar with logarithmic scales, so for purposes of presentation it is better to plot the data in percentage terms on ordinary arithmetic paper.

Considerations similar to those which hold for ordinary arithmetic paper rule here. It is not the plotting of the data on logarithmic scales that enables elasticity to be read directly from the chart; it is the fact that the horizontal and vertical scales are equal that does it.

EFFECT OF MIDDLEMAN'S MARGINS ON ELASTICITY

The factors that determine elasticity are discussed in any good textbook on elementary economic theory, and there is no need to repeat the discussion here. But most discussions of this sort deal with the elasticity of demand at the retail store, or wherever the consumer buys the goods. The elasticity of demand at the farm is affected by still another thing in addition to these—by the size and stability of the middleman's charges, that is, the margins between the prices of goods at the farm and at the retail store.

Middleman's margins remain rather stable through periods of high prices and low prices resulting from fluctuations in supplies.[9] They change from periods of prosperity to periods of depression (fluctuations in general demand) because wages, although comparatively stable, do change to some extent from peak to trough of industrial activity. But during periods of relatively stable industrial activity, the margin between potato prices at the farm and potato prices at the retail store, for example, remains much the same when potato supplies are short and prices high as when supplies are plentiful and prices low.

In that case, if the demand curves for potatoes at retail and for potatoes at the farm were plotted on the same chart with arithmetic

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[8] Technically speaking, the elasticity is not the same as the slope; it is the reciprocal of the slope. For the slope is the number of units that the curve rises per unit of horizontal run; it is $\frac{p}{q}$. But elasticity is $\frac{q}{p}$. The greater (i.e., steeper) the slope the less the elasticity.

[9] *See Price Spreads Between Farmers and Consumers for Food Products, 1913–44,* USDA Misc. Pub. No. 576, 1945, pp. 20–24.

scales, the two curves would be parallel, the one lying above the other. The curves would look something like those in Figure 23. This figure is based on hypothetical data, that enable the exposition to be made arithmetically simple.

In this chart the average price of potatoes at the retail store is 20 cents a pound, the average price of potatoes at the farm is 10 cents a pound, and the margin between the two prices remains fixed at 10 cents a pound. The elasticity of the demand for potatoes at retail is represented as unity. From the parallelism of the two curves, one might conclude that the elasticity of the demand for potatoes at the farm must be unity also.

But that would be a mistake. Application of the regular elasticity formula to these hypothetical data shows that whereas the elasticity of the demand at retail is unity, that at the farm is only -0.5. The two calculations, based upon figures read off the chart, follow:

For potatoes at retail $$\frac{12-8}{16-24}\cdot\frac{20}{10}=\frac{80}{-80}=-1.0$$

For potatoes at the farm $$\frac{12-8}{6-14}\cdot\frac{10}{10}=\frac{40}{-80}=-0.5$$

Looking at the two sets of calculations, we see that they are identical in all respects except the average price. For potatoes at retail, the average price is 20; for potatoes at the farm it is 10.

It is clear from this formula that if you halve the average price, other things being the same, you halve the elasticity. It shows that the width and fixity of the margin between farm prices and retail prices affects the elasticity of the demand at the farm. The wider and more stable the margin, the less elastic is the demand at the farm compared with the demand at the retail store.[10]

EFFECT OF TIME UPON ELASTICITY

Economists since at least as far back as Marshall[11] have recog-

[10] The effects of changes in middlemen's margins are shown in Appendix C of *Marketing Farm Products*, The Iowa State College Press, 1946, by the present author.

[11] Marshall, *Principlès of Economics*, pp. 109–12. For more recent discussions see E. J. Working, "Statistical Demand Curves." *Encyclopaedia of the Social Sciences*, V, 1931, pp. 74–75, and R. L. Mighell and R. H. Allen, "Demand Schedules—Normal and Instantaneous," *Journal of Farm Economics*, XXI, No. 3, Part I, August, 1939, pp. 555–69.

A broader treatment of dynamic demand is given in C. F. Roos, *Dynamic Economics*, Principia Press, 1934. The subject is treated mathematically in Griffith C. Evans, *Mathematical Introduction to Economics*, McGraw-Hill, 1930, Chap. IV, and in Gerhard Tintner, "The Theoretical Derivation of Dynamic Demand Curves," *Econometrica*, VI, No. 4, October, 1938, pp. 375–80.

nized that it is incorrect to speak of "*the* elasticity" of the demand for a commodity, for the elasticity differs according to the length of time involved. The subject has been given extensive theoretical discussion, with the aid of hypothetical data, but not much has been offered in the way of empirical demonstration. A few studies may be brought together to serve this purpose.

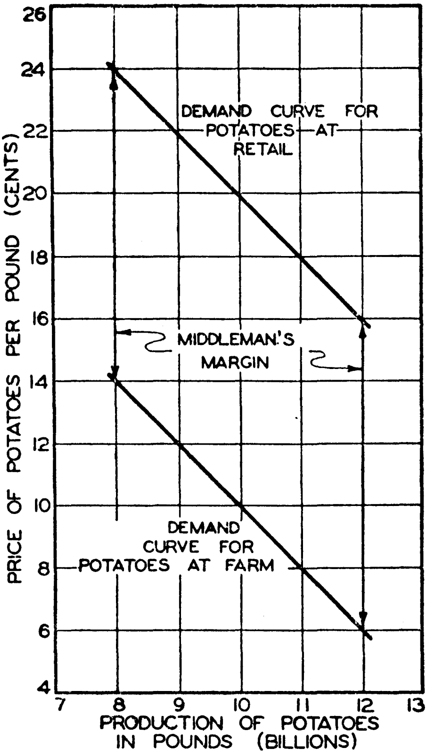

FIG. 23.—Hypothetical demand curves for potatoes at the retail store and at the farm.

Short-time elasticities. Statements have been made that "*the* elasticity" of the demand for hogs is —0.65[12] or —0.7.[13] But all that these statements mean is that the elasticity of the demand for hogs based upon annual data is (or, more accurately, was) —0.65 or —0.7. Other empirical studies have shown that the elasticity of the demand for hogs derived from weekly data is much greater than this, and that the elasticity derived from daily data is still greater. Stover[14] found that over the period 1921–28, inclusive, the elasticities of the demand for hogs at Chicago based on daily, weekly, and yearly data were as follows:

Saturday	—5.8
Wednesday	—2.8
Week	—2.5
Year	—1.0

Among the various days of the week, the elasticity was greatest

[12] Geoffrey Shepherd and Walter Wilcox, *Stabilizing Corn Supplies by Storage,* Iowa Agr. Exp. Sta., Bul. 368, 1937, pp. 337–38.

[13] Preston Richards, "Livestock Marketing Methods and Livestock Prices," *Journal of Farm Economics,* XXI, No. 1, February, 1939, pp. 219–27.

[14] Howard J. Stover, *Relation of Daily Prices to the Marketing of Hogs at Chicago,* Cornell Univ. Agr. Exp. Sta., Bul. 534, 1932, p. 33.

on Saturday and least on Wednesday; the elasticity on Wednesday was almost as high as the elasticity for the week as a whole.[15]

Similarly, the elasticity of the demand for eggs, based upon annual data, is about —0.4,[16] whereas the elasticity based upon monthly data averages about —3.0.[17] Other instances of this sort could be given. It is not surprising that the short-time elasticities differ from the annual-data elasticities; they refer to different demands. The short-time elasticities should be greater than the long-time elasticities, because a large part of the short-time fluctuations in supplies thrown on the market are absorbed by short-time storage operations. Dealers buy eggs, for example, for storage, whenever they believe that the price of eggs some time in the future (within the probable storage life of an egg) will be higher than it is at present—and higher by more than the cost of storage to that future time. The future changes in prices that dealers can predict most confidently are those associated with regular seasonal changes in egg receipts, so that storage is largely a seasonal phenomenon. At the time of large egg receipts and low prices, therefore, the storage dealer's demand for eggs is added to the consumer's demand; this keeps prices from falling as low as they would in the absence of purchases for storage. Later on in the season, when egg receipts are light and prices high, the storage dealer's eggs are added to the current receipts from producers. This keeps prices from rising as high as they would otherwise. Longer-time (annual) fluctuations in supplies, however, cannot be thus absorbed, because the commodity is too perishable to stand storage for more than a few months.

Long-time elasticities. The elasticities of demand based on daily, weekly, or monthly data are likely to be greater than for annual data. What about the elasticities based on items each of which covers more than a year, perhaps five or ten years?

There are reasons for believing that these elasticities based on long-time data may be greater than the elasticities based on annual data. These reasons are not the same as those which make the

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[15] The elasticity he found for the yearly data was higher than that which has been found in the more recent studies referred to in the two preceding footnotes, because his data were Chicago (not national) data, and he found the gross regression of receipts on prices, not the net regression.

[16] Henry DeGraff, unpublished study, Economics Department, Iowa State College, 1940.

[17] K. L. Cannon, unpublished study, Economics Department, Iowa State College, 1939.

elasticities for weekly data greater than for annual data; they are related not to storage, but to the ease of substitution.

If some year the grapefruit crop is short, for example, consumers who have established a place for it on their breakfast table may bid grapefruit prices up to a high point in an attempt to keep it there. They know that grapefruit will probably be plentiful again within another year, and they dislike to change their consuming habits merely for a year only to change them back again when the year is over. But if grapefruit acreages were more or less permanently reduced and grapefruit rose to a place in the luxury price class, many consumers would replace it on their breakfast table with something else, and prices would not be bid so high as for a one-year shortage.

Another example is corn. The demand for corn, based upon annual data, is only about —0.5 at its lower end; but if large supplies and low prices seemed likely to persist for years in the future, power alcohol plants would be set up to use the cheap corn, and would open up a demand that would be very elastic indeed. Similarly, at the upper end of the scale, if scarcity and high prices appeared likely to persist for a decade or more, consumers would have time to cultivate new tastes and manufacturers would have time to bring new substitute products on the market, which would render the upper part of the curve more elastic also.

This boils down to the simple fact that the more time you give people to change their tastes, the more they will change them. This principle operates continuously, from the shortest periods of time, only a few moments long, up to the longest periods, decades and more in length. Within the short periods of time, however, the effect of this principle is more than offset by the opposite effect of storage and subsequent "unstorage" of temporary surpluses. The lowest elasticity of demand for a good, therefore, is that which is based on data each of which represents a period just a little longer than the storage life of that good. For extremely perishable goods like strawberries, this period is only a few days or weeks in length. For many farm products which are semiperishables, such as meat, eggs, and butter, this period is a year. Most analyses of the demand for farm products are based on annual data, and the elasticities found for the semiperishables are likely to be the minimum elasticities; both shorter-period and longer-period data yield higher elasticities than the annual data. For grains, which are stored to some extent for longer periods than one year, the minimum elasticity period is likely to be longer than one year. For cotton, which is stored for still longer periods than grain, the minimum elasticity period is likely to be still longer.

DIFFERENT KINDS OF ELASTICITY

The elasticity of demand dealt with in this chapter has been the price elasticity of demand—the responsiveness of quantity to changes in price. There are many other kinds of elasticity. The income elasticity of demand, for example, shows the responsiveness of quantity to differences in incomes. A chart showing the income elasticity of demand would have the income scale plotted up the side and the quantity scale for the good in question along the bottom.

The income elasticity for the staple foods is low. A man with twice as much income as another does not eat twice as much bread and potatoes; he may in fact eat less of these foods than the man with the low income; but he may buy more than twice as much of luxury goods, housing, medical care, savings, etc. The income elasticity for bread and potatoes is low, and may even be negative; but for these other products it is high, and of course positive.

Most of the empirical investigations of the income elasticity of demand show the different per capita *expenditures* for specific goods, not the different per capita *quantities* of the goods taken, by people with different incomes. The scale along the bottom of the chart represents the expenditures for the particular good, not the quantities. This shows the income elasticity of expenditure rather than the income elasticity of demand (which is expressed in quantities). This type of curve is called an income-expenditure curve.

Curves of this sort differ from price elasticity demand curves. The latter show the changes in quantity taken when the price changes, all other things except the price of the good remaining the same; income-expenditure curves measure approximately the changes in quantity taken when all prices, *including* the price of the good in question, change in the same proportions.

Income-expenditure curves based on 1935–36 data[18] show that the curve for savings has the greatest elasticity of all the curves shown. The curve for food becomes very inelastic as incomes increase above $4,000 per year. Similar information is given in greater

[18] *Consumer Expenditures in the United States,* U. S. National Resources Committee, 1939, pp. 38–39. The charts are plotted with income along the bottom and expenditures up the side, the reverse of the usual procedure as defined above.

detail in a study of data for wage earners and lower-salaried groups in two different areas—New England and the Southeast—in 1935.[19] The income-expenditure elasticities for the most important food items, as computed by Waite and Cassady,[20] are shown by districts in Table 5.

TABLE 5
INCOME EXPENDITURE ELASTICITIES
(Arranged in order of magnitude)

New England States		Southeast	
Article		*Article*	
Sugar	0.15	Milk, cream, ice cream	0.29
Potatoes	0.20	Bread	0.34
Flour	0.24	Sugar	0.35
Bread	0.25	Potatoes	0.35
Milk, cream, ice cream	0.29	Butter	0.46
Butter	0.36	Eggs	0.55
Eggs	0.66	Flour	0.59
Meat, poultry, fish	0.66	Fresh vegetables	0.76
Fresh vegetables	1.16	Meats	0.79
Fruits	1.20	Fruits	1.13

Another sort of elasticity is the elasticity of substitution. This has been defined as "the proportionate change in the ratio of the amounts of the factors employed divided by the proportionate change in the ratio of their prices to which it is due."[21] "It represents the additional amount of the factor B, from the given combination of factors, necessary to maintain product unchanged when a small unit reduction is made in the use of the factor A."[22] The definition with respect to consumers' goods is similar to this.

An illustration with reference to consumers' goods is the elasticity of substitution between two classes of wheat—Soft Red Winter and Hard Red Winter.[23] This is shown in Figure 24. The elasticity of substitution here is about -3.0. The elasticity of substitution

[19] *Monthly Labor Review,* U. S. Department of Labor, XLII, April, 1936, p. 892.

[20] Warren C. Waite and Ralph Cassady, Jr., *The Consumer and the Economic Order,* McGraw-Hill, 1939, p. 158.

[21] Joan Robinson, *Economics of Imperfect Competition,* Macmillan, London, 1933, p. 256.

[22] R. G. D. Allen, *Mathematical Analysis for Economists,* Macmillan, London, 1939, p. 341.

[23] D. R. Kaldor, unpublished marketing study, Economics Department, Iowa State College, 1940.

between White and Hard Red Winter shown in Figure 24 is lower than this; it is about — 2.0. Apparently, Soft Red Winter wheat can

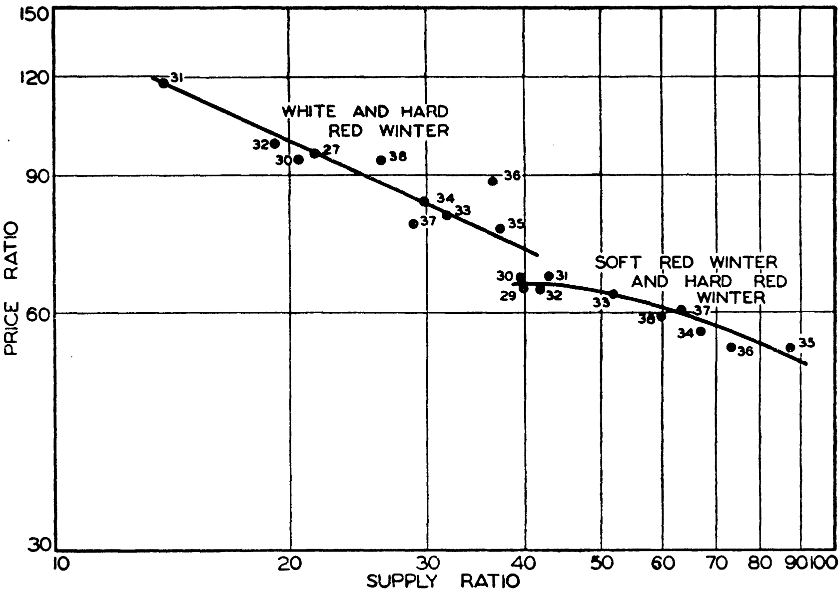

Fig. 24.—Elasticities of substitution between White wheat and Hard Red Winter wheat, shown by the upper line, and between Soft Red Winter wheat and Hard Red Winter wheat, shown by the lower line, 1928–38.

be substituted for Hard Red Winter wheat more easily than White wheat can.

One more kind of elasticity is "cross-elasticity." This is found by computing the changes in the quantity of a good that will be taken per unit change in the price, not of that good but of a related good; for example, by computing the changes in the sales of Fords per unit change in the price of Chevrolets.