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Elasticity of the Supply of Individual Farm Products

Supply curves are more difficult to measure than demand curves. Many statistical studies of demand have been published, but statistical studies of supply are not so numerous.

The nature of the difficulties, and their effects on the results, are well shown in the work of the pioneers in this field.

Warren and Pearson at Cornell derived coefficients of elasticity of supply for pre-World War I data which were all lower than 0.2 (some were negative) and probably were statistically not significant.

Later investigations constitute interesting background for current analyses, revealing how some of the difficulties were overcome or at least partially solved. These studies are grouped under two heads: Short-time elasticities of supply, where the supply represents market supply — the supply already produced, or in some stage or other of production — and long-time elasticities of supply, where the supply represents the quantities which farmers produce (plant or breed) in response to a change in price.

SHORT-TIME ELASTICITIES OF SUPPLY

DAY-TO-DAY CHANGES

O. V. Wells[1] investigated the effect of changes in hog prices upon the market receipts of hogs. In a study of short-time, day-to-day changes in prices and receipts of hogs at Sioux City in 1929–30, he found a positive relation between changes in price from Monday to Tuesday, and changes in truck receipts from Tuesday to Wednesday. A change of 10 cents per 100 pounds in hog prices was followed,

[1] O. V. Wells, "Farmers' Response to Price in Hog Production and Marketing," USDA Tech. Bul. 359.

on the average, by a change in the same direction of 15 per cent in hog receipts. At Chicago, served mainly by railroads that bring in hogs from longer distances than the trucks that serve Sioux City, a longer lag between changes in prices and changes in receipts was observed; the effects of price changes from Saturday to Monday showed up most strongly on receipts from Monday to Thursday. At this market and with this lag, a change of 10 cents in prices was followed, on the average, by a change of 10 per cent in receipts.

The price of hogs during 1929–30 averaged, in round figures, $10.00 per 100 pounds. The change of 10 cents per 100 pounds was, therefore, a change of 1 per cent. The elasticity of supply (short-time supply) at Sioux City, therefore, was 15, and at Chicago, 10.

H. J. Stover found that a change in the price of hogs at Chicago from Saturday to the next Monday had a direct effect on hog receipts at Chicago on the later days of the week.[2] The elasticity of this response of hog receipts to changes in prices was as follows:

Tuesday	4.4
Wednesday	8.8
Thursday	12.0
Friday	7.2
Saturday	4.4
Monday (one week later)	7.6

YEAR-TO-YEAR CHANGES

How do these short-time elasticities compare with the elasticities based upon longer periods? Wells also investigated that question and found that whereas the elasticities of supply of hogs based on daily data were high (much higher than unity, as we have just seen), the elasticities based upon annual data were low, only a fraction of unity. He used data for various states and markets, among them the average western Corn Belt corn-hog price ratio for October through March for the preceding two years (instead of the price of hogs) and the western Corn Belt hog marketings (October through September) as the measure of receipts. The elasticity of supply based upon the changes in these annual data (from the year before in each case) was only about 0.56. For Iowa data the elasticity was about 0.50; for Ohio and Missouri data the elasticities were nearly as high as unity; for the other states the elasticities ranged between 0.5 and 1.0.

This is interesting. It was shown in Chapter 5 that the elasticity

[2] Howard J. Stover, "Relation of Daily Prices to the Marketing of Hogs at Chicago," Cornell Univ. Agr. Exp. Sta., Bul. 534, pp. 46–48.

of demand for hogs, based on daily data, ranged from 5.8 on Saturdays to 2.8 on Wednesdays, whereas the elasticity based on annual data was about 0.6. Apparently, the elasticity of supply and demand for hogs is both high in the short run (day-to-day), and low in the long run (year-to-year).

Less is known about other products. Louis Bean found that the elasticities of supply for several other agricultural products were all less than unity, although his curves were less steeply sloped in their central parts, and in those parts the curves for rye, flax, and watermelons were more elastic than unity. The elasticity of the supply of broomcorn (acreage) is reported to be about 0.9, and of sweet potatoes, 0.5. The elasticity of the supply of cotton also appears to be about 1.0.[3] Pubols and Klaman[4] found that a change of 10 per cent in the (deflated) price of potatoes in the United States was associated with a change in the same direction of 2.3 per cent in acreage one and two years later.

LIMITATIONS OF SHORT-TIME STUDIES

The results of these studies are open to some question. The chief cause of variations in potato prices from year to year is variation in the size of the crop, caused chiefly by good or bad weather. Bad weather and a resulting short crop and a high price for potatoes one year should not induce much increase in potato acreage the next year. The new crop could only be expected to be average in size; this would bring only an average price, not a high price like the preceding year's short crop. High prices resulting from a strong demand should result in an increase in acreage, but high prices resulting merely from a short crop should not.

LONG-TIME SUPPLY SCHEDULES

The elasticity of supply curves is greatly affected by "the element of time, the source of many of the greatest difficulties in economics." [5] Ever since Marshall illustrated the effect of time upon production-response by reference to short, medium, and long-time changes in the demand for fish,[6] economists have been conscious of its importance. There is no curve which can be regarded as the *one-and-only* supply curve for any particular commodity. The character of each

[3] F. L. Thomsen and R. J. Foote, *Agricultural Prices,* McGraw-Hill, 1952, pp. 484–85.

[4] Ben H. Pubols and Saul B. Klaman. "Farmers' Response to Price in the Production of Potatoes, 1922–41," BAE, USDA, processed, 1945.

[5] Marshall, *Principles of Economics,* p. 109.

[6] *Ibid.,* pp. 369–71.

depends on the time specifically allowed for variations in output to take place. What we have, as a matter of fact, is a whole series of supply curves for each commodity representing all possible conditions between the most perfect long-run normal adjustment and most rigid momentary fixity of supply. Graphically speaking we may think of the supply curve for the very shortest period as a vertical line on the familiar two-dimensional chart and the supply curve for the very longest period as a line approaching the horizontal. Then, between these two extremes there will be a fanlike system of curves, each with a slope of its own, representing the various conditions of supply when adjustment periods of intermediate lengths are allowed for.

Accordingly, the length of time involved should be carefully noted in studies of the elasticity of supply, by the investigator so that he can adapt his methods to them, and by the reader so that he can appraise the results. The statistical supply curves discussed in this chapter so far have been mostly short-time curves. We will turn next to long-time supply curves.

It is difficult to derive long-time supply schedules. If each item in the series is to be the average of five years, or ten years, the conditions of supply may change (the whole supply curve may shift up or down). If production has changed, the investigator may not be able to tell how much of the change is due to a change in price and how much is due to the change in supply. The same difficulty is present in the derivation of demand schedules, but it is easier to solve, because fairly adequate measures of changes in demand exist (changes in the total national income, or in the general price level, for example). Measures of changes in supply of a similar sort are difficult to work out. Many variables have to be taken into account, and not all of them can be measured quantitatively—changes in the prices of various cost-items, in rents and interest, in technological production processes, and the like.

One possible way of getting around these difficulties is to analyze data on a geographical basis. If several different areas can be found with similar conditions of production but different prices, and if these price differences have persisted long enough for the production in the different areas to become adjusted to them, then the prices and production per square mile in the different areas can be used as points on a long-time supply curve. One illustration of this is the differences in the prices for fluid milk at various distances from the market, which result in great differences in output from different farms that are otherwise quite similar.

Another possibility is the experimental method. It would cost too much to guarantee certain farmers higher prices than the regular market prices for their products over a period of ten or fifteen years in order to measure the resulting changes in their production, but some research can be done on the physical relations which underlie the responses of production to price. An example of the latter is Einar Jensen's study of the response of dairy cows to varying inputs of feed.[7] Similar studies could be conducted with the feeding of hogs and cattle, and the application of fertilizer and different cultural practices to crops.

Still another possibility is the budget method. This method is based upon the study of individual records from representative samples of farms. It consists in going over the records for each farm and working out budget estimates of production for each farm separately, ten years hence, under several different price situations—higher prices for the product (say 15 per cent higher), constant prices, and lower prices. These estimates, added up, then provide three points on a long-time supply curve.

This method presents difficulties of its own, and involves a good deal of estimation, but it is realistic and shows promise. The results of applying this method to a study of milk production in the Cabot-Marshfield area of Vermont are shown in Figure 6.1. The heavy solid line *BAC* shows the estimated responses of production ten years later to milk prices 15 per cent higher, constant, and 15 per cent lower than they were originally. A short-term (three-month) supply curve for the same area, worked out by another investigator by other methods, is shown by the curve *SS,* shifted over to S′ S′ in order to allow closer comparison with *BAC.* The long-time curve is more elastic than the short-time curve, as would be expected.

SUPPLY CURVES, "OTHER THINGS BEING UNEQUAL"

Most of the supply curves reported above represent the supply curves of economic theory—that is, they show the response of producers to changes in the price of a particular commodity, "other things being equal." They show what happens when a short crop, for example, raises the price of potatoes. Even though farmers know that the price is as likely to be low again as it is to be high when the new crop is harvested, still they increase their acreage of potatoes in response to the temporarily higher price.

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[7] Einar Jensen, "Determining Input-Output Relationships in Milk Production," *Journal of Farm Economics,* Vol. 22, No. 1, pp. 249–58.

Fig. 6.1 — Long-time and short-time responses of milk production to price changes. (From USDA Tech. Bul. 709.[8])

This type of supply-response should be carefully distinguished from another type that results when all prices move up and down more or less together, as they do in periods of prosperity and depression. The supply curves derived above, "other things being equal," do not hold when "other things" (prices) are changing too, even though the periods of time involved may be similar.

Most demand curves are free from this sort of complication. The fluctuations in supply that make it possible to measure demand curves for agricultural products are fluctuations in the supply of individual products. They are large, rapid, and random, because they result chiefly from changes in weather. Moreover, the fluctuations in the supply of any one product are usually independent of those of other products. It is not often that shortages in one food are accompanied by shortages in another. Even in the record-breaking widespread drouth of 1934, total agricultural production fell only 3 per cent from the year before; and in the drouth year of 1936, it rose 3 per cent. The condition *caeteris paribus* (other things being equal) of classical economic theory is usually well fulfilled in the case of fluctuations in the supply of agricultural crops; the effect of

[8] R. H. Allen, Erling Hole, and R. L. Mighell, "Supply Responses in Milk Production in the Cabot-Marshfield Area, Vermont," USDA Tech. Bul. 709.

The subject is pursued further — although dealing mostly with physical relationships — in C. R. Hoglund *et al.*, *Nutritional and Economic Aspects of Feed Utilization by Dairy Cows*, Iowa State Univ. Press, 1959.

changes in the supply of one commodity can be measured "other things being equal" (i.e., unchanged), or at least having changes that are uncorrelated with the changes in the particular commodity being studied.

By contrast, the big fluctuations in demand that make it possible to measure supply curves are those that come with prosperity and depression; they affect all goods (not identically, but similarly). Other things do not remain equal; they change too. A decrease in demand for hogs is accompanied by a decrease in the demand for beef, lamb, poultry, butter, and eggs. The only changes in demand that affect one particular farm product and not others (like fluctuations in supply) are usually slow and gradual changes in consumers' tastes that take years to express themselves in sizeable figures. We now eat less starchy foods than our ancestors did, and more vegetables; but it has taken two or three generations to effect the change.

When a sudden change in *supply* takes place, as for instance when severe drouth cuts the production of butter 10 or 20 per cent, prices rise and less butter is bought; consumers eat something else instead. The readjustment in consumption takes place at once. But if an industrial depression comes, and the *demand* for butter declines 10 or 20 per cent, producers cannot make adjustments in production quickly. They are all set up to produce butter, and they cannot readily turn to produce something else. Even if they could change their setup rapidly and easily, it would do them no good; for the demand for other goods they might produce instead has also fallen.

Statistical demand curves show or at least purport to show what happens to prices when the supply of one product changes, the supplies of other products either remaining unchanged or else undergoing changes uncorrelated with the changes in the supply of the first product. But during periods of rapid change in general demand, statistical supply curves show what happens to prices when the demand for a specific product changes, *the demand for other products changing too and in a similar manner to the changes in the demand for the specific product.* This sort of supply curve is considerably less elastic than the supply curve "other things being equal."

One-Way Curves

There is an additional complication. When a general change in demand takes place, the supply curve is a more complex thing than the supply curve of classical economic theory. The situation is simple enough when the demand for butter, for example, is increasing in response to growth in human population, increase in per capita purchasing power, or a reduction in the costs of distribution. The demand curve shifts to the right and/or upwards, the price of butter rises, and butter production goes up. These things take place without much friction; agricultural production expands easily.

But when the demand for butter decreases, the situation is different. Farmers do not decrease their production of butter as readily as they formerly increased it. Their investment has been made, their plant is a going concern; it cannot be shut down without loss of the time and money invested. Most of the labor is supplied by the farmer and his family, and they cannot be discharged. It does no good to turn to some other farm products instead, for the demand for those products would have fallen too. Farmers take a lower return than they anticipated, rather than take no return at all. They continue to produce, perhaps almost as much as before, perhaps even more, but at lower prices than before. The path marked out by the intersection points of the demand and supply curves when the demand for butter increases is not retraced when the demand for butter declines.

Figure 6.2 represents the situation. The demand is shown as

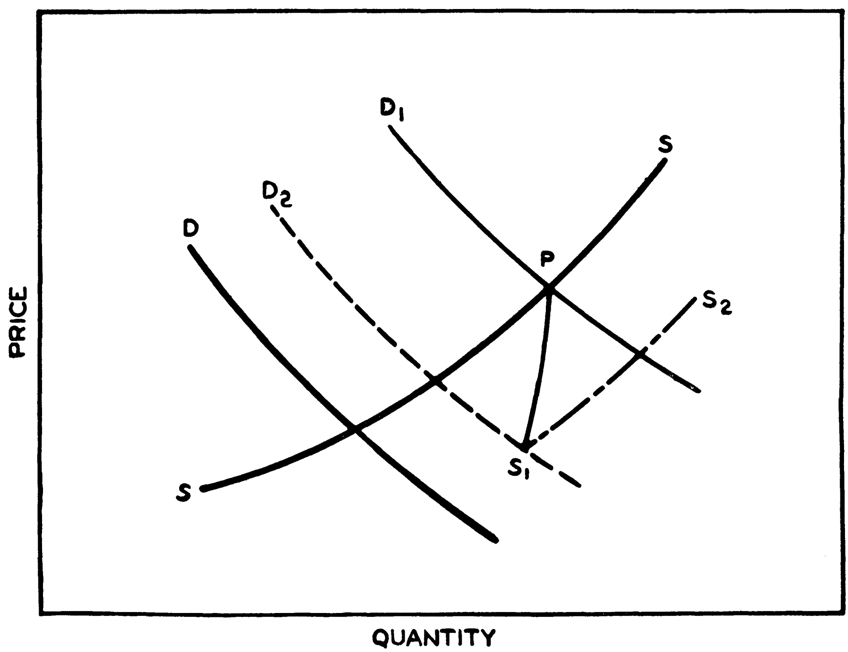

Fig. 6.2 — "One-way" supply curves. Hypothetical data.

increasing from D to D_1 and then decreasing to D_2. The curve SS is the supply curve under conditions of increasing demand. The other curve, running from P to S_1, is the supply curve established under conditions of decreasing demand. It is highly inelastic.

We saw in the section dealing with demand curves that "*the* elasticity" of the demand for a product varies according to the length of time represented by each unit in the series. The same phenomenon exists in the case of supply curves. But the complication shown in Figure 6.2 is a different and additional complication; it results not from different lengths of time (for it is revealed by annual data throughout) but from different directions of change in demand.

The one-way nature of the supply curves for most agricultural products is shown in the statistics of crop acreage and livestock population or slaughter, both after World War I and after the beginning of the industrial depression in 1929. In the case of most products, the production increased, rather than decreased, when prices fell; the supply curve actually had a slight negative slope for a time, as farmers attempted to offset lower prices by increasing production.

As to the effect of the passage of time on the difference between the elasticities of a supply curve "going up" and "coming down" on the curve, the evidence is inconclusive. After a few years of low prices after World War I, large wheat areas in the northwestern states—the "black triangle"—were abandoned. But by 1938 wheat acreage in the United States was the largest in history, with the single exception of 1919. Corn acreage in 1932 was also almost the largest in history, being only slightly exceeded in one previous year, 1917. It was reduced after 1932 only under the combined influence of two record-breaking drouths and the AAA programs. Hog and beef cattle production also held up. But so many other variables are also involved—changes in production costs, changes in domestic human population and in export demand—that clear-cut, simple conclusions can hardly be drawn.

It may be possible to derive useful supply curves for different farm products by what are essentially budgeting methods. One such supply curve, for hogs, derived by the application of linear programming methods to a typical 160-acre dairy farm in northeastern Iowa, is shown in Figure 6.3. Note that this chart is made, as so many are, to fit a pre-conceived shape of space on a page, rather than to show elasticity directly by having both scales run down to zero, and set proportionally equal in length. A little arithmetical compu-

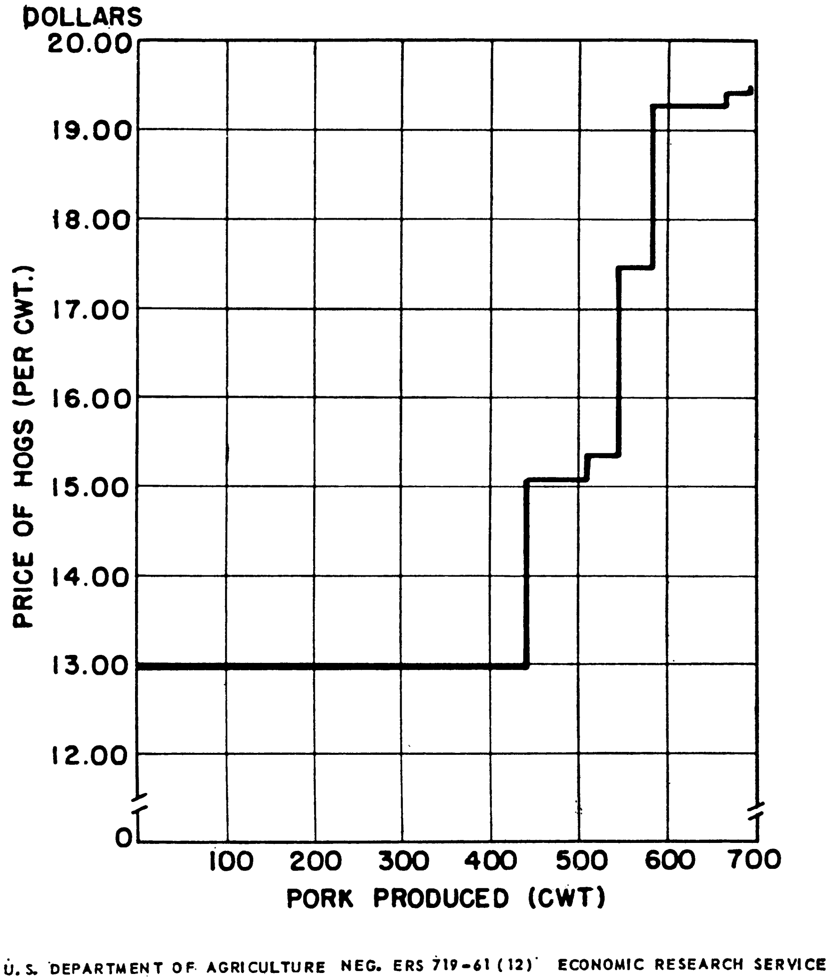

Fig. 6.3 — Supply function for pork.

tation shows that the curve, upward and to the right of the $13 and 400 cwt. point, has an elasticity of about 1.2.[9]

Another study of supply curves, in this case for cotton in the rolling plains area of Oklahoma-Texas, derived a "reversed S" curve. This curve is inelastic close to zero, curves over to become

[9] R. D. Krenz, R. V. Baumann, and E. O. Heady, "Normative Supply Functions by Linear Programming Procedures," *Agricultural Economic Research,* USDA, Vol. 14, No. 1, Jan., 1962, p. 17.

highly elastic in the central part, and then curves upward to less than unit elasticity at right-hand end.[10]

GRAPHIC REPRESENTATION OF ELASTICITY OF SUPPLY

An interesting feature of the graphic representation of the elasticity of supply is the fact that two straight lines such as *A* and *B* in Figure 6.4, which have obviously different slopes, have the same elasticity, namely, + 1.0. As a matter of fact, all straight lines passing through the origin have the same elasticity, + 1.0.

A moment's reflection, however, shows that this is necessarily true, from the definition of or formula for elasticity. The figures for a line with a 1 to 1 slope (where $y = x$) at the point where $x = 10$ and $y = 10$, give the following result:

$$\frac{1}{1} \cdot \frac{10}{10} = 1.0$$

The figures for a 2 to 1 slope (where $y = \frac{x}{2}$) at the point where $x = 10$ and $y = 5$, give the same result:

$$\frac{2}{1} \cdot \frac{5}{10} = 1.0$$

All that this shows, however, is that elasticity is a proportional concept, as we found earlier in the study of demand. All it means is that if the second case just given ($y=2x$) were plotted in its original data form, on arithmetic paper, the diagram would be twice as high as it was wide. If the diagram were squashed down (scales, supply curves, and all) until it were square, it would then be identical in appearance with the first case given above ($y = x$). The slope of the supply curve would be the same as in that case (45°). True, the slope of the curve would still be expressed numerically, as

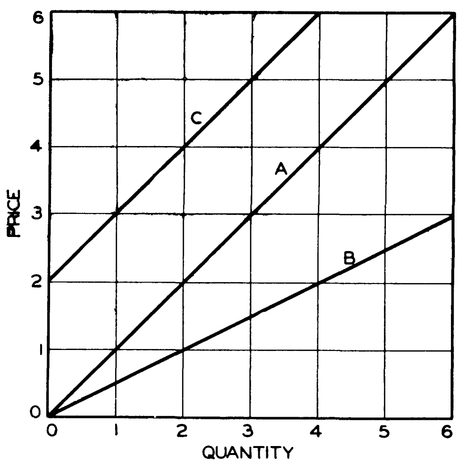

Fig. 6.4—Supply curves of different slopes and elasticities. Hypothetical data.

[10] John William Goodwin, "Aggregation of Normative Microsupply Relationships For Dry-Land Crop Farms in the Rolling Plains of Oklahoma and Texas," Ph.D. Thesis, Oklahoma State University, May, 1962, p. 105.

$y=2x$, but $2x$ in the second case means the same thing proportionally as x in the first case. That is, $2x$ would equal, for example, 10 per cent (of the average) in the one case, and x would equal 10 per cent (of the average) in the other, so the two elasticities should be the same, as in fact they are. This is shown clearly enough if the two cases are plotted on double logarithmic paper, which as we saw earlier is the proper paper for representing elasticity accurately. The curves then appear as two parallel lines, with identical slopes (45°).

The discussion above does not mean, of course, that all straight-line, positively sloping curves have an elasticity of unity. It is only straight lines that go through the origin that do so. Straight lines that cut the Y axis at some positive value (i. e., above zero), like the line C shown in Figure 6.4, all have elasticities that are greater than unity. Conversely, lines that cut the Y axis at some negative value below zero (or, to put the same thing in other words, that cut the X axis at some positive value, to the right of zero) have elasticities that are less than unity. As with straight line demand curves (with negative slopes), the elasticity varies from point to point along any straight line positively sloping curve, if it does not go through the origin.

three

MEASURING CHANGES IN DEMAND AND SUPPLY