CHAPTER 12

The Theory of Price Stabilization and Price Discrimination

It was shown in earlier chapters that the effect of production-control programs on the total revenue from the sale of the crop depends upon the elasticity of the demand for that crop. It will be shown in the present chapter that the effect of *price stabilization* programs on the total revenue from the sale of the crop depends primarily upon the curvature of the demand curve for the crop, and secondarily upon its elasticity.

There appears to be a general belief that in actual life most demand curves are curved lines, concave from above, on arithmetic paper. Practically all of the hypothetical curves found in economic textbooks are thus curved. These concave curves are also common in technical articles in professional journals.

These curves are misleading in two respects. Most of them apparently reflect the belief that the demand curve characteristically is more elastic at the lower end of the curve than at the upper end. This sounds like a reasonable assumption, yet it is incorrect in two respects: (1) Most of the hypothetical curves which are shown as concave on arithmetic paper are actually convex on logarithmic paper, and therefore are less elastic at the lower end than at the higher, as shown in Figure 50.[1] And (2) most of the demand curves for agricultural products which have been empirically derived are not concave curves on arithmetic paper; they are approximately straight lines; accordingly, they are strongly convex on logarithmic paper, which means that they are much less elastic at the lower end than at the upper.

This is shown by a study of a considerable number of demand curves empirically derived from market statistics. These curves are shown on logarithmic paper in Figure 50. The curves are taken from the published charts, without any comment as to their accuracy other than the closeness (or lack of it) of the scatter of the dots

[1] Sources of data are given in the *Journal of Farm Economics,* XX, No. 4, November, 1938, p. 806.

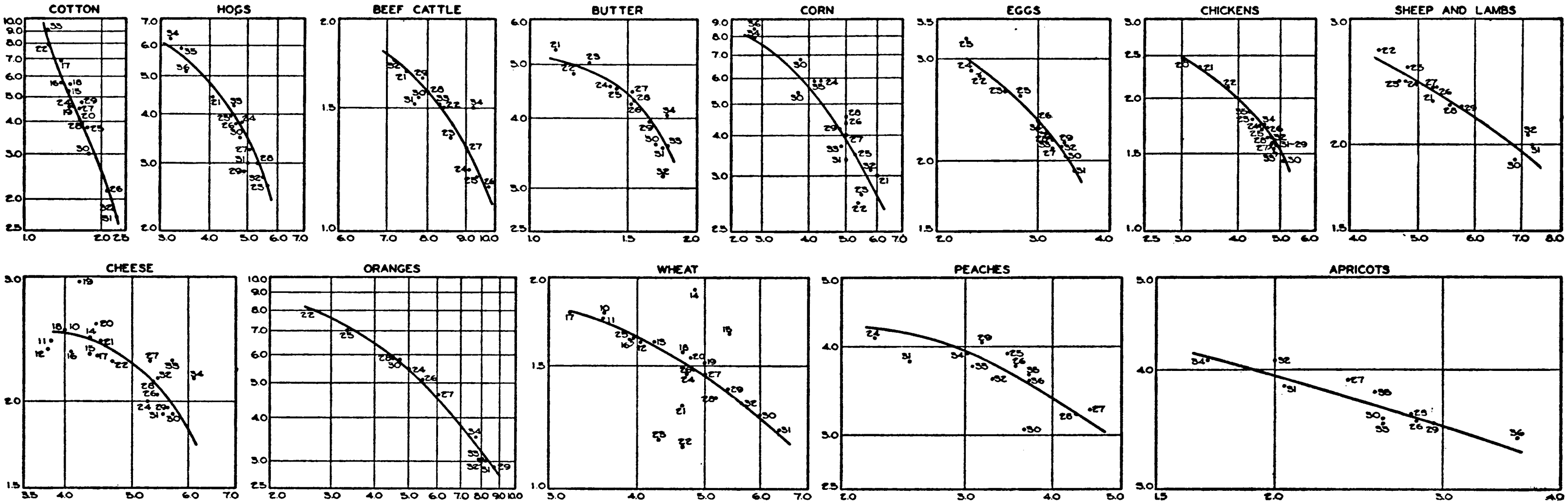

FIG. 50.—Empirically derived price-quantity curves for various farm products.

about the curves, which is shown in each case. These analyses are the most recent ones available, but some of them are several years out of date, and several of them would be improved by the use of better indexes of demand than were available when the studies were made. They should all be brought up to date, but nobody competent to do the job seems to have time to do it. Figure 50 should be regarded only as tentatively establishing a hypothesis that needs to be investigated more thoroughly and confirmed, amended, or proven erroneous.[2]

All of the curves were published on arithmetic paper in the original analyses. Many of them were straight lines on arithmetic paper. On logarithmic paper, as shown in Figure 50, they are all convex, with the exception of the curve for apricots and the upper end of the curve for cotton.

This means that the elasticity is high in the upper part of the curve and low in the lower part. This in turn means that in the simplest case of a straight line demand curve on arithmetic paper with an average elasticity of unity, both a small crop and a large crop are worth less than an average-sized crop. For the elasticity in the upper half of the curve is higher than unity, so a small crop is worth less than an average crop. Conversely, the elasticity in the lower half of the curve is lower than unity, so a small crop is worth more than an average crop. The crop that is worth the most is the average-sized crop that cuts the whole curve at the middle where the elasticity is unity. This means that stabilization of supplies by storing surpluses from large crop years over to small crop years would not only stabilize prices but would also increase total incomes from the sale of the crop.

This can be shown clearly with the help of a few hypothetical figures. The prices and total revenues for a crop with a straight-line demand curve (on arithmetic paper) with an average elasticity of unity are shown briefly in Table 21. The data are all in index form with an average equal to 100.[3]

It is clear from Table 21 that a large crop, for instance 130 per cent of average in size, which would sell for an index price of 70, would bring in a total revenue of only 91. A small crop, 70 per cent of average in size, would sell at 130 and also bring in a total revenue

[2] Adolf Kozlik, "Shape of Total Revenue Curves," *Journal of Farm Economics,* XXIII, No. 4, November, 1941, pp. 843–54.

[3] These relationships were shown in graphic form in Figure 25, Chapter 5.

of 91. These two crops, then (a large crop and a small crop), would bring in total revenues averaging only 91 per cent of normal. If the surplus (the excess over 100) were withheld from the large crop and added to the small crop, that would convert them both into average-sized crops. They would bring in an average total revenue

TABLE 21

PRICES AND TOTAL REVENUES FOR VARIOUS QUANTITIES: STRAIGHT LINE DEMAND CURVE WITH AN AVERAGE ELASTICITY OF UNITY

(1) Size of Crop in Percentage of Average	(2) Price per Unit in Percentage of Average	(3) Total Revenue in Percentage of Average ((1) x (2) omitting 00)
60	140	84
70	130	91
80	120	96
90	110	99
100	100	100
110	90	99
120	80	96
130	70	91
140	60	84

over the two years of 100 per cent of normal. Stabilizing supplies in this case would not only stabilize prices, but would also increase total revenues from the sale of the crops.

What is the effect of a stabilization program in cases where the demand curve is not a straight line on arithmetic paper, but has some sort of curvature?

If the demand curve is so shaped that it has a constant elasticity of unity throughout its length, then no matter what the size of the crop—large, average, or small—it brings in the same total revenue. In fact, a curve with constant unit elasticity is the same thing as a constant revenue (or constant total value) curve. In that case, of course, stabilization operations have no effect on total revenue, since the total revenue is unaffected by the size of the crop. But if a demand curve with an average elasticity of unity is more concave than a constant total revenue curve, then a large crop and a small crop are both worth more than an average crop, and stabilizing supplies would decrease total revenues.

The section can be summarized in these terms: the way to maximize total revenue is to produce the amount that will cut the demand curve as close as possible to the point where the elasticity is unity (where the marginal revenue is zero and the total revenue is the greatest). Where the demand curve is inelastic, reducing the size of the crop (cutting the demand curve at a higher point) will increase total revenue; where the demand curve is elastic, increasing the size of the crop will increase total revenue. In the case of straight-line demand curves with an average elasticity of unity, the elasticity of the demand curve is less than unity in the lower part of the curve and greater than unity in the upper part, and the way to maximize total revenue is to move toward the center from both directions, that is, to convert both large crops and small crops to average-sized crops by storing the excess over average from the large crops and adding it to the small crops. The more convex the demand curve is, the more will stabilizing supplies add to total revenue, and the more concave it is, the less it will add, until the point is reached where the curve is more concave than a constant-total-revenue curve; beyond that point stabilizing supplies will decrease total revenue.

DEMAND CURVES WITH CONSTANT BUT NOT UNIT ELASTICITY

If the demand curve has a constant elasticity that is greater or less than unity, the situation is more complicated. The total revenue curves then are not straight lines, as they are when the demand curve has a constant elasticity of unity. If the elasticity of the demand curve is constant, but less than unity, the total revenue curve associated with it has a concave curvature. It has the same shape as a constant total returns curve; that is, it is a symmetrical hyperbola approaching the x and y axes as asymptotes. In Figure 26, Chapter 5, a demand curve with a constant elasticity of —0.5 is shown both on logarithmic and arithmetic paper, in the upper part of the chart, and the total revenue curve associated with it is shown in the lower part of the chart. (The elasticity figure, —0.5, written beside the curves shows the elasticity of the original demand curve for purposes of identification, not the elasticity of the total revenue curve; that is —1.0.)

In that case, a large crop, represented by six quantity units along the scale at the bottom of the chart, is shown to bring a total revenue of about 1.5. A small crop, represented by two quantity units, brings a total revenue of 5. The sum of these two total revenues is 6.5. But if the excess of the large crop over average were removed from the large crop and added to the short crop, that would convert them into two average-sized crops (four quantity units) each of which would bring in a total revenue of about 2.5; the sum of these two total revenues would therefore be 5, and this is less than the sum of the large and small crop, 6.5, computed above. A stabilization program in this case would therefore reduce total revenues.

The opposite is true of demand curves with a constant elasticity greater than unity. A curve of this sort, with a constant elasticity of —2.0, is also shown in the upper part of Figure 26, with the total revenue curve associated with it in the lower part. The total revenue curve in this case is convex from above; it is a parabola with apex at the origin of the X and Y axes. Stabilizing supplies in this case would increase total revenues.

"STANDARD" DEMAND CURVES WITH STRAIGHT-LINE TOTAL REVENUE CURVES

It was shown earlier that a demand curve with a constant elasticity of unity makes a convenient standard for determining whether stabilization of supplies would increase or decrease total returns. If the demand curve for the particular crop considered has an average elasticity of unity but is less concave than this standard curve (if, for example, it is a straighter line, or a convex line) then stabilization would increase total revenues; if it is *more* concave than this standard curve, stabilization would decrease total revenues.

It was shown above that this standard applies only to demand curves with an average elasticity of unity. Is there another convenient standard or set of standards that can be used for crops whose demand curves have other elasticities than unity?

There is. The criterion for such a set of standard curves is that the total revenue curves associated with them must be straight lines. In that case stabilization will have no effect on total revenues over a period of large and small crops. Figure 26 shows that demand curves of constant elasticity (other than unity) cannot be used as standards because their total revenue curves are not straight lines. They may have a positive slope (as where the demand curve is elastic) or a negative slope (as where the demand curve is inelastic) but they must be straight.

Adolf Kozlik has worked out mathematically the sort of demand curves required here, and shown graphically that they are merely curves of constant unit elasticity shifted up or down by constant absolute amounts all along the curve.[4] The validity of this standard set of curves can be understood in everyday language thus: The total revenue curve associated with a constant-unit-elasticity demand curve is a horizontal straight line. If now the demand curve is shifted up one price unit all along its length, the resulting total revenue curve will start in, at the first quantity unit, one value unit higher than the original total revenue curve ($1 \times 1 = 1$); at the second quantity unit it will be two value units higher ($2 \times 1 = 2$); at the third, three units higher, and so on. This total revenue curve therefore will be a straight line, with a positive slope. Similar calculations apply to demand curves lower by constant amounts than a curve with a constant elasticity of unity.

If the demand curve for the particular crop concerned, therefore, has an average elasticity other than unity, stabilization would increase or decrease total revenues accordingly as the demand curve is more or less curved than the appropriate standard curve for that elasticity. Since these standard curves are ordinary constant-unit-elasticity curves shifted up (for elastic demand curves) or down (for inelastic demand curves) the comparison of the standard demand curve with the demand curve for the particular crop can be made by sliding a transparent chart with a family of constant-unit-elasticity curves up and down on it (but keeping the Y axes on the two charts superimposed) until a section of one of the standard curves is found which has the same average elasticity as the demand curve for the crop in question. If the demand curve for the crop is less concave from above (that is, if it is straighter than the standard curve, or actually convex), then stabilization of that crop would increase total revenues. If, on the other hand, the demand curve is more concave (more curved) than the standard curve, stabilization would decrease total revenues.

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[4] Adolf Kozlik, "Conditions for Demand Curves Whose Curves of Total Revenue, Consumers' Surplus, Total Benefit, and Compromise Benefit are Convex," *Econometrica*, VIII, No. 3, July, 1940, pp. 263–71.

A short mathematical proof of this runs as follows:

The total revenue curve $R(Q)$ of a demand curve with the equation $F(Q) = a/Q + b$ is $R(Q) = Q.F(Q) = a + bQ$. This is a straight line, because R increases proportionally with Q. The demand curve whose total revenue curve is a straight line is a demand curve of constant unit elasticity $F(Q) = a/Q$ shifted up and down by the amount b. The total revenue curves of demand curves which are more concave than these demand curves are concave, and the total revenue curves of demand curves which are more convex than these are convex.

DOES STABILIZATION BENEFIT CONSUMERS?

It could be argued that consumers are harmed by stabilization to the same extent that farmers are benefited by the increased total value of their crops, for the increased total value of crops to farmers emerges as an increase in the cost of food to consumers. If stabilization increases the total value of a series of crops 6 per cent, as in the illustration just used, it must increase the cost of consumers' purchases by the same amount.

The harm or benefit to consumers cannot be measured, however, merely by the increase or decrease in the amount of money they pay for corn. If a monopolist restricted the production of his product, and the demand for that product were inelastic, consumers would pay more for the small quantity than they did before. They would clearly be harmed, but the harm would not be measured by the extra amount of money they had to pay. For if the demand were elastic instead of inelastic, consumers would pay less for the small quantity than before. No one could claim that they would be benefited because their total outlay for the product had been reduced; least of all could anyone claim that they would be benefited by the amount of the reduction in their total outlay for the product.

The question can be approached from a different direction. Any one consumer gets more satisfaction from a fairly even consumption of a particular food than he does from a scarcity at one time and a glut at another. In technical terms, the total-utility curve is convex from above. A stable supply is therefore worth more to him than a fluctuating supply. The extra worth of the stable supply may be greater or less than the extra money he has to pay for it—there is no way of telling which—so the consumer may benefit by more or less than the extra money he pays. The important point is merely that he does benefit to some extent; the extra money he pays is not all loss, and may even be less than the benefit he receives.

But fluctuations in the production of different foods have a differential effect on different classes of consumers. When supplies and prices fluctuate, consumers with low incomes can make those incomes go farther by buying most heavily of those foods that are cheapest at the time, and buying least heavily—or perhaps not at all—of those foods that are temporarily scarce and high priced. At first thought, therefore, it would appear that stabilizing supplies would work some hardship on the low-income groups; they would be obliged to pay more for their food.

F. V. Waugh has made a further point. He shows that consumers are harmed if the price of any product is stabilized at the simple arithmetic mean of the fluctuating prices. This point is independent of the points made above. It is based upon the concept of consumers' surplus, and depends only upon the fact that the elasticity of the demand curve is negative.[5]

Waugh shows that with any negatively-sloping demand curve (sloping downward to the right) the loss in consumers' surplus from averaging two prices is always greater than the gain. For example, when egg prices vary from 40 cents to 60 cents a dozen, consumers' surplus is greater than it would be if the price were stabilized at 50 cents a dozen. He then confirms this conclusion by an analysis based on indifference curves.

Waugh's theorem is illustrated in Figure 51. This figure shows that the gain to consumers when prices are below average is always greater than the loss when prices are above average. That is, the area in Figure 51 marked G (for gain) is always necessarily larger (because of the negative slope of the demand curve) than the area marked L (for loss). Thus consumers are harmed by price stabilization. This is true not only of consumers as a group, but of each consumer separately.

This theorem appears to run counter to common sense, but so far it has stood up pretty well under criticism. Two critics[6] have made the point that the theorem is true only if prices are stabilized at or above the arithmetic mean of the variable prices. They point out that if prices are stabilized at or below the *weighted* average of the prices (weighted by the consumption at each price), consumers would be *benefited,* not harmed, by the stabilization. This reduces the status of Waugh's theorem from a general rule to a special case.

The argument then arises as to which is the more reasonable level for prices to be stabilized—at or above the arithmetic mean, or at or below the weighted average? Lovasy points out that the weighted average is the more reasonable level, since it would maintain producers' incomes at the same average level as before, and benefit them by reducing risks and lowering costs. Waugh replies

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[5] F. V. Waugh, "Does the Consumer Benefit From Price Instability?", *The Quarterly Journal of Economics,* August, 1944, pp. 602–14.

[6] L. D. Howell, "Does the Consumer Benefit From Price Instability?, Comment," pp. 287–95; Gertrud Lovasy, "Further comment," pp. 296–301; Frederick V. Waugh, "Reply," pp. 301–303. *The Quarterly Journal of Economics,* LIX, No. 2, February, 1945, Harvard University Press, Cambridge, Mass.

that producers would not be interested in stabilization at that level; they would want a level at least as high as the arithmetic mean. This argument gets out of the field of statistics and economic theory. But

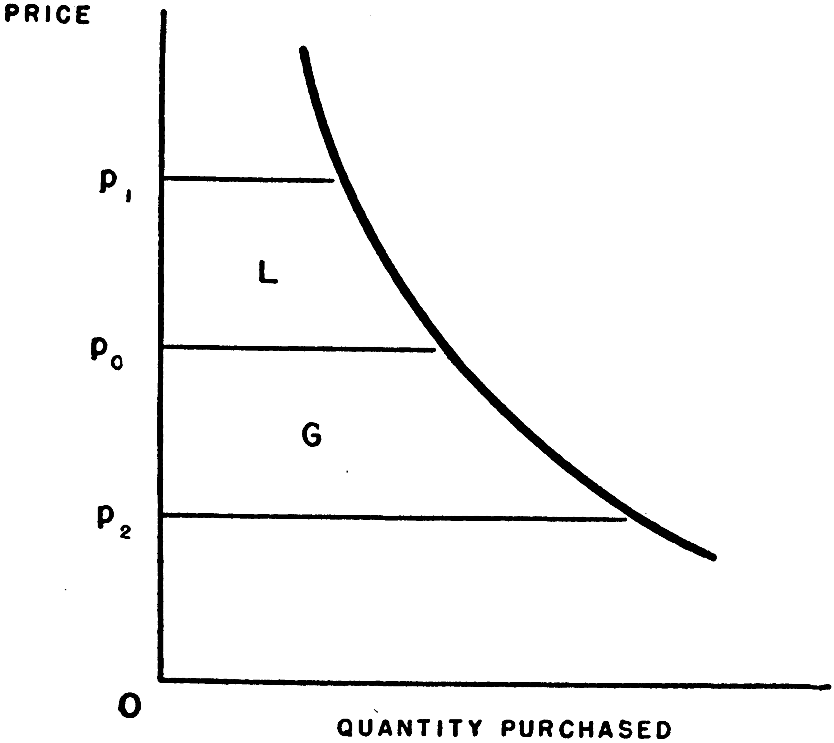

FIG. 51.—Comparison of loss and gain from fluctuating prices, showing that the gain is greater than the loss.

it seems to me that it would be settled by the curvature of the demand curve, not by the desires of producers.

An additional point has been made by D. Gale Johnson, who shows that stabilizing *supplies* at the arithmetic mean of the fluctuating supplies always benefits society as a whole (at least, if carrying costs are neglected). In some cases this would reduce consumers' surplus, but in all such cases this loss would be more than offset by a gain in producers' income.[7] In all such cases the pro-

[7] See his Ph.D. Thesis, "The Theory of Forward Prices for Agricultural Products," Department of Economics, Iowa State College.

ducers could afford to pay consumers compensation for their losses, and would still have a net profit from stabilizing supplies.

THE THEORY OF PRICE DISCRIMINATION

The theory of price stabilization outlined above is in essence the theory of equalizing prices in different time-markets—that is, in markets separated by intervals of time. It is comparatively simple; it is based directly on the relations between point elasticity and marginal, average, and total revenue laid down in earlier chapters. The theory of price *discrimination* is in essence the theory of *unequalizing* prices. The basic theory of price discrimination is the same as the basic theory of price stabilization. Its exposition is more complicated, however, because it involves two or more different demand curves. The theory of price stabilization involves two or more curves also, one for each year, but they are not different curves; they are identical curves, and are therefore treated as one.

The theory of price discrimination and of price stabilization both call for maximizing total revenue by cutting the demand curve (or curves) as close as possible to the point (or points) of unit elasticity. But whereas the theory of price stabilization deals with a succession of identical demand curves in markets separated by intervals of *time,* the theory of price discrimination deals with two or more different demand curves in contemporaneous markets separated in *space,* in *form,* or in some other basic characteristic. Export-dumping plans are examples of price discrimination between two or more markets separated in *space.* Milk price plans are examples of price discrimination between two or more markets separated in *form* (the original product is sold in two or more different forms, fluid milk, and butter, cheese, ice cream or some other manufactured product). The food stamp plan is an example of price discrimination between two *income-group* markets.

The general principle underlying price discrimination has not always been adequately stated in the literature of the subject. Joan Robinson wrote, "If it is possible for a monopolist to sell the same commodity in separate markets, it will clearly be to his advantage to charge different prices in the different markets, provided that the elasticities of demand in the separate markets are not equal. For if he charges the same price in each market, he will find that, at that price, the marginal revenue obtained by selling an increment of output in each market separately is greater in some markets than in others. He can, therefore, increase his profit by selling less in those markets where the elasticity of demand is less and the marginal revenue smaller, and selling more in those markets where the elasticity of demand is higher and the marginal revenue greater. He will, therefore, adjust his sales in such a way that the marginal revenue obtained from selling an additional unit of output in any one market is the same for all the markets."[8]

This is a good clear statement, but it is incorrect in two respects. In the first place, it is not necessary that the elasticities in the different markets be different, in order for total revenues to be increased by price discrimination, as we shall see later. And in the second place, the statement gives the conditions for maximizing or *minimizing* total revenues; it gives only the necessary, not the necessary and sufficient, conditions for maximizing total revenues. The same shortcoming appears to be evident in the statement from another source:

"If the purpose of discriminative marketing is to obtain the greatest possible net income for a given supply to be marketed, the principle to be followed is not that of equal net prices in all markets, but the principle of equal marginal net returns from all markets."[9]

In this case, however, the shortcoming results only from the summary nature of the statement and the prominence that is given to it. At several points further on in their paper, the authors point out that under certain conditions, which are specified, the equalization of marginal returns will minimize, not maximize, total returns. They also give a good mathematical treatment of the subject. The principle can be put in everyday words as follows:

GENERAL THEORY OF PRICE STABILIZATION AND PRICE DISCRIMINATION

Total revenues are maximized or minimized by the equalization of the marginal revenues in the different markets. In price stabilization, the demand curves in the separate markets (in time) are identical; the equalization of marginal revenues is accomplished by the equalization of the prices in the different markets. This maximizes total revenues if the demand curves are less concave than the

[8] Joan Robinson, *Economics of Imperfect Competition,* Macmillan, London, 1933, p. 181.

[9] F. V. Waugh, E. L. Burtis, and A. F. Wolf, "The Controlled Distribution of a Crop Among Independent Markets," *Quarterly Journal of Economics*, LI, November, 1936, p. 6.

"standard" curves defined above (whose associated total revenue curves are straight lines). It minimizes total revenues if the demand curves are more concave than the "standard" curves.

The principle for price discrimination runs in similar but opposite terms. In this case the demand curves in the separate markets may be identical, or they may be different. The principle is the same in either case, but it can be most simply stated for the case where the curves are identical. In that case, the equalization of the marginal revenues may require *unequalizing* prices—charging different prices in the different markets. This maximizes total revenues if the demand curves are more concave than the "standard" curves, and minimizes total revenues if they are less concave. If the demand curves in the different markets are not identical, the principle is the same, but a full exposition of it requires somewhat complicated mathematics. The general idea can be conveyed verbally in terms of the total revenue curves associated with the two demand curves. It is phrased in terms of two different markets here. The principle is the same for more than two markets; only its exposition is more complicated. If the total revenue curves are both concave from above, price discrimination carried to the point where marginal revenues are equal maximizes total revenues; if they are both convex, price discrimination minimizes them. If one of the curves is concave, and the other one is convex, the outcome depends on which curve has the greater curvature. This curvature may be measured by the absolute value of the second derivate of the curve. If the algebraic sum of the two second derivatives is positive, then price discrimination carried to the point where marginal revenues are equal maximizes total revenues; if the sum is negative, it minimizes it.