In the preceding chapters, we assume that prices achieve an equilibrium so that prices at spatially separated points differ at most by cost of transfer; that prices of different products made from a common raw product source differ at most by cost of transformation; and that prices at one time period differ from prices in an earlier time period at most by costs of storage from the earlier time period to the later time period. This perfect-market model is a useful approximation of the real world, but we need not be satisfied with it as a final analytical device. In this chapter, we investigate market price relationships when price discrimination among markets is possible.

12.1 TYPES OF PRICE DISCRIMINATION

Price discrimination may take a variety of forms. First, it is possible that spatially separated markets, in fact, may be cut into two or more independent units, and supplies may be allocated in such a way that prices will differ by more than costs of transfer. Clearly, such a division would be effective only if leakage could be prevented; that is, firms in the market in which a lower price was established must be restrained from reselling
the product in the higher priced market. A second possibility is that the market for a raw product sold in two or more forms may be separated in such a way that the price of the product in one form exceeds the prices of other product forms by more than the cost of transformation. A third possibility is that temporal separation of markets is feasible, making it possible to raise the price in one time period by more than the cost of storage from earlier time periods. Other possibilities include the separation of markets according to user group, that is, of charging one group of customers a higher price for a given product at a given point in time at a given geographic location than is charged other groups. Or there may be an opportunity for price discrimination according to the use to which a particular product is put, such as the division of the market for a particular product between industrial and home users.

None of these possibilities is admissible under pure competition (the market situation in which no firm is sufficiently large to influence the price of the product by its output decisions or sufficiently important to have its actions be of any concern to other producers of a similar product). We now examine alternative modes of behavior of the firm in order to identify situations in which price discrimination opportunities might be considered.

12.2 MODES OF BEHAVIOR OF THE FIRM

In this section we concentrate on the modes of behavior of selling firms, although a comparable analysis of buying firms could easily be provided. Schneider has identified five modes of behavior which are useful in this analysis. We now briefly discuss each of these types of firms.

The Quantity Adjuster. The quantity adjuster is faced with a decision concerning the quantity of goods to be sold at the ruling price. Such a seller is too small to influence price and, therefore, the only variable in the plan of the firm which he is able to manipulate is the quantity he wishes to sell. This is the type of firm that populates the world of pure competition.

The Price Fixer. The price fixer has as his action parameter the price at which he wishes to sell his product. This decision is based on the expected price-sales relation which he perceives for his product. He takes as his expectation parameter the quantity which can be sold at alternative prices and chooses his price in such a way as to maximize revenue or to achieve some other goal which has been selected.

Several classes of price fixers can be identified. If the sales of a particular firm depend only on the price established by the firm in question, his behavior can be described as that of a monopolist. However, it is possible that his sales also depend on the prices established by other
firms. If it is assumed that other firms will not modify their prices in response to changes in his price, his behavior will be polypolistic. Of course, it is possible that his sales depend on prices fixed by others and, furthermore, that other firms will react to changes that he makes in his price. In this situation, he will behave as an oligopolist.

**The Quantity Fixer.** As suggested by the title of this class of firm, their action parameter consists of the quantity of output they wish to offer for sale. This quantity is selected on the basis of an expected price-sales relation as in the price-fixer mode with the price at which a given quantity can be sold resting with the buyer. Again, we can identify three subclasses of quantity fixers—those for which the outcome is influenced solely by the quantity they choose, those firms whose price-sales relation also is affected by the actions of others and, finally, that class of firm for which the actions of other firms influence their price-sales relation and which need to be concerned about possible reactions by other firms to choices they make concerning the quantity to be sold.

**The Fixer of Options.** Firms in this class have, as their action parameter, the setting of both price and quantity. Obviously, this is not to be thought of as dictating what the consumer will choose. Instead, such a firm establishes an option that the buyer of his product is free to accept or reject. Clearly, the willingness of buyers to accept or reject a particular option depends on the price and quantity characteristics of the offer. The types of options that are proposed, therefore, will reflect the expected response by these buyers to alternative price-quantity combinations.

**The Economic Warrior.** It is necessary to include this fifth class in order to allow for the possibility that the behavior of firms will no longer consist of the type of peaceful adaptation provided for in the first four classes. Here, we find ourselves in the world of strategy and maneuver on the part of individual firms—the relevant variables including not only the behavior of rivals, given the fact that peaceful coexistence is to be maintained, but also the recognition that the choices open to a particular firm may include some that in the long run will defeat competitors and will leave a larger share of the market to the firm engaging in this behavior.

We now observe that it is only the first class of sellers, the quantity adjusters, whose behavior will automatically bring about a set of market prices such as those described by the perfect market model that we have used thus far. Furthermore, introductory economics texts to the contrary, the agricultural sector of the United States is ill-defined in terms of quantity adjusters alone. In fact, the existence of cooperative and other groups of firms that band together to influence prices and sales and the role of state and federal governments in price-setting and quantity-
regulating decisions in agriculture are sufficiently important to require our careful attention.

Price discrimination is perhaps the most common tool used to regulate markets in order to provide for an orderly flow of products to consumers and to benefit selected groups of producers over a short- or longer run period. Before examining specific types of price discrimination, we review briefly some analytical tools that will help to clarify the basis for price discrimination.

12.3 PRICE ELASTICITY REVIEWED

Elasticity is a pure measure that relates proportional changes in dependent and independent variables for any function. In approximate terms, elasticity may be defined as the percent change in a variable $Y$ that results from a 1 percent change in variable $X$. Suppose that we have given two points $(X_1, Y_1)$ and $(X_2, Y_2)$ on a particular function (Figure 12.1). The change in $Y$ is apparently $(Y_2 - Y_1)$, and the corresponding change in $X$ is $(X_2 - X_1)$. These changes must be expressed in relative terms, and this creates a problem: Shall we use the $X_1$ and $Y_1$ values or the $X_2$ and $Y_2$ values? Inspection of the diagram indicates that the straight line connecting point 1 and point 2 does not represent the slope or the rate of change in the curve at either point. The slope of this straight line, however, is about the same as the slope of the curve at a point midway between the two points. For this reason, we select an arbitrary and approximate rule—the changes in $Y$ and $X$ shall be expressed relative to the average values for these variables.

Following this rule, expressions for elasticity are given below:

$$ E = \frac{\text{percent change in } Y}{\text{percent change in } X} $$

$$ E = \frac{(Y_1 - Y_2)/(Y_1 + Y_2)/2}{(X_1 - X_2)/(X_1 + X_2)/2} $$

$$ E = \frac{(Y_1 - Y_2)/(Y_1 + Y_2)}{(X_1 - X_2)/(X_1 + X_2)}. $$

It should be clear from the diagram that this is only an approximate procedure, measuring roughly the average elasticity between two points on the function. Such a measure is called arc elasticity. A precise measure defining elasticity at a selected point on the function is called point elasticity.

Suppose that we reexpress the above formulas by using $\Delta Y$ and $\Delta X$ to represent the changes in $Y$ and $X$ and that we simply use $Y$ and $X$ to
denote the average values for these variables. We then have

\[ E = \frac{\Delta Y / Y}{\Delta X / X} \]

This is a convenient form for it expresses elasticity as the slope of the straight line connecting the two points multiplied by the ratio of \( X \) to \( Y \). And notice that as \( \Delta X \) and \( \Delta Y \) become smaller and smaller, the slope of the line segment approaches closer and closer to the true slope of the function. The limit to this is the slope of the tangent at a single point on the function, and the correct expression for elasticity is

\[ E = \frac{dy}{dx} \cdot \frac{X}{Y} \]

where \( \frac{dy}{dx} \) represents the slope of the tangent.\(^1\)

\(^1\)While \( \frac{dy}{dx} \) represents the slope of the tangent to the function at any point, it is no longer a ratio as was \( \Delta Y / \Delta X \) but a compound symbol representing the first derivative of the function. For functions that are or can be expressed in algebraic terms, the simplest and only precise procedure for determining elasticity is to use the above equation and to quantify it from the algebraic function. Consider the function

\[ Y = a + bX - cX^2 \]

a function, in general, similar to that shown in Figure 12.1. The derivative is

\[ \frac{dy}{dx} = b - 2cX \]

and elasticity is, therefore,

\[ E = \frac{dy}{dx} \cdot \frac{X}{Y} = \frac{(b - 2cX)X}{a + bX - cX^2} \]

With this expression, it is a simple matter to select any value for \( X \) and to evaluate \( E \) exactly by substitution.
As these expressions for elasticity hold true for any function, it should be relatively simply to apply them to demand and supply relationships. Suppose that we are given a demand curve as in Figure 12.2 and want to evaluate elasticity at some point $C$. Tangent $BE$ has the same slope as the demand curve at point $C$ and should permit us to define elasticity without difficulty. Notice, however, that elasticity expresses the proportionate change in the dependent variable $Y$ to the proportionate change in the independent variable $X$, and that, by convention, price is taken as independent and quantity as dependent in demand and supply functions, even though American custom plots price on the $Y$ axis as shown. With this in mind, the expression for the elasticity of demand with respect to price is

$$n_p = \frac{dQ}{dP} \cdot \frac{P}{Q}.$$ 

In terms of our diagram, the slope $dQ/dP = DE/CD$, $P = OA = CD$, and $Q = OD$. The expression for elasticity, thus, is equivalent to

$$n_p = \frac{DE}{CD} \cdot \frac{CD}{OD} = \frac{DE}{OD}$$

and, by similar triangles,

$$n_p = \frac{DE}{OD} = \frac{CE}{BC} = \frac{OA}{AB}.$$
Thus, the geometric or graphic determination of price elasticity of demand involves construction of a tangent such as BE to the demand curve at given point C and the determination of the proportions CE to BC into which the tangent is divided by point C. Alternatively, the corresponding proportions for line segments OE and OB may be used. In the present example, the elasticity at point C is approximately \(-0.5\) with the negative sign reflecting the negative slope of the demand curve.

Let us consider the case of a linear or straight-line demand curve (line BE in the previous diagram). From the above, we know that the price elasticity at any point on this line will be represented by the proportions into which the point divides the line. Thus, at point C the elasticity is represented by \(CE/BC\), at point F by \(EF/BF\), and so on. From this, it is clear that elasticity at the midpoint F on such a linear demand curve must have a value of \(-1.0\) unit elasticity. Points between F and E will have elasticities between \(-1.0\) and 0; such points are called inelastic. And as the selected point approaches E, the value for elasticity approaches 0. A vertical line on this diagram will have zero elasticity throughout and so be perfectly inelastic. At the other extreme, points between F and B will have elasticities ranging from \(-1.0\) and approaching \(-\infty\) as the point selected approaches B. These points are called elastic, but a horizontal line with elasticity of \(-\infty\) is termed perfectly elastic. The study of this diagram will indicate why all linear demand curves through B will have identical elasticity values for any selected price, just as all linear demand curves through point E will have identical elasticities for any selected quantity. These curves are called isoelastic with respect to price or to quantity.

![Diagram](image_url)
The straight-line demand curve may also serve to eliminate confusion between elasticity and the slope of a curve. Often a curve that appears steep is thought to be inelastic, just as one that is relatively flat is judged to be elastic. Yet here we find that on a single line with constant slope throughout, elasticity actually ranges from 0 to \(-\infty\). This point is also stressed by the curves given in Figure 12.3. Here, we have plotted a straight-line demand curve together with curves having constant elasticities of \(-0.5\), \(-1.0\), and \(-2.0\). In spite of the fact that these last curves have constant elasticities, each has very steep and very flat segments.\(^2\)

**12.4 REVENUE FUNCTIONS REVIEWED**

Although demand functions summarize the reactions of buyers to price changes, to sellers they represent schedules of potential revenue. The prices paid by consumers are received by producers and, hence, represent their *average revenue* per unit of sale. Total revenue, then, is the product \(PQ\), or the average revenue multiplied by the quantity sold. In a conventional demand diagram, price or average revenue is measured along the vertical axis—for example, the dimensions \(OD\), \(OE\), or \(OF\) in Figure 12.4. Corresponding to these prices are quantities purchased (and sold)—\(OG\).

\(^2\)These three curves are based on the equations \(Q = kP^{-0.5}\), \(Q = kP^{-1.0}\), and \(Q = kP^{-2.0}\). The student may wish to take derivatives of these functions and demonstrate to himself that constant elasticities are involved.

![Figure 12.4](image-url)
OH, and OJ. Apparently, the total revenue obtained from the sale of any quantity may then be represented by the area of these rectangles as ODAG, OEBH, and OFCJ.

Elasticity of demand coefficients are especially interesting in their relation to revenue. It will be recalled that these coefficients are the relative change in quantity divided by the relative change in price. We observe that the demand curve shown in Figure 12.4 is somewhat inelastic in the B–C range; coefficients have numerical values ranging from less than −0.5 to about −0.75. They indicate that a one percent change in price will result in a 0.5 to 0.75 percent change in quantity or, conversely, that one percent quantity changes will accompany price changes ranging from about 2.0 to 1.3 percent. From them, it is clear that increases in the quantity sold will bring more than proportionate decreases in price and that quantity increases will be associated with actual decreases in the total revenue to sellers. This can be confirmed by comparing the total revenue area OEBH with the area OFCJ. In a similar way, we may conclude that, with elastic demand curves, total revenue will increase with increases in the quantity sold. Finally, if demand has unit elasticity, changes in quantity will be exactly compensated by changes in price or average revenue, and total revenue will be constant regardless of the volume of sales.

Total revenue curves based on the demand or average revenue curves from Figure 12.3 are shown in Figure 12.5. They confirm the generalizations just made with respect to the relation between demand elasticity and total revenue. The demand curve with unit elasticity results in a

![Total revenue curves](image)

**FIGURE 12.5** The total revenue curves that correspond to the demand or average revenue curves in Figure 12.3. (Note. The labels identify the average revenue curves in Figure 12.3 and do not indicate the elasticities of the total revenue functions.)
horizontal total revenue function; total revenue is constant for all values
of sales. The inelastic demand results in a negatively sloping total
revenue function, just as the elastic demand corresponds to a positively
inclined total revenue curve. Finally, the straight-line demand curve
yields a total revenue curve that starts at zero, increases as quantity
increases in the elastic portion of the demand curve, reaches a peak when
elasticity is $-1.0$ at the midpoint, and then declines to zero through the
range of inelastic demand.\(^3\)

Marginal revenue is the rate of change or slope of the total revenue
function. From the above discussion, plus an examination of the graphs of
total revenue functions, it is clear that marginal revenue is positive when
demand is elastic with respect to price, negative for inelastic demand
functions, and zero when demand has unit elasticity. Marginal revenue
curves derived from the total revenue curves in Figure 12.5 are given in
Figure 12.6. These values may be determined graphically by constructing
tangents to points on total revenue curves, but a somewhat more con­
venient approach based on average revenue curves (demand curves) is
illustrated in Figure 12.7. Suppose that we are given the linear average
revenue curve $BE$ and wish to determine the marginal revenue corre­
sembling to a point $C$ (output $OD$). Find point $G$ bisecting line $OE$ (or any
horizontal line such as $AC$) and construct a straight line through points

\[^3\]Perhaps these relationships may be better understood in algebraic rather than geo­
metric terms. Consider the linear demand function,

$$Q = a - bP.$$  

This may readily be converted to the form,

$$P = c - dQ,$$

where $c = a/b$ and $d = 1/b$. The total revenue function then will be

$$PQ = cQ - dQ^2.$$  

This is the general form of the revenue function shown in Figure 12.5.

The general form for the constant elasticity demand equation is

$$Q = kP^n.$$  

This may be transformed to show quantity as the independent variable,

$$P = Q^{1/n} / k^{1/n}.$$  

Total revenue then will be represented as

$$PQ = Q^{1+1/n} / k^{1+1/n}.$$  

From this, it is clear that with values of $n$ greater than $-1.0$, the total revenue function will
be positive; with values less than $-1.0$, the revenue function will be negative (reciprocal);
but with unit elasticity, the revenue function reduces to a constant.
FIGURE 12.6 The marginal revenue curves that correspond to the average and total revenue curves in Figures 12.3 and 12.5.

FIGURE 12.7 The graphic determination of marginal revenue.
240 DIMENSIONS OF MARKET PRICE

$B$ and $G$. Drop perpendicular $CD$ to the $Q$ axis and extend as required to intersect line $BG$ at point $H$. This point indicates the required marginal revenue; here, $-DH$ or $-OK$. An inspection of the diagram will indicate that all points of marginal revenue corresponding to the linear average revenue line $BE$ will fall along this line $BGH$ with positive values where the average curve is elastic, zero value at unit elasticity, and negative values for the inelastic portion of the average revenue curve. An alternative graphic determination involves dropping perpendiculars from $C$ to both average revenue and quantity axes and constructing line $AH$ through $A$ and parallel to $BE$. Point $H$ at the intersection of $AH$ and $CH$ again is the required marginal revenue.

Graphic determination of marginal curves corresponding to curvilinear average revenue functions proceeds by drawing the tangent to a selected point on the curve, determining the marginal revenue for that point, and repeating the process for other points until enough marginal revenue points have been obtained to smooth in the entire marginal revenue curve. This is suggested in Figure 12.7 by point $C$ on the straight line $BE$ and, also, on the curvilinear average revenue function tangent at this point.

12.5 PRICE DIFFERENTIATION AMONG MARKETS – SPACE

In our discussion of price discrimination, it will be convenient to refer to specific empirical studies. Hopefully, this approach will assist the reader to realize that the topic is of more than theoretical interest, not only in the United States but throughout the world.

Since the marginal revenue represents the slope of the total revenue curve, it is readily expressed in algebraic terms as the first derivative of the total revenue function. With total revenue defined as the product of price $P$ and quantity $Q$, marginal revenue will be

$$MR = \frac{dPQ}{dQ} = P + Q\frac{dP}{dQ} = P + P\left(\frac{Q}{P}\frac{dP}{dQ}\right).$$

The price elasticity of demand is the relative slope of the average revenue curve, or

$$\eta_p = \frac{dQ}{dP}\frac{P}{Q}.$$ 

By substituting in the above equation for marginal revenue, we have

$$MR = P + \frac{P}{\eta_p} = P\left(1 + \frac{1}{\eta_p}\right).$$

Remembering that the price elasticity of demand will be negative, the above equation makes it clear that marginal revenue will be positive when $\eta_p$ falls between $-1.0$ and $-\infty$, negative when $\eta_p$ falls between $-1.0$ and zero, and equal to zero when $\eta_p$ is exactly equal to $-1.0$. 

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Our first example consists of an examination of the domestic and export markets for cotton produced in the United States—a case of spatially separated markets. A recent study has provided an estimate of the demand for United States cotton in these two markets for the year 1975. Figure 12.8 is a three-part diagram that provides the following information: the demand curves for the domestic and export markets (part a), the relationship between price and total revenue (part b), and the relationship between quantity sold in each market and total revenue (part c). This presentation makes it possible to compare total revenue relationships with price choices by using parts a and b and to view the relationship between price and total revenue for given quantities using parts a and c.

FIGURE 12.8 The domestic and export demand functions for United States cotton, projected 1975. Identification. (a) Demand functions ($D_d$). (b) Price-revenue functions ($PR_d$). (c) Quantity-revenue functions ($QR_d$). (Note. Revenue expressed in $5.00 units since 1 bale = 500 lb.)
The demand and revenue relationships necessary for analyzing discrimination among these spatially separated markets are given in Table 12.1. The demand curves for the export and domestic markets are shown in section A. If we assume that the price in these two markets is identical, then we are entitled to draw an aggregate demand curve $D_t$. For prices higher than 29.3 cents (the highest price at which any cotton will be sold abroad) the aggregate and domestic demand curves are identical. Equations in Table 12.1A, correspond with the demand curves shown in Figure 12.8a.

The equations for the price-revenue curves shown in Figure 12.8b, are provided in Table 12.1B. Again, we are entitled to produce a price-revenue relationship for the two markets together only so long as uniform

### TABLE 12.1 Domestic and Export Demand for United States Cotton Projected 1975

<table>
<thead>
<tr>
<th>Equation Description&lt;sup&gt;a&lt;/sup&gt;</th>
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<tbody>
<tr>
<td><strong>A. Demand functions</strong></td>
</tr>
<tr>
<td>1. Export market</td>
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<tr>
<td>2. Domestic market</td>
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<td>3. Aggregate market</td>
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<tr>
<td><strong>B. Price-revenue functions</strong></td>
</tr>
<tr>
<td>1. Export market</td>
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<td>2. Domestic market</td>
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<td>3. Aggregate market</td>
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<tr>
<td><strong>C. Quantity-revenue functions</strong></td>
</tr>
<tr>
<td>1. Export market</td>
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<td>2. Domestic market</td>
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<td>3. Aggregate market</td>
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</table>

Sources. For demand functions, *Cotton: Supply, Demand, and Farm Resource Use*, Arkansas Agricultural Experiment Station, Southern Cooperative Series 110 (Fayetteville, 1966), pp. 42–52. For price-revenue and quantity-revenue functions, computations were made from demand functions in section A.

<sup>a</sup>For convenience, price is expressed in cents per pound, quantity in millions of bales, and revenue, therefore, in $5.00 units (1 bale = 500 pounds).
prices are maintained in the two markets. These curves are simply the demand curves multiplied by price. The demand curve for United States cotton in the export markets has been adjusted for added marketing costs by adding 4 cents to the United States farm price.\(^5\)

The quantity-revenue relationships shown in Figure 12.8c, are provided in equation form in Table 12.1C. Notice that the quantity-revenue curve for the two markets together is not unique since quantity-revenue relationships depend on how a given quantity is distributed between the domestic and export markets. Again, however, if we assume a distribution that will result in equal prices in the two markets, we can produce a quantity-revenue relationship shown as Equation C3.

If the United States cotton industry were in a position to set prices in the two markets, that is, to act as a price adjuster, the relevant information for decision purposes would be the revenue associated with alternative levels of price in each market. Changes in total revenue, illustrated in Figure 12.8b, can be described in terms of the marginal price-revenue curves provided in Table 12.2 for the export and domestic markets.

\(^5\)That is, the export price \(P_x\) is expressed in United States farm price units but is actually \(P_a + 4\) cents, or \(Q_x = 23.3 - 0.70(P_a + 4) = 23.3 - 2.8 - 0.70P_a = 20.5 - 0.70P_a\).

**TABLE 12.2 Marginal Revenue Functions for United States Cotton Projected, 1975**

<table>
<thead>
<tr>
<th>Equation Descriptiona</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>D. Marginal price-revenue functions</strong></td>
<td></td>
</tr>
<tr>
<td>1. Export market</td>
<td>(MPR_x = 20.5 - 1.40P_x)</td>
</tr>
<tr>
<td>2. Domestic market</td>
<td>(MPR_d = 19.7 - 0.86P_d)</td>
</tr>
<tr>
<td>3. Aggregate market</td>
<td>Not unique but, if (P_x = P_d = P) (\leq 29.3), then (MPR_I = 40.2 - 2.26P).</td>
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<tr>
<td><strong>E. Marginal quantity-revenue functions</strong></td>
<td></td>
</tr>
<tr>
<td>1. Export market</td>
<td>(MQR_x = 29.3 - 2.86Q_x)</td>
</tr>
<tr>
<td>2. Domestic market</td>
<td>(MQR_d = 45.8 - 4.66Q_d)</td>
</tr>
<tr>
<td>3. Aggregate market</td>
<td>(MQR_I) is not unique but depends on distribution between export and domestic markets. If (P_d = P_x \leq 29.3) and (Q_I \geq 7.1), then (MQR_I = 35.6Q_I - 1.76Q_I).</td>
</tr>
</tbody>
</table>

*Source.* Derived from equations in Table 12.1.

aFor convenience, price is expressed in cents per pound, quantity in millions of bales, and revenue, therefore, in $5.00 units (1 bale = 500 pounds).
Should the decision be made to charge equal prices in the two markets, again we are entitled to produce Equation \( D3 \); but we must remember that this is not unique in the event that prices are not equal in the two markets and that it holds true only for prices no larger than 29.3 cents, as pointed out earlier.

A visual inspection of Figure 12.8b, shows that maximum revenue from sales on the domestic market are achieved at a price of 23 cents and at sales of 9.8 million bales. Maximum revenue on the export market would be achieved at a price of 14.6 cents per pound and sales would total 10.2 million bales.

If industry decisions are to be made on the basis of the quantity of cotton sold, then we are interested in marginal quantity-revenue relationships that are provided in the second portion of Table 12.2. The earlier qualifications concerning the relevant quantity-revenue relationship for the two markets taken jointly should be observed. Clearly, the quantities at which maximum revenue is achieved, as illustrated in Figure 12.8c, correspond exactly with the prices shown in Figure 12.8b, for the reason that they are derived from the identical demand relationships.

As a practical matter, we are interested in prices ranging from 15 to 35 cents per bale. The authors of the study from which these data are drawn conclude that United States producers of cotton would supply 1.5 million bales at the low price and 31 million bales at the high price. This suggests that we need to be concerned only with a rather narrow range of prices and quantities and that we need not be overly disturbed at the use of linear demand relationships at this point. However, the reader will recognize that, in other situations, nonlinear demand relationships may be much preferred. For ease of illustration and, in this case, for practical application, the linear relationships are satisfactory.

We now use this information to compare two price policies for United States cotton, one where equal prices (with proper adjustment for marketing cost differences) prevail in the two markets and the other where equal marginal revenue prevails in the two markets. Suppose that United States cotton production amounts to 16 million bales. This amount could be sold at a price of 21.5 cents, as shown in Figure 12.9. Domestic sales would total 10.4 million bales and export sales 5.6 million bales, as shown in the back-to-back diagram and the aggregate demand diagram. However, as shown in Figure 12.8b, 21.5 cents falls on the increasing range of the domestic price-revenue function but on the decreasing range of the export function. Clearly, revenue would be larger if the domestic price were raised and the export price were lowered by appropriate changes in quantities sold.

By using the back-to-back format of Figure 12.10, it will be observed
that equal marginal revenue equilibrium will occur at 7.2 cents with 8.3 million bales sold at 26.5 cents per pound in the domestic market and 7.7 million bales sold at 18.3 cents per pound in the export market. These values can be verified by using the equations in Tables 12.1 and 12.2. An obvious question to be answered is how a net price difference of 8.2 cents per pound can be maintained in the two markets. The answer is that some nonprice market regulator must be introduced—the topic of the next chapter.

The graphic solution to the equal marginal revenue case is illustrated best by Figure 12.11. Again, marginal revenue curves for each market are shown individually and in the aggregate. Notice that the aggregate
FIGURE 12.10 The equal marginal revenue equilibrium, back-to-back marginal revenue functions, $Q_x = 16$ million bales. (Note. $D = \text{demand function}$; $M = \text{marginal revenue function}$; $d = \text{domestic market}$; and $x = \text{export market}$.)

FIGURE 12.11 The equal marginal revenue equilibrium, aggregate marginal revenue function, $Q_t = 16$ million bales. (Note. $D = \text{demand function}$; $M = \text{marginal revenue function}$; $d = \text{domestic market}$; $x = \text{export market}$; and $t = \text{two-market aggregate}$.)
marginal revenue function has a sharp break at the quantity 7.1 million bales as do the aggregate demand and aggregate revenue functions at a price of 29.3 cents. Recall that any point on the marginal revenue function refers to the quantity read directly below it and to the price on the demand curve read directly above it.

Although this spatially separated market example has many additional intricacies that might be pursued, such as competition from synthetics and changes in trade policies and programs, they will be left to the reader and we shall move on to new ground.

12.6 PRICE DIFFERENTIATION AMONG MARKETS—FORM

To illustrate price discrimination among product forms, we return to the fluid milk and manufactured milk products markets. Our example, drawn from a study of northeastern milk markets, refers to the New York area in the early 1960's. The demand functions for these two markets, illustrated in Figure 12.12, can be written as follows:

Fluid milk: \( Q_f = 6.15 - 0.12P_f \)

Manufactured milk products: \( Q_m = 9.10 - 0.96P_m \).

In 1960, the observed price of fluid milk was $6.27 per hundredweight and sales were 5.4 billion pounds, while the price of manufactured milk products was $2.93 per hundredweight with total sales amounting to 6.3 billion pounds for the year. The elasticity of demand for these two markets at the 1960 price level was \(-0.14\) and \(-0.45\), respectively. Notice that in the fluid milk market the demand is very inelastic at "going" prices and that in the manufactured milk products market demand is more elastic.

It is obvious that at these prices substantial increases in total revenue could be achieved if it were possible to reduce the total quantity marketed. This is true for both the fluid milk and manufactured milk products markets. Unitary elasticity in the fluid milk market occurs at a price of roughly $25 per hundredweight. The reason why milk prices are not closer to $25 per hundredweight is quite simple. The milk from every cow east of the Rocky Mountains would immediately be shipped to the New York area. This may be a roundabout way of making the point that we are looking at only one-half of the factors that establish equilibrium.

*D. A. West and G. E. Brandow, Equilibrium Prices, Production, and Shipments of Milk in the Dairy Regions of the United States, 1960. Pennsylvania State University, Department of Agricultural Economics and Rural Sociology, AE and RS No. 49 (University Park, 1964).*
market prices (namely, the demand side) and have, to this point, ignored the simultaneous relationships that exist in the real world between demand and supply.

Let us suppose, for ease of computation, that 11 billion pounds of milk were provided to the New York market. With equal prices, equilibrium would be reached at a price of $3.96, or roughly $1.00 per hundredweight above the 1960 manufactured milk price. At this price, fluid milk sales would amount to 5.7 billion pounds and manufactured milk sales 5.3 billion pounds. Equating marginal revenues, on the other hand, would have produced prices of $22.51 and $1.63 and sales of 3.4 and 7.6 billion pounds, respectively. The observed prices, although not differing by more than $20 per hundredweight as in our second case, reflect the opportunity to increase the gross revenue from milk sales by charging different prices in these two product-form markets. The answer to the question of how this is possible again lies in nonprice constraints on milk markets—in this case, state and federal milk marketing orders that establish minimum prices based on use of the raw product.

The usual textbook example is concerned with equating marginal revenues in two markets, both of which have positive values. The usual
case in agriculture will be the drive for equalization of marginal revenues in markets where elasticity is less than one, therefore, where marginal revenue is negative, as in Figure 12.12. Once the reader is convinced of the necessity for the presentation of marginal revenue curves with large negative values on the vertical axis, he will begin to understand some of the behavior of agricultural prices and an important underlying force that bears on modern United States agricultural policy and, in fact, agricultural policy the world over.

12.7 PRICE DIFFERENTIATION AMONG MARKETS—TIME

The avocado is a fruit for which the demand function, or quantity demanded, varies systematically throughout the year. In the 1950's, California provided 70 percent of the United States' total supply; Florida, about 20 percent; and Cuban shipments, 10 percent. When the Calavo Growers of California, a cooperative of avocado producers, was organized in 1924, its 100 members produced roughly 80 percent of the total California crop, although at the present time Calavo handles approximately 50 percent of the California output. Avocado production in California centers in the Los Angeles area where about 25 percent of the Calavo sales are made, with 20 percent sold in other California areas, 30 percent sold in other western areas, and 25 percent sold east of the Mississippi River.

From the turn of the century to the early 1960's imports have come predominantly from Cuba, although small amounts have been shipped from other countries in the Central America region. This is understandable, since Cuban shipments have been exempt from the import duty of 15 cents per pound set in 1930 and 7.5 cents per pound in 1947 under the Reciprocity Treaty of 1902—amounts that usually exceed the value of the fruit. Furthermore, supplies could clear Cuban ports only from June 1 through September 30.

The annual demand for avocados can be expressed as follows:7

\[
\hat{P} = -66.1 - 0.327C + 44.6 \log Y
\]

where \( \hat{P} \) = "predicted" season-average Calavo selling price, f.o.b. Los Angeles, in cents per pound

\( C \) = million pounds of California avocados sold during the season

\( Y \) = billion dollars of United States nonagricultural personal income.

This function implies that for each additional million pounds of California avocados sold, the selling price decreases 0.327 cents per pound. By taking the average values of the variables for the two-decade period of the 1940's and 1950's, the price flexibility with respect to volume is -0.69, and the price flexibility with respect to income is 0.91 (the corresponding values for price elasticities are reported as -1.44 and 1.32, respectively).

Although the annual demand for avocados is elastic, the problem facing the avocado industry is to allocate the year's crop in such a way as to maximize returns to the growers. To do this, information is needed concerning seasonal variations in the demand for avocados.

There are three ways in which seasonal shifts in the demand may be considered. The first approach is to treat each subperiod as a completely separate set of observations. The second treats all observations as a single set and obtains a single regression equation containing dummy variables that allow the demand curve to shift while holding the slope of the function constant. The third treats all observations as a single set and obtains a single regression equation but treats changes from week to week in a nonlinear fashion.

By using the third approach, the following demand function was estimated for California avocados:

\[
P = -69.5 - 28.4C + 1.40CW - 0.0274CW^2 - 7.14N + 46.7 \log Y
\]

where \( \hat{P} \) = "predicted" weekly average Calavo selling price, f.o.b. Los Angeles, in cents per pound

\( C \) = million pounds of California avocados sold during the week

\( W \) = week of California season

\( N \) = million pounds of Florida and imported avocados sold during the week

\( Y \) = seasonally adjusted annual rate of nonagricultural personal income for the week, in billion dollars.

The variable \( C \) can be factored out of the second, third, and fourth terms of this equation, and the remaining values \((-28.4 + 1.40W - 0.0274W^2)\) can be treated as a new variable \( B_w \).

The values of Calavo sales, the estimated Florida sales, and the estimated imports for the 1958-59 season are shown in Table 12.3 together with values for the coefficient described above, \( B_w \). The slopes of the weekly demand functions estimated in this fashion range from 30 to 90 times the slope of the annual function. Price flexibilities for these midweek demand functions for each month range from -0.30 in November...
### TABLE 12.3 Monthly Variations in Avocado Sales and Estimated Monthly Demand Shifters Selected Weeks, 1958–59 Season

<table>
<thead>
<tr>
<th>Week in middle of month</th>
<th>Calavo’s Sales of California Crop</th>
<th>Non-California</th>
<th>Demand Shifters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Florida</td>
<td>Imports</td>
<td>Total</td>
</tr>
<tr>
<td>October</td>
<td>365</td>
<td>350</td>
<td>30</td>
</tr>
<tr>
<td>November</td>
<td>416</td>
<td>620</td>
<td>0</td>
</tr>
<tr>
<td>December</td>
<td>743</td>
<td>350</td>
<td>0</td>
</tr>
<tr>
<td>January</td>
<td>700</td>
<td>350</td>
<td>0</td>
</tr>
<tr>
<td>February</td>
<td>1,346</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>March</td>
<td>1,578</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>1,543</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>1,222</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>835</td>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>July</td>
<td>918</td>
<td>110</td>
<td>800</td>
</tr>
<tr>
<td>August</td>
<td>638</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>September</td>
<td>409</td>
<td>590</td>
<td>490</td>
</tr>
<tr>
<td>Twelve-week total</td>
<td>10,713</td>
<td>2,510</td>
<td>1,440</td>
</tr>
</tbody>
</table>

**Sources.** Column 1: Stephen H. Sosnick, “Orderly Marketing for California Avocados,” *Hilgardia*, Vol. 33, No. 14 (December, 1962), Appendix Table 2; Column 2: Ibid., Appendix Table 6; Column 3: Ibid., Appendix Table 7; and Columns 5 and 6: Ibid., Table 9, p. 740.

The graphic solution to this problem is complicated, but it illustrates the procedure by which the orderly flow of avocados can be arranged in order to equate marginal revenue in each time period and so maximize grower returns (Figure 12.13). The 1958–59 output of Calavo avocados was 46.172 million pounds. If the quantity sold each week had been selected so as to result in equal marginal net income in all weeks, this would have resulted in an increase of 0.7 cents per pound and an increase in income of $300,000 or 8 percent. This volume was slightly larger than the 45 million pounds that profitably could have been sold fresh. If sales had been limited to this quantity, the processing, carry-over, or abandon-
ment of the remaining one million pounds would have increased members’ returns only about 0.007 cents per pound and would have increased the returns to independent growers by 0.3 cents per pound.

The potential payoff associated with a variety of alternative sales strategies is evaluated in the Sosnick study. Here an important nonprice factor is the marketing contract between member growers and Calavo. Under this contract they agree to deliver all commercial production to the Association, with harvesting schedules and warehousing decisions made by Calavo.
The lemon market provides an interesting combination of space, form, and time choices. Lemon production in the United States is concentrated in the state of California where approximately 16 million boxes are produced annually. A much smaller quantity, usually less than one million boxes, are produced in Arizona and a still smaller quantity is grown in Florida. Approximately one-half of the California-Arizona output of lemons is sold as fresh lemons, and the remainder is sold as lemon products. The fresh market for lemons can be divided into three

---

submarkets: the winter market, the summer market, and the export market.

In 1958–59, fresh lemon sales during the winter season, extending from November to April, amounted to 2.7 million boxes, and sales during the summer season, extending from May to October, amounted to 4.5 million boxes. Export sales totaled 1.5 million boxes (Table 12.4). Lemon products production totaled 28.6 million gallons in 1958–59 and included 15.6 million gallons of concentrate juice, 8.7 million gallons of frozen lemon concentrate, the remainder being distributed among several other products which included single-strength juice and nonfrozen lemon concentrate. During the 1958–59 crop year, the output of concentrate juice doubled and the fourfold buildup of inventory of concentrate juice occurred at the end of the season. The average on-tree price for fresh lemons was $2.64 per box in 1958–59, although the average on-tree return for lemon products was −38 cents per packed box equivalent. Again, in 1959–60, the on-tree return to lemon products was negative.

We now consider an analysis of the demands for lemons and lemon products and alternative strategies for product allocation among these four markets. Table 12.5A provides the market demand functions ex-

| TABLE 12.4 Three-Year Summary, California-Arizona Lemon Sales |
|---------------------------------|----------------|----------------|----------------|
| Crop allocation    |                 |       |                 |       |                 |       |
| Fresh shipments    | 10.4            | 2.24  | 8.7             | 2.64  | 9.4             | 2.42  |
| Lemon products     | 6.9             | 0.20  | 8.5             | −0.38 | 8.7             | −0.70 |
| Total crop         | 17.3            | 1.43  | 17.2            | 1.16  | 18.1            | 0.93  |
| Fresh product allocation |            |       |                 |       |                 |       |
| Winter market      | 2.78            | 2.24  | 2.74            | 2.50  | 2.00            |       |
| Summer market      | 4.26            | 2.24  | 4.45            | 2.72  |                 |       |
| Export market      | 3.36            | 2.24  | 1.51            | 2.64  |                 |       |
| Total, fresh       | 10.40           | 2.24  | 8.70            | 2.64  | 9.40            | 2.42  |


"Million-box equivalent.

"On-tree price in dollars per packed box equivalent.

"Blanks indicate no data available.
TABLE 12.5 The Demand for California-Arizona Lemons: A Form-Time-Space Example

<table>
<thead>
<tr>
<th>Equation Description</th>
<th>A. Market demand functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fresh lemons, winter market</td>
<td>$P_{fw} = 10.20 - 1.84Q_{fw}$</td>
</tr>
<tr>
<td>2. Fresh lemons, summer market</td>
<td>$P_{fs} = 10.05 - 1.05Q_{fs}$</td>
</tr>
<tr>
<td>3. Fresh lemons, export market</td>
<td>$P_{fx} = 6.75 - 0.60Q_{fx}$</td>
</tr>
<tr>
<td>4. Processed lemon products</td>
<td>$P_{p} = 4.95 - 0.50Q_{p}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Derived on-tree demand functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fresh lemons, winter market</td>
</tr>
<tr>
<td>2. Fresh lemons, summer market</td>
</tr>
<tr>
<td>3. Fresh lemons, export market</td>
</tr>
<tr>
<td>4. Processed lemon products</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. On-tree marginal revenue functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fresh lemons, winter market</td>
</tr>
<tr>
<td>2. Fresh lemons, summer market</td>
</tr>
<tr>
<td>3. Fresh lemons, export market</td>
</tr>
<tr>
<td>4. Processed lemon products</td>
</tr>
</tbody>
</table>


*Million-box equivalent: on-tree price in dollars per packed box equivalent.

F.o.b. packinghouse.

pressed in terms of f.o.b. packinghouse prices and quantities in millions of 79-pound packed box equivalents. However, the cost of placing lemons on these four markets differs. For this reason, we need the derived on-tree demand functions shown in Table 12.5B. Fresh winter and fresh summer lemons involve a cost of $2.70 per box to cover the cost of picking, hauling, and packing. Equations 1 and 2 in Table 12.5B, therefore, are adjusted downward by this amount. We assume that export sales of fresh lemons involve an additional 50 cents per box, hence, Equation 3 has been adjusted downward by a total of $3.20. Finally, the processed lemon demand curve has been shifted downward by $1.20, which represents the costs of picking and hauling lemons for this market. In section C of 12.5, we find marginal revenue functions for each of the four markets. They are comparable to the equations in section B, but the slope of each is twice that of the corresponding demand curve (Figure 12.15).

We are now in a position to calculate the optimum distribution of a
(a) FOB demand functions. (b) On-tree demand functions. (c) On-tree marginal revenue functions. (Source: See equations in Table 12.5.)

crop the size of the 1958–59 crop—namely, 17.2 million boxes. If we specify that marginal revenue in every market must be the same, then we have four equations with five unknowns. The fifth equation is derived by setting down the fact that all lemons must be sold; that is, total quantity must be equal to the sales in all four markets. We then solve this system of five simultaneous equations and find that marginal revenue for a crop of
this size is $1.91. The optimum allocation of the 17.2 million boxes among the four markets is as follows:

<table>
<thead>
<tr>
<th>Lemon Market</th>
<th>Sales in Million Boxes</th>
<th>On-tree Price</th>
<th>F.o.b. Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh, winter</td>
<td>2.56</td>
<td>$2.79</td>
<td>$5.49</td>
</tr>
<tr>
<td>Fresh, summer</td>
<td>4.41</td>
<td>2.72</td>
<td>5.42</td>
</tr>
<tr>
<td>Fresh, export</td>
<td>4.56</td>
<td>0.81</td>
<td>4.03</td>
</tr>
<tr>
<td>Processed products</td>
<td>5.67</td>
<td>0.91</td>
<td>2.11</td>
</tr>
</tbody>
</table>

By comparing this allocation with the observed 1958-59 allocation, we find that the quantity sold as processed lemon products is substantially smaller and that the quantity exported is considerably larger, with minor changes in fresh winter and summer sales. The export demand function used here is probably the least reliable of the four, but serves well for illustrative purposes.

Notice that processed lemon products are not necessarily sold in the year in which they are processed and, therefore, there is always the opportunity for profit associated with storage and sale in a later year in the event of a short crop. However, since lemon production is reasonably uniform from year to year, the uncertain outlook for profit making as a result of a heavy inventory carried over into the following crop year (as in the 1958-59 crop year described above) suggests that new export or processed products sales must be developed or that a major shift must be made in the rate of output of lemon products in the California-Arizona area to approach a break-even price in these two markets.

12.9 SUMMARY

We have examined four cases in which industry groups and/or government have taken actions that tend to distort the perfect market equilibrium in form, time, and space. These distortions are perhaps the rule rather than the exception, but we believe that the model can deepen our understanding of the economic world in which we live, can encourage the consideration of a framework that goes beyond the pinhead economy, and can provide a benchmark with which to compare still more realistic situations in which firms do not behave purely as quantity adjusters, where government participates in the marketing process, and where the realms of political science and economics intersect.
SELECTED READINGS

Price Discrimination among Markets


Schneider, Erich, *op. cit.*, pp. 120-129.

