PUBLICATIONS OF
THE INSTITUTE OF ECONOMICS

INVESTIGATIONS IN INTERNATIONAL ECONOMIC RECONSTRUCTION

GERMANY'S CAPACITY TO PAY (1923)*
RUSSIAN DEBTS AND RUSSIAN RECONSTRUCTION (1924)*
THE REPARATION PLAN (1924)*
THE FRENCH DEBT PROBLEM (1925)
THE RUHR-LORRAINE INDUSTRIAL PROBLEM (1925)
WORLD WAR DEBT SETTLEMENTS (1926)
ITALY'S INTERNATIONAL ECONOMIC POSITION (1926)
THE INTERNATIONAL ACCOUNTS (1927)
AMERICAN LOANS TO GERMANY (1927)

INVESTIGATIONS IN INTERNATIONAL COMMERCIAL POLICIES

MAKING THE TARIFF IN THE UNITED STATES (1924)*
SUGAR IN RELATION TO THE TARIFF (1924)*
THE TARIFF ON WOOL (1926)
THE CATTLE INDUSTRY AND THE TARIFF (1926)
THE TARIFF ON ANIMAL AND VEGETABLE OILS (1928)

INVESTIGATIONS IN AGRICULTURAL ECONOMICS

AMERICAN AGRICULTURE AND THE EUROPEAN MARKET (1924)*
THE FEDERAL INTERMEDIATE CREDIT SYSTEM (1926)
FINANCING THE LIVESTOCK INDUSTRY (1926)
INDUSTRIAL PROSPERITY AND THE FARMER (1927)
THE LEGAL STATUS OF AGRICULTURAL CO-OPERATION (1927)

INVESTIGATIONS IN INDUSTRY AND LABOR

MINERS' WAGES AND THE COST OF COAL (1924)*
THE CASE OF BITUMINOUS COAL (1925)
THE COAL MINERS' STRUGGLE FOR INDUSTRIAL STATUS (1926)
WORKERS' HEALTH AND SAFETY: A STATISTICAL PROGRAM (1927)
THE BRITISH COAL DILEMMA (1927)

INVESTIGATIONS IN FINANCE

INTEREST RATES AND STOCK SPECULATION (1925)
TAX-EXEMPT SECURITIES AND THE SURTAX (1926)

* Published by the McGraw-Hill Book Company

THE TARIFF ON ANIMAL AND VEGETABLE OILS

BY

PHILIP G. WRIGHT

WITH THE AID OF THE COUNCIL AND STAFF
OF THE INSTITUTE OF ECONOMICS

New York
THE MACMILLAN COMPANY
1928

AUTHOR'S ACKNOWLEDGMENTS

The author makes grateful acknowledgment to Director Harold G. Moulton, Dr. Thomas Walker Page, Dr. Edwin G. Nourse, and Dr. Charles O. Hardy of the Institute of Economics for their painstaking collaboration and criticism made in the preparation of this book. The manuscript was also carefully read by several persons not connected with the Institute, whose criticism proved most helpful. These were L. B. Zapoleon, of the Food Research Institute of Stanford University, J. B. Gordon of the Bureau of Raw Materials for American Vegetable Oils and Fats Industries, Charles W. Holman of the National Cooperative Milk Producers' Federation, and A. M. Loomis of the National Dairy Union. Acknowledgment is also made to C. K. Lewis and P. W. Bidwell of the United States Tariff Commission for valuable suggestion and criticism. Sheldon B. Akers rendered invaluable aid in the collection and compilation of data. Ralph P. Ward prepared the many charts and diagrams which appear in the text and in the appendices.

PHILIP G. WRIGHT.

Washington, D. C.,
November, 1927.

CONTENTS

CHAPTER III

CHAPTER IV

CHAPTER V

CHAPTER VI

CHAPTER VII

CHAPTER VIII

APPENDICES

APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

APPENDIX E

APPENDIX F

THE TARIFF ON ANIMAL AND VEGETABLE OILS

APPENDIX B

EFFECTS OF A DUTY ON PRICE AND OUTPUT WITH SPECIAL REFERENCE TO BUTTER AND FLAXSEED

I. FORMULAE FOR ESTIMATING THE EFFECT OF A DUTY

In levying a duty on any article it is desirable to be able to estimate with some accuracy the price, output, and import changes which are likely to follow its enactment. If it is levied for revenue the question of first importance is the amount of revenue it will yield, and this is dependent both upon the magnitude of the duty and its effect upon imports. If it is levied for protection the important considerations are (1) to what extent may it be expected to expand the domestic industry, that is, to increase the domestic production of the taxed article, and (2) to what extent will the price of this article be raised.

If we had complete knowledge of the following nine factors all of these questions could be answered with mathematical precision: (1) The magnitude of the duty, T_f; the elasticities (2) of the domestic supply, e_d; (3) of the foreign supply, e_f; (4) of the domestic demand, η_d; (5) of the foreign demand, η_f; (6) the domestic output, o_d; (7) the foreign output, o_f; (8) the domestic consumption, c_d; and (9) the foreign consumption, c_f.

If P represents the international price established under free trade and ΔP the increase in price which will follow the imposition of the duty T_f, then

$$(A)^1 \qquad \Delta P = T_f \frac{1}{1 + \frac{e_d o_d - \eta_d c_d}{e_f o_f - \eta_f c_f}}$$

[1] A simple demonstration of the formula for ΔP from which the others are derived, follows:

Let θ, φ, α, and β be the angles respectively which tangents to the domestic supply, foreign supply, domestic demand, and foreign demand curves make with a horizontal line. Let P be the international price established under free trade, and c, k, m, and n, be constants, then

$c + P \cot \theta =$ the domestic output and $k + P \cot \varphi =$ the foreign output,

$m + P \cot \alpha =$ the domestic consumption and $n + P \cot \beta =$ the foreign consumption, and (I) $c + P \cot \theta + k + P \cot \varphi = m + P \cot \alpha + n + P \cot \beta$ (since world output = world consumption). Now let $P' =$ the domestic price resulting from the duty and $P' - T_f =$ the foreign price resulting from the duty. Then (under the duty T_f)

$c + P' \cot \theta =$ the domestic output and $k + (P' - T_f) \cot \varphi =$ the foreign output,

$m + P' \cot \alpha =$ the domestic consumption and $n + (P - T_f) \cot \beta =$ the foreign consumption, and (II) $c + P' \cot \theta + k + (P' - T_f) \cot \varphi = m + P' \cot \alpha + n + (P' - T_f) \cot \beta$

$$\text{From (I), } P = \frac{m + n - c - k}{\cot \theta + \cot \varphi - \cot \alpha - \cot \beta}$$

$$\text{and from (II) } P' = \frac{m + n - c - k + T_f (\cot \varphi - \cot \beta)}{\cot \theta + \cot \varphi - \cot \alpha - \cot \beta}$$

$$\text{Hence } P' - P = \Delta P = \frac{T_f (\cot \varphi - \cot \beta)}{\cot \varphi - \cot \beta + \cot \theta - \cot \alpha}$$

$$= T_f \frac{1}{1 + \frac{\cot \theta - \cot \alpha}{\cot \varphi - \cot \beta}} = T_f \frac{1}{1 + \frac{e_d o_d - \eta_d c_d}{e_f o_f - \eta_f c_f}}$$

[Since, in general, elasticity = cotangent of the slope $\frac{\text{price}}{\text{output}}$]

The increase in the domestic production will be

$$(B) \qquad \Delta o = \frac{\Delta P}{P} e_d o_d$$

and the decrease in imports and domestic consumption will be

$$(C) \quad \Delta i = \frac{\Delta P}{P}(e_d o_d - \eta_d c_d) \qquad (D)\ \Delta c = \frac{\Delta P}{P}\eta_d c_d$$

Other consequences of the duty, such as the effect upon foreign price and foreign production, may be derived from the above data, as may also the lowest duty which will be prohibitive. If the lowest prohibitive rate be denoted by T_p, we shall have

$$(E) \quad T_p = P(c_d - o_d)\left(\frac{1}{e_d o_d - \eta_d c_d} + \frac{1}{e_f o_f - \eta_f c_f}\right)$$

The value of ΔP depends on the value of the fraction $\frac{e_d o_d - \eta_d c_d}{e_f o_f - \eta_f c_f}$. Since η is negative both numerator and denominator of this fraction are positive. The fraction

Pigou's formula is $AP = \frac{e_f o_f}{e_f o_f + e_d o_d - \eta_w(o_d + o_f)}$, η_w being the elasticity of the world demand. See "The Known and Unknown in Mr. Chamberlain's Policy," *Fortnightly Review*, June, 1904, p. 44; or "Economics of Welfare," page 942. It is believed that the formula here given, because of its symmetry, is more convenient than Pigou's. It is also from the standpoint of theory more accurate. When the duty is imposed the domestic price rises and the foreign price falls. These changes in price affect the quantity which will be taken and the quantity which will be forthcoming both at home and abroad. Pigou's formula does not take into account the lowering of foreign price in connection with the quantity *taken* abroad. When allowance is made for this difference the two formulae become identical.

may have all values from 0 to $+\infty$; if 0, $\Delta P = 1$, if $+\infty$, $\Delta P = 0$. In general the larger the domestic factors (e_d, o_d, η_d, c_d) as compared with the foreign, the greater will be the value of the fraction and hence the less the effect of the duty (ΔP).

From (A) and (B) it may be shown that, other factors remaining constant, as e_d increases ΔP decreases and Δo_d increases.

From (A) and (D) it may be shown that, other factors remaining constant, as η_d increases numerically ΔP decreases and Δc_d increases.

It thus appears that high elasticity of domestic supply tends to lessen the effect of a duty on price and increase its effect on output, and that high elasticity of domestic demand tends to lessen the effect of a duty on price and increase its effect in diminishing consumption.

Before proceeding to the statistical problem of ascertaining from existing data the values of the constants appearing in the formulae, a word may be said about their meaning. T_f is the duty, which, in order to be adaptable to the formula, must be fully effective, that is, result in a domestic price higher than the foreign price by the full amount of the duty,[2] and must be a specific duty—so many cents per pound, cents per bushel, or dollars per ton as the case may be. The outputs, o_d and o_f, and the consumption, c_d and c_f, are the total number of pounds, bushels, gallons, tons, etc., of the article in question produced and consumed in the United States and in all foreign countries, respectively. All of these quantities are perfectly definite and present no problems calling for discussion. Either the data are available or they are not.

[2] In practice this condition is seldom perfectly realized.

The elasticities, e and η, call for more extended explanation. In a general way these terms have reference to the responsiveness of buyers or sellers to changes in price. As an economic concept the picture is that of a "market" made up of an indefinite number of competing buyers and an indefinite number of competing sellers, the latter holding in their possession an indefinite quantity of a certain article. Under the concept of *demand* it is believed that if at a given instant of time the sellers had thrown on the market a definite portion of their stock, that portion would all have been taken at a certain definite price. If, however, *at the same instant,* they had offered more, the price would have been less, and, if less, the price would have been more. That is, for an offering of any portion of the stock there is, *at that instant,* a definite price at which that portion will be absorbed. Likewise, with reference to *supply* it is supposed that at a given price a definite quantity will be forthcoming from sellers. If, at that instant, the price had been higher more would have been forthcoming; if lower, less. To give mathematical definiteness to the concept, the coefficient of elasticity may be defined as the ratio of the percentage change in quantity to the percentage change in price, and may be represented by the expression:

$$\begin{matrix} e \text{ [elasticity of supply]} \\ \eta \text{ [elasticity of demand]} \end{matrix}^{3} \text{ or } = \frac{\frac{\Delta x}{x}}{\frac{\Delta y}{y}}$$

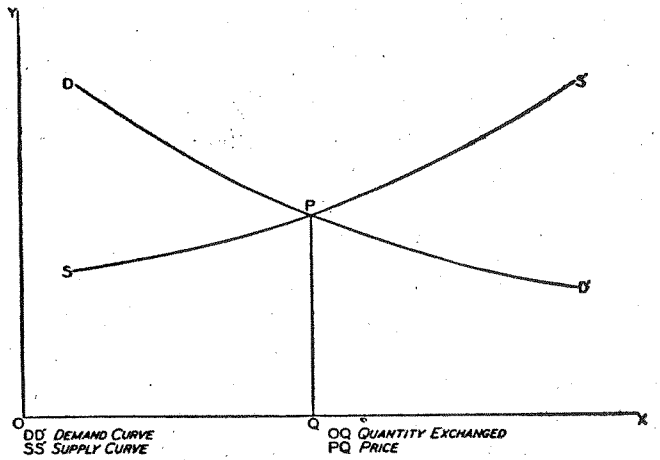
Since, with reference to supply, an increase in price is accompanied by an increase in quantity, $\frac{\Delta x}{x}$ and $\frac{\Delta y}{y}$

[3] In this expression Δx (read delta x) means the increase or decrease in quantity; Δy, the increase or decrease in price.

will have the same sign and hence e will be positive. With reference to demand, however, since at an increase in price a smaller quantity will be taken, $\frac{\Delta x}{x}$ and $\frac{\Delta y}{y}$ will have opposite signs and hence η will be negative.

From what has been said it is obvious that supply conditions at any instant of time may be represented by

FIGURE 1. TYPICAL SUPPLY AND DEMAND CURVES.



an ascending, and demand conditions by a descending, curve. The point where the curves intersect determines the price and quantity exchanged at that instant. This is shown in Figure 1.

The economic concept of elasticity supposes different experiments with prices in the same market at a single instant of time. Obviously such experiments cannot be made. Actual observations must be made at different times and during the period between observations conditions both of supply and demand may change. Indeed,

they not only may change, but one of them must change, if any estimate is to be made of elasticity. For if they remained constant then every observation would show the same output and the same price, and while it might be imagined that at a higher price a smaller quantity would be taken or a greater quantity forthcoming no evidence of this would be afforded by the data.

Moreover, for the purposes under discussion, a concept of the supply curve quite different from that based primarily on the psychology of sellers must be formed. Instead of an indefinite stock in the hands of sellers the picture becomes that of a flow of goods coming into the market from producers. Now, different producers produce at different unit costs; indeed, the same producer generally produces different parts of his output at different costs, hence the units constituting this flow are produced at different costs. But it may be assumed that every producer is producing every unit of his output at as low a cost as he can and it may be further assumed that he will not intentionally produce any part of his output at a loss. Hence the units making up the flow that comes into the market in a given period of time may be arrayed with respect to their costs of production beginning with the lowest and increasing up to a cost which is equal to the price. The *cost* curve constructed from this array will resemble in some respects the *supply* curve, above described, and is the type of supply curve whose elasticity e is called for in the formula.

It will resemble the first mentioned type of supply curve in this respect: at a higher price a greater output will be forthcoming and at a lower price the output will fall off. For, as was noted, since no producer will intentionally produce at a loss, the costs will ascend to a

point where they become equal to the price. At that point the cost enables the producer incurring it just to "break even." It may be called the *marginal cost.* But if the price increases producers can profitably increase their output up to a point where the new marginal cost equals the new price.

From what has been said it is clear that if a true cost curve could be constructed the value of the expression $\frac{\Delta x}{x} \div \frac{\Delta y}{y}$ for any point on that curve would be the elasticity of supply at that point and could be substituted for e in the formula.

The United States Tariff Commission has made cost studies for a considerable number of industries. Unfortunately for the present purpose, these studies were made by establishments. The average cost per unit for each establishment was ascertained. But it may be safely assumed that each establishment was producing units of output at varying costs up to a cost approximating the marginal cost, otherwise a low cost producer would already have increased his output, thus lowering the price and squeezing out one by one the higher cost producers until the price was reduced to his own cost. Hence, when the price rises it will not be merely one producer at the margin who will find it profitable to increase his output, but all of the low cost producers as well, and therefore, the response in output to an increase in price will be in fact much greater than would be indicated by the cost curve constructed from the Commission's data.[4] The true value of e cannot be less than the

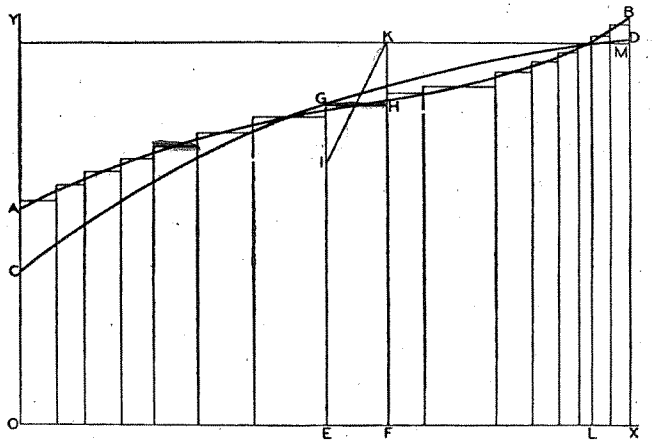
[4] The diagram, Figure 2, will help to make clear the above statement. The "steps" AB, smoothed into the curve AB, are typical of the Commission's cost curves, when costs are taken by establishments. Consider the producer whose output is

value derived from one of the Commission's cost studies but it may be much greater.

Aside from the Commission's cost studies, which are open to the objection specified, price, output, and consumption data, and such factors as may be supposed to influence supply and demand conditions are our only resource. As was noted, unless supply or demand condi-

EF. His average cost is GE, but his unit costs may be assumed to range from IE to KF. Since what is true of this producer is true of all, it is clear that a "true" cost curve would show a much

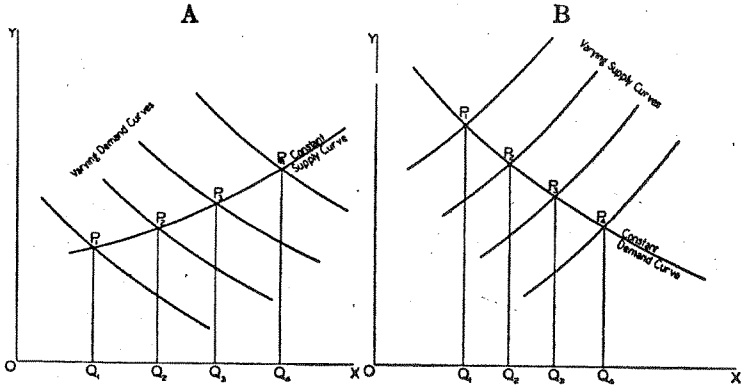
FIGURE 2. COST CURVES BY UNITS OF OUTPUT AND BY ESTABLISHMENTS.



greater part of the output produced at or near the marginal cost, and would assume some such form as AD. From the Commission's cost curve we should have $e = \frac{\frac{LX}{OL}}{\frac{BM}{MX}}$: from the "true" cost curve $e = \frac{\frac{LX}{OL}}{\frac{DM}{MX}}$. Obviously the latter value is much the greater,

tions change, no information with respect to elasticity can be obtained from such data. However, this limitation need give us little concern, because as a matter of fact both conditions do change greatly from year to year, from month to month, and even from day to day. Demand is said to strengthen when a greater quantity will be taken at the same price. This will be shown graphi-

FIGURE 3. PRICE-OUTPUT DATA REVEAL—
(A) SUPPLY CURVE
(B) DEMAND CURVE



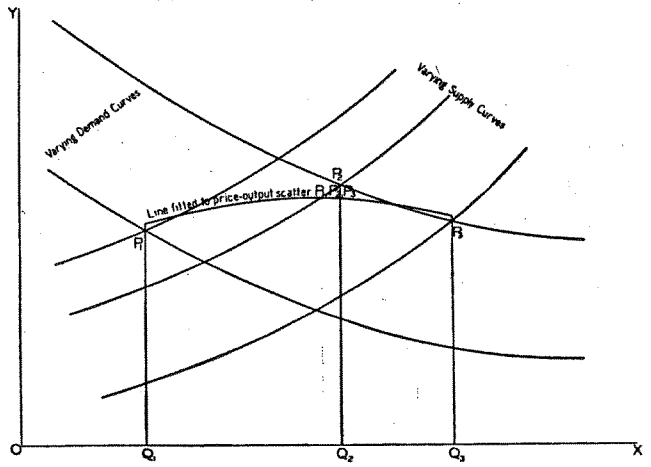
cally by a bodily shifting of the demand curve to the right. Supply conditions are said to move toward lower costs when a greater quantity will be forthcoming at the same price. This also will be shown graphically by a bodily shifting of the supply curve to the right. A weakening of demand or a movement toward higher costs will be shown by a shifting of the curves to the left.

If it can be shown that during a period of time covered by two or more observations either curve remains fixed while the other moves to right or left, price-output data

will reveal points on the curve that remains fixed. This should be obvious from the analysis given above but may be illustrated by a diagram. (Figure 3.)

If both supply and demand conditions change, price-output data yield no direct information as to either curve. (Figure 4.)

FIGURE 4. PRICE-OUTPUT DATA FAIL TO REVEAL EITHER SUPPLY OR DEMAND CURVE.



Unfortunately for our problem, the case represented by Figure 4 is the more common, and even if either curve does remain fixed during the period covered by the observations there is no certain way of knowing this fact in advance.[5]

It may be said at once that the numerical results obtained for the elasticity of supply or demand can be at best but estimates based upon a reasonable agreement

[5] For a fuller discussion of the point here made see Working, E. J., "What Do 'Statistical Demand' Curves Show?" *Quarterly Journal of Economics*, February, 1927, Vol. XLI, p. 212.

of results obtained by different tests and upon such *a priori* evidence as may be available.

Such estimates may be made, but before proceeding further it is well to emphasize the conclusion so far reached. Aside from estimates based on cost studies, such as those undertaken by the Tariff Commission, the estimate must be based on the principle that price-output data afford evidence with respect to the supply or demand curves only on the condition that one of the curves is constant while the other varies, and the problem consists in so handling the data as to have a reasonable assurance that that condition is realized.

II. EXPLANATIONS AND QUALIFICATIONS

In order to avoid confusion several explanations and qualifications have been purposely omitted. These must be disposed of before approaching the problem of estimates.

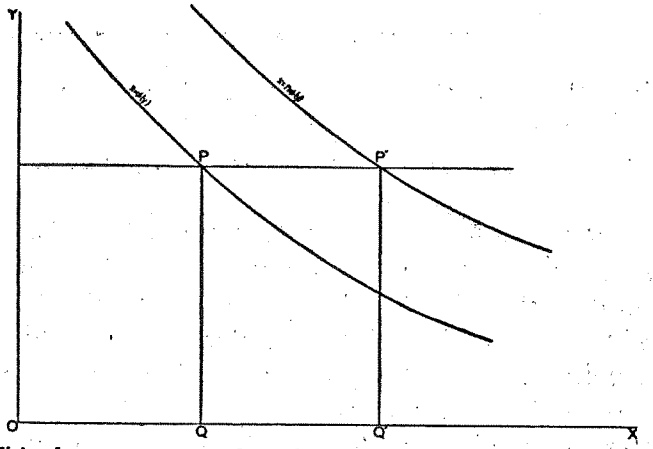
Elasticity may remain constant through bodily shiftings of the supply and demand curves. The question naturally arises whether through the constantly changing conditions of supply and demand there is any reality corresponding with the term elasticity. Is it not one thing to-day and another to-morrow? Doubtless the elasticities of supply and demand do change, but there is reason for believing that they are at least relatively constant. Suppose demand conditions change. It can easily be shown that if the ratio of the quantity now taken to the quantity formerly taken at a given price is constant, whatever the price, the elasticity of demand at that price remains unchanged,[6] and similarly under the

[6] Let $x = \varphi(y)$ [Figure 5] be the demand curve in its first position, and $x = n\varphi(y)$ the demand curve in its second posi-

same conditions the elasticity of supply may be shown to remain unchanged. Such a condition is believed to be, on the whole, normal. For example, if under the new conditions the quantity which would be taken at 10 cents is doubled, it is probably approximately true that the quantity which would be taken at 5 cents, at 8 cents, or at 12 cents would also be doubled.[7]

tion. Then η (the elasticity of demand in the first position) $= \frac{y}{x}\frac{dx}{dy} = \frac{y}{\varphi(y)}\varphi'(y)$ and η' (the elasticity of demand in the second position) $= \frac{y}{x}\frac{dx}{dy} = \frac{y}{n\varphi(y)}n\varphi'(y) = \frac{y}{\varphi(y)}\varphi'(y)$ $\therefore \eta = \eta'$.

FIGURE 5. SHIFTING DEMAND CURVE: CONSTANT ELASTICITY.



[7] This does not mean that the elasticity of demand, in any of the positions of the demand curve, is necessarily the same for 10 cents as for 5 cents or 8 cents or 12 cents. The demand curve which does have the same elasticity for any price or any output must be of the form $xy^{\eta} = n$, where η is the elasticity and n a constant determining the position of the curve with reference to the origin. Thus, by definition, $\eta = -\frac{dx}{dy}\cdot\frac{y}{x}$ or $\frac{dx}{x} = -\eta\frac{dy}{y}$

$\therefore \log x = \log n - \eta \log y = \log \frac{n}{y^{\eta}}$ $\therefore xy^{\eta} = n$.

Similarly, the equation of the cost curve of constant elasticity is $x = ny^{e}$.

The data must be handled intelligently with respect to time intervals in estimating the elasticity of supply. Attention has been called to the distinction between the supply curve and the cost curve, the former depending solely on the responsiveness of sellers holding an indefinite stock to changes in price, the latter depending on the increase in marginal cost resulting from an increase in output. If the immediate effect of the tariff is in question, the elasticity of supply should be obtained from the supply curve as defined above. Ordinarily the long-run effect of the tariff is what is desired, and for this the elasticity of supply should be obtained from the cost curve.

Price is the only evidence available of marginal cost but, at the time of any specific observation, may differ widely from it. However, as the desire for profit is always urging producers to expand their output up to the point where some part of it is produced at marginal cost, while the impossibility of long continuing to produce at a loss is tending to curtail parts of the output produced at a higher cost, it would seem that forces were at work tending always to adjust output to demand in such a manner that the price would equal the marginal cost. An average of prices over a considerable period of time should approximate the marginal cost of producing the average output.

In the case of an agricultural product the process of adjustment may extend over several years. At the close of harvest the quantity available for sale is fixed until the next harvest. Prices may be expected to fluctuate throughout the year calling from sellers varying portions of the existing stock, but the average price for the year should be the price at which the market would absorb

the entire stock. Suppose this price to be above the cost of producing all except an inappreciable portion of the crop. Production will be stimulated and the next crop will be likely to be so large that, at the reduced price at which it will sell, much of it will be produced at a loss. The next year will therefore show a small crop and a high price, and so on, with a tendency, however, if demand conditions remain constant, to adjust the price to the marginal cost.[8] It may require a period of four or five years to affect the adjustment. Since there is no way of telling just how many years are required, it is well in practice to make several computations; one, say, with a period of four years; another of five years; and another of six years. The average value of e obtained from such computations is probably safer than that obtained from any one of them.

Marginal cost was provisionally defined as the cost which just enables the producer who incurs it to "break even." This definition implies identity between price and marginal cost. In the light of what has been said such an identity can be accepted only as a long-run tendency. A more precise definition of marginal cost would be the cost equal to the equilibrium price determined by existing cost and demand conditions.

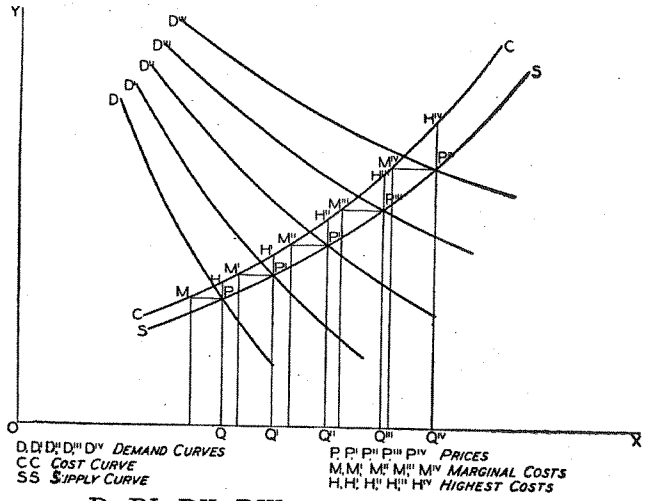
Since no producer would intentionally produce any

[8] The statement in the text calls for some qualification. The entire stock is not necessarily absorbed. There may be a hold-over and the hold-over may differ from year to year. Nor is the supply absolutely inelastic. With a given stock the quantity which will be offered for sale will vary somewhat with the price. With a very low price some part of the stock will never come to market at all. The *annual* supply curve for an agricultural crop will be a curve whose elasticity approaches zero. Finally, the possibility of increasing or diminishing the stock available as a result of the harvest, by increasing or diminishing imports, must be taken into account.

part of his output at a loss, the marginal cost and price would also tend to be equal to the highest cost. But because of accident, fallibility in the estimates of producers, and the constantly changing conditions of demand, it is usually found that some portion of the crop is annually produced at a loss. However, economic forces are always tending to bring price, marginal cost, and highest cost together whenever they depart from a common level.[9]

[9] The cost studies undertaken by the Tariff Commission indicate that even in equilibrium the price and marginal cost are less than the highest cost, that is, that some portion of the output is normally produced at a loss. If this is true, the long-time supply curve instead of being identical with the cost curve would lie somewhat below it. Suppose that 10 per cent of the marketed output is normally produced at a loss. This situation is represented in Figure 6.

FIGURE 6. SUPPLY CURVE MAY DIFFER FROM COST CURVE.



D, D^{I}, D^{II}, D^{III}, etc.—demand curves
CC—cost curve
SS—supply curve
P, P^{I}, P^{II}, etc.—prices
M, M^{I}, M^{II}, etc.—marginal costs
H, H^{I}, H^{II}, etc.—highest costs.

The equilibrium prices, even when imports and exports exist, should be also marginal costs, and, taken in connection with domestic output, should determine the cost curve. Hitherto no account has been taken of imports and exports. It has been assumed that domestic production was also domestic consumption. If, however, there are imports or exports or both, the price will be the ordinate to the demand curve from the point indicating the total consumption. This follows from the definition of the demand curve. Moreover, the price, if an equilibrium price, will also by definition equal the marginal cost and should determine that point on the cost curve whose abscissa is the domestic output. (Or if n per cent production at a loss is normal, an abscissa n per cent less than the domestic output).[10]

The above principle is illustrated in Figure 7.

D_1, D_2, etc.,—demand curves
CC'—cost curve
SS'—supply curve (production + imports — exports)
P_1, P_2, P_3, etc.,—prices
M_1, M_2, M_3, etc.,—marginal costs
OO_1, OO_2, OO_3, etc.,—domestic outputs
O_1S_1, O_2S_2, etc.,—imports

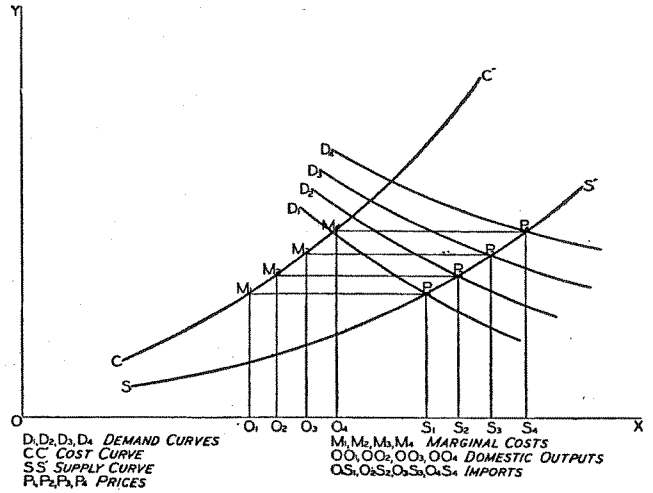
Footnote 9, continued.—The diagram shows the successive equilibria supposing cost conditions to remain constant and demand to strengthen from year to year. The prices are determined by the ordinates from the successive outputs to the successive demand curves (D, D^I, D^{II}, etc.), the highest costs by the ordinates from the successive outputs to the cost curve (CC), and the marginal costs are ordinates to the cost curve equal to the successive prices.

It will be observed that the long-time supply curve lies a little below the cost curve. Price-output data reveal the long-time supply curve rather than the cost curve but as the two curves have virtually the same elasticity this circumstance need give no concern.

[10] If from any point in a curve a vertical line be drawn to the line OX, shown in the diagram, the vertical line is called the *ordinate*, and the distance from its foot to O, the *abscissa* of the point.

Assume P_1S_1, P_2S_2, etc., to be prices, determined by the fixed total supply curve SS' and the moving demand curve D_1, D_2, etc. If these are equilibrium prices, they are also the marginal cost of producing the domestic outputs OO_1, OO_2, etc. [O_1S_1, O_2S_2, etc., are net imports] and hence determine the cost curve, CC', assuming no part of the output to be produced at a loss.

FIGURE 7. ELASTICITY OF SUPPLY WHEN THERE ARE IMPORTS.



Increase in output may be forthcoming without necessarily implying improved methods of production or increase in price. On the assumption that each establishment is producing units of output at varying costs up to the marginal cost (see page 293) it would seem as though the only possibility of increased output would be either an increased price permitting increased output at a new and higher marginal cost, or improvements in methods of production permitting increased output at the same marginal cost, or some combination of these factors. The

first alternative would be shown by a shifting of the demand curve to the right, the second by a shifting of the supply curve to the right. If conditions surrounding all other industries except the one under consideration remained constant, such a conclusion would be warranted. But if the cause of a strengthening demand is one which affects industry as a whole, as, say, growth of population, the result will be an automatic shifting to the right of both demand and supply curves without necessarily implying increase in price or improved methods of production in any of them. The strengthening demand will call forth increased output all along the line, and the same quantity of one commodity will tend to exchange for the same quantity of each of the others. Hence there will be no change in the *real* prices of any of them. Neither, if the quantity of money just keeps pace with the increasing volume of business, will there be any change in the *money* prices of any of them. It follows that in a normally expanding country there will be a close correlation between supply and demand conditions; for every industry both supply and demand curves should be steadily shifting to the right. Of course, there will be "perturbations" in this "cosmic drift" resulting from the special conditions peculiar to each industry.

III. THE HANDLING OF DATA

The preceding discussion reveals the extreme elusiveness of the cost and demand curves which lie embedded in any existing data. Estimates of their elasticities may be made, but any hope of obtaining numerical values comparable with results to be obtained in physical science must be abandoned.

Cost data, *if arrayed by units of output,* should yield the cost curve immediately. Such cost data never have been assembled and probably never will be. If arrayed by establishments, as are the cost studies of the Tariff Commission, they should yield a minimum value of e (see pages 293-294).

The only other data available are price quotations, statistics as to output and consumption, and factors which may affect demand and supply conditions. The one guiding principle to be kept in mind in handling such data is that if cost conditions remain fixed while demand conditions vary, prices will lie on the supply curves; if demand conditions remain fixed while cost conditions vary, prices will lie on the demand curve. As a secondary principle it may be assumed that preference should be given to interpretations which involve moderate rather than violent shiftings to right or left of the demand and cost curves, especially the latter.

In applying these principles no rule to be followed blindly can be laid down. Each case must be studied on its own merits, and success will depend largely upon the skill of the statistician. A few general suggestions may, however, be made.

Every industry is subject to the action of two antagonistic sets of forces, those tending to raise the marginal cost and those tending to lower it. Since the cost curve is an ascending curve, the mere strengthening of demand (shifting of the demand curve to the right) assuming that at the same time no change takes place in the position of the cost curve, tends to raise the marginal cost. (Figure 3-A.) This tendency is increased, if in conjunction with strengthening demand such factors as depletion of raw materials are tending to increase the costs of pro-

duction all along the line, resulting in a shifting of the cost curve to the left. On the other hand, improvements in methods and machinery are always tending to lower marginal costs, which tendency would be evidenced by a shifting of the cost curve to the right. (Figure 3-B.)

When, as a net result of the action of these two sets of antagonistic factors, the marginal cost over a period of years trends upward, the industry may be said to be subject to increasing costs. When the trend is downward it may be said to be subject to decreasing costs. Every industry is of course subject at all times to tendencies in both directions, but it is the net result which is of chief concern, and on the nature of this net result, price, output, and net-import data may throw some light.[11]

Suppose that, over the period of years covered by the investigation, the data are graphed so that price, output, and imports are shown on the same sheet as ordinates to successive time units, then if the trends of both prices and outputs are upward, it is evidence that the industry is subject prevailingly to the law of increasing costs. The demand curve has been moving progressively to the right, while the cost curve, if it has been moving to the right at all, has not changed its position

[11] "Increasing cost" and "decreasing cost" are here used in a sense somewhat different from that given to these terms in formal economic theory. As ordinarily understood an industry is said to be subject to the law of "diminishing returns" or "increasing cost" when, assuming that a given demand calls forth a certain output at a certain marginal cost, a stronger demand applied *at the same instant* would have called forth an increased output at a higher marginal cost. An industry is said to be subject to the law of "decreasing cost" when, owing to the economies of large-scale production, a stronger demand applied *at the same instant* would have called forth an increased output at a lower marginal cost. Obviously, under this concept it is implied that any shifting to the right of the demand curve automatically carries with it a shifting to the right of the cost curve also.

sufficiently to overcome the tendency to increasing marginal cost. If from a general knowledge of the industry there is reason to believe that demand has strengthened during the period under investigation, or at least has not weakened, and the graph still shows an upward trend of prices but a downward trend of outputs, the case for the industry's being subject to the law of increasing costs is even stronger. The cost curve has apparently been shifting to the left.

In either of these cases the imposition of a duty would be one factor added to those already tending effectively to raise marginal cost and price.

But now suppose that an upward trend of outputs is accompanied by a downward trend of prices. In this case the evidence points to progressive improvements in methods and machinery and relatively stationary demand conditions, a progressive shifting of the cost curve to the right and a relatively stationary demand curve. Here we have an industry subject prevailingly to the law of decreasing costs, and while the imposition of a duty would check the downward tendency of prices, it might not be sufficient to overcome it. Prices might continue to fall. Indeed, the stimulus given to the industry by the duty might accelerate improvements in methods and machinery and result in an even greater decline in prices and increase in output than would have occurred had the duty not been imposed. In this case the industry would have been one to which the familiar "infant industries" argument for protection was applicable.

Comparing production with imports, their relative magnitudes and their relative trends should be noted. Inferences of considerable tariff significance may be made from such a comparison. (1) Since price is determined

by the interaction of demand with total supply—production plus imports—if imports constitute at best but an insignificant part of total supply, the tariff can have but little effect on either price or output. The effect of a duty will tend to increase with the relative importance of imports. (2) Provided demand conditions in the United States and in the country from which imports are received continue to occupy about the same relative position, it may be assumed that if imports show a tendency to increase more rapidly than domestic production the forces that tend to a lowering of costs in the foreign country are gaining on similar forces in the United States. Under these conditions foreign competition is tending to become more severe. From the standpoint of the industry a duty is needed, but from the standpoint of consumers, it simply shuts them off from sharing in the improved methods of production by which foreigners are profiting. If on the other hand domestic output is increasing more rapidly than imports, it is evidence that domestic producers are getting more and more into a position of competitive advantage, and a duty is of less consequence to either producers or consumers. If the process continues the United States will change from an importing to an exporting country and the duty will become purely nominal.

The inferences which have so far been pointed out as possible to be derived from inspection of the data are based on the evidence which the data afford of changes in the conditions of demand and supply, that is, of shiftings to right or left of the cost and demand curves. Nothing has yet been said to indicate how the data may be handled so as to give evidence of the shape and character of these curves from which the elasticities of demand and

supply may be computed. Yet the effects directly attributable to the tariff depend on these elasticities. The changes in demand and supply conditions so far discussed may afford some evidence as to the wisdom or unwisdom of imposing a duty, but they are not themselves caused by the duty. Presumably they would take place in much the same way whether the duty were imposed or not. The only effects directly attributable to the tariff are the effects which it can produce on price, production, and imports under the supposition that foreign and domestic demand and supply conditions undergo no change.[12]

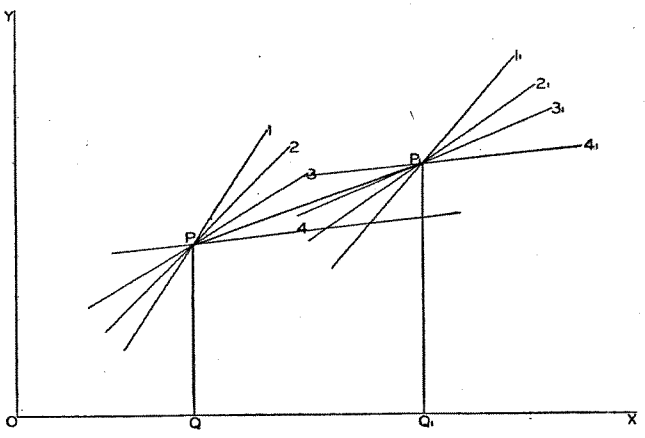
The elasticities of supply and demand cannot be computed from price, output, and consumption data alone. The unknown quantities are too numerous for the equations. This statement is susceptible of algebraic demonstration, but the following graphical explanation is believed to be sufficient to make the point clear to the reader. (Figure 8.)

Suppose the data show that in two successive observations price changes from PQ to P_1Q_1, and output from OQ to OQ_1. This change must have been effected by a strengthening of demand, that is, by a shifting of the demand curve from a position passing through P to a position passing through P_1. So long as it satisfies this condition, its shape does not matter. It may be straight or curved, its slope may be steep or gentle. If now we knew that while the demand curve was moving from P to P_1 the cost curve had not moved at all, we could at

[12] The one exception to this statement is to be found in the possibility that the duty may stimulate the accumulation of capital, and hence hasten the action of those forces which tend to lower costs—it may be a cause of a more rapid shifting of the cost curve to the right.

once compute the elasticity of supply from the portion of the supply curve PP_1. But the change in price and output can equally well be accounted for by supposing that while the demand curve moved from P to P_1, the cost curve from a position P1 moved to a position $P_1 1_1$, or from P2 to $P_1 2_1$, or from P3 to $P_1 3_1$, or from P4 to

FIGURE 8. PRICE-OUTPUT DATA ALONE, INADEQUATE.



$P_1 4_1$. The possibilities are infinite. So far as evidence afforded by the data is concerned one supposition is as likely as another.

Similarly, if the slope of the line PP_1 had been downward instead of upward the change in output and price would necessarily have involved a movement to the right of the cost curve, while there might or might not have been a movement of the demand curve.

Elasticity of $\frac{supply}{demand}$ *can be computed only when assurance is obtained that the* $\frac{cost}{demand}$ *curve remains fixed*

while the $\frac{demand}{cost}$ *curve is changing its position.* Such assurance may come from an intimate knowledge of the industry or from statistical methods introducing additional data.

Obviously if it is known that over the period covered by the observations cost conditions have not appreciably changed while demand conditions have changed, the elasticity of supply can be computed directly from the trend of the price-output scatter, and similarly if it is known that there has been great improvement in methods while demand conditions have not changed the elasticity of demand can be computed from the trend of the price-consumption scatter.

The principle in the last paragraph may be extended further. If there is reason to believe that over a period of years the variability of demand conditions greatly exceeds that of supply conditions and furthermore that such variations of supply conditions as exist are as likely to be in one direction as the other, then the elasticity of supply may be computed in the following manner: From a price-output scatter select all the chronologically successive pairs of observations in which the line connecting them shows an up-slope and compute a value of e from each pair. The median of these values should approximate the true value of e. Similarly, when the variability of supply conditions greatly exceeds that of demand conditions, the median of the values η computed from the pairs of observations showing a down-slope should approximate the true value of η.

In the absence of intimate knowledge of demand and supply conditions, statistical methods for imputing fixity to one of the curves while the other changes its position

must be based on the introduction of additional factors. Such additional factors may be factors which (A) affect demand conditions without affecting cost conditions or which (B) affect cost conditions without affecting demand conditions.[13] An example of a factor of type A is the price or output of an important substitute for the article under investigation or some index of prosperity of an industry using that article as a raw material. An example of a factor of type B, in the case of an agricultural crop, is yield per acre or the price of the given article the preceding year.[14]

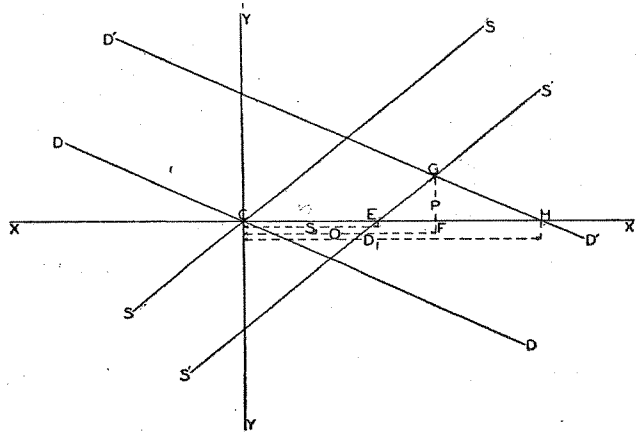
Suppose, now, that the problem is to compute the elasticity of supply (e). Price (P′), output (O′), and price of substitute (A′) should be tabulated and the ratio of each observation to that preceding should be computed. This will give us a table of link relatives for price, output, and price of substitute. Then the deviation of each link relative from the mean link relative should be found and the results tabulated. We shall then have a table showing for each pair of successive observations the percentage deviation in the price of the substitute corresponding with the percentage deviation in output and also with the percentage deviation in price. Denote these percentage deviations from their means by A, O, and P. (Figure 9.)

[13] A complementary process would obviously be to find the relation between output and price, after eliminating the effects of all factors (A) which affect cost conditions or after eliminating the effects of all factors (B) which affect demand conditions. This may be possible by the method of partial correlation.

[14] This last-named factor does not affect cost conditions but it does affect supply conditions, that is, the quantity which will be forthcoming at a given price. The essential point is that it does *not* affect demand conditions, and all that is essential in order to compute elasticity of demand is to find different points on a stationary demand curve.

Through C draw the line SS so that the ratio of any abscissa to its ordinate shall be e, that is, the ratio of the percentage increase in output to the percentage increase in price. Similarly OD should be drawn so that the ratio of abscissa to ordinate will be η. Now suppose that one of the pairs of price-output deviations in the table is represented by a deviation of CF per cent in output and GF per cent in price. These deviations must obviously have been brought about by a change in supply conditions from those represented by the line SS to those represented by the line S′S′ and a change in demand conditions from those represented by the line DD to those represented by the line D′D′, the change in supply conditions being denoted by S_1 and that of demand condition by D_1.[15] Using symbols as indicated on the diagram we have:

FIGURE 9. TYPICAL PRICE-OUTPUT PERCENTAGE DEVIATION.



[15] In this investigation the supply and demand curves must be assumed to represent conditions of constant elasticity for all

$$e = \frac{EF}{GF} = \frac{CF-CE}{GF} = \frac{O-S_1}{P} \text{ or } eP = O-S_1$$

Now multiply each term in this equation by A (the corresponding deviation in the price of a substitute) and we shall have:

$$eA.P = A.O - A.S_1$$

Suppose this multiplication to be performed for every pair of price-output deviations and the results added, then:

$$e\Sigma A.P = \Sigma A.O - \Sigma A.S_1 \quad \text{or} \quad e = \frac{\Sigma A.O - \Sigma A.S_1}{\Sigma A.P}$$

But A was a factor which did not affect supply conditions; hence it is uncorrelated with S_1; hence $\Sigma A.S_1 = 0$; and hence $e = \frac{\Sigma A.O}{\Sigma A.P}$.

Similarly if B is a factor, say, yield per acre, which does not affect demand conditions we shall have:

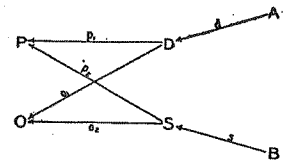
$$\eta = \frac{FH}{FG} = \frac{O-D_1}{P};\ \eta P = O-D_1;\ \eta\Sigma B.P = \Sigma B.O-\Sigma B.D_1;\ \eta = \frac{\Sigma B.O-\Sigma B.D_1}{B.P}.$$

$$\text{But } \Sigma B.D_1 = 0 \quad \text{Hence } \eta = \frac{\Sigma B.O}{\Sigma B.P}$$

Success with this method depends on success in discovering factors of the type A and B. Several such factors of each type should be used if possible. Because of the slow adjustment of price to marginal cost five-year (or four-year or six-year) averages should be used for P′, O′, and A′ in computing e instead of annual data. Since the price lies at the intersection of the demand and total supply curve (which may include imports) instead of at the intersection of the demand and cost curve, consumption data instead of output data should be used in computing η.

A more complete analysis of the method here suggested may be made by introducing the principles of path coefficients; for which see "Correlation and Causation," *Journal of Agricultural Research,* January 3, 1921, by Sewall Wright, and "The Theory of Path Coefficients," *Genetics,* May, 1923, by the same author. The analysis of this method is outlined as follows (symbols used with same meanings as above): (Figure 10.)

FIGURE 10.



The path coefficients involved are d, s, p_1, p_2, o_1, o_2. The solution is based on the assumption that P and O are completely determined by S and D and that, as before, for all points on the curves representing supply or demand conditions the elasticity of supply or the elasticity of demand is constant. By the principles of path coefficients (1) $O = o_1D\frac{\sigma_O}{\sigma_D} + o_2S\frac{\sigma_O}{\sigma_D}$ and (2) $P = p_1D\frac{\sigma_P}{\sigma_D} + p_2S\frac{\sigma_P}{\sigma_D}$. If we divide (1) by (2) on the supposition that the conditions of supply are constant, that is, that $S = 0$, we have $\frac{O}{P} = \frac{o_1\sigma_O}{p_1\sigma_P}$. That is, for the observed percentage deviations of output and price, O and P, we find that their ratio, *under the condition that supply con-*

points on the curve, that is, they must be of the types $x = ny^\eta$ and $xy^\eta = n$ respectively (page 298). With such curves the elasticity at any point would be the ratio of the abscissa to the ordinate of any point on a straight line.

ditions are constant, is given by the expression $\frac{o_1\sigma_O}{p_1\sigma_P}$. But this ratio is, by definition the elasticity of supply. Hence, $e = \frac{o_1\sigma_O}{p_1\sigma_P}$. Similarly if we divide (1) by (2), assuming $D = 0$, we have $\eta = \frac{o_2\sigma_O}{p_2\sigma_P}$.

Now by the principles of path coefficients we have $r_{AP} = p_1 d$ and $r_{AO} = o_1 d$ and hence $\frac{o_1}{p_1} = \frac{r_{AO}}{r_{AP}}$ and $e = \frac{r_{AO}\sigma_O}{r_{AP}\sigma_P}$. Similarly $\eta = \frac{r_{BO}\sigma_O}{r_{BP}\sigma_P}$. Finally, since $r_{AO} = \frac{\Sigma AO}{n\sigma_A\sigma_O}$, $r_{AP} = \frac{\Sigma AP}{n\sigma_A\sigma_P}$, $r_{BO} = \frac{\Sigma BO}{n\sigma_B\sigma_P}$ and $r_{BP} = \frac{\Sigma BP}{n\sigma_B\sigma_P}$, we have

$$e = \frac{r_{AO}\sigma_O}{r_{AP}\sigma_P} = \frac{\frac{\Sigma AO}{n\sigma_A\sigma_O}\sigma_O}{\frac{\Sigma AP}{n\sigma_A\sigma_P}\sigma_P} = \frac{\Sigma AO}{\Sigma AP}$$ as before, and similarly $\eta = \frac{r_{BO}\sigma_O}{r_{BP}\sigma_P} = \frac{\Sigma BO}{\Sigma BP}$, as before.

An attempt was made to compute the values of e_d and η_d for butter and flaxseed by the methods which have been described. By the method of segregating successive observations in which price and output change in the same direction from those in which they change in opposite directions the following values were obtained: for butter, $e_d = 1.65$, $\eta_d = -.53$; for flaxseed, $e_d = 1.88$; $\eta_d = -.81$. By the method of introducing external factors the results were: for butter, $e_d = 1.43$; $\eta_d = -.62$; for flaxseed $e_d = 2.39$; $\eta_d = -.80$. The only available data included the war period, when both supply and demand conditions were far from normal and when, moreover, money prices were greatly inflated. In all cases it is desirable to use "real" prices rather than money prices: in this case it was imperative. But when the inflation and subsequent depression are so extreme as during the period under discussion, considerable doubt is necessarily cast on results obtained by any method of reducing money prices to real prices. Too much confidence should not be placed on the above numerical values, but it is believed that they may be accepted as affording strong evidence of elasticity of supply and inelasticity of demand for both butter and flaxseed.

This conclusion may be accepted with the more confidence as it agrees with *a priori* conclusions. Elasticity of output is to be anticipated for several reasons. (1) Both butter and flaxseed are in the nature of alternative crops. They may be produced by the same men and on the same land as are other crops in which we are now on an export basis. To increase the output it is not necessary to resort to inferior land or to inferior types of business management. Hence it is probable that increase in output would be forthcoming at but slight increase in marginal cost. (2) Dairy products and beef are all derived from cattle. There are considerable herds of dual-purpose animals in the United States. Hence a moderate increase in the price of butter would tend to lead owners of such dual-purpose animals to emphasize milk production and the output of butter would thereby be greatly increased at comparatively small increase in cost. (3) Butter is one of several dairy products. Milk may be marketed as such or it may be used to manufacture butter, cheese, or evaporated milk. A moderate increase in the price of butter would lead to the diversion of milk from other purposes. Condensed milk is on a strong export basis, and even taking dairy products as

a whole, including fresh milk and cream, the difference between exports and imports is not great. Exports were in excess in 1924 and imports in 1925.[16] The diversion would be expected to be accomplished without great increase in cost.

With respect to demand conditions the *a priori* case is not so clear. Butter is regarded as a necessity, and the demand for necessities is ordinarily inelastic. It may, however, be elastic if a ready substitute exists and margarin is a substitute for butter. However, in the United States the consumption of margarin is ordinarily only about 10 per cent of that of butter. People are reluctant to change their food habits. The presence of margarin tends to moderate the inelasticity of demand rather than to make it positively elastic.

In regard to the demand for flaxseed *a priori* reasoning is even more inconclusive. The products of linseed oil, which is the principal product of flaxseed, are less ob-

[16] The trade in dairy products is shown in the table below:

FOREIGN TRADE IN DAIRY PRODUCTS 1924-1925
(In millions of pounds)

Commodity	1924				1925			
	Imports	Exports	Net Imports	Net Exports	Imports	Exports	Net Imports	Net Exports
Fresh milk and cream	80.7	0.6	80.1	...	108.3	0.7	107.6	...
Condensed, evaporated, and powdered milk	8.5	211.8	...	203.3	12.4	151.4	...	139.0
Cheese	59.2	4.3	54.9	...	62.0	9.2	52.8	...
Butter	19.3	8.3	11.0	...	6.9	5.4	1.5	...
Total	167.7	225.0	...	57.3	189.6	166.7	22.9	...

viously necessities than butter. It is highly probable that the amount of painting done is influenced considerably by the price of paint. It will be noted that the values, —.80 and —.81, indicate that the demand for flaxseed is much less inelastic than is the demand for butter, for which the values are —.62 and —.53, but the statistical evidence that the demand is inelastic rather than elastic is strong. The value —.80 was the average of results obtained by six independent computations using different external factors. Four of the results were numerically less than 1, two slightly over 1.

Unfortunately data were not available for computing the elasticities of foreign demand and supply, but the domestic elasticities alone have an important bearing on the effectiveness of the tariff. Referring to formulæ B and C, page 288, $\Delta o = \frac{\Delta P}{P} e_d o_d$ and $\Delta i = \frac{\Delta P}{P}(e_d o_d - \eta_d c_d)$ it will be seen that the large values of e_d, o_d, and c_d indicate that production is likely to respond generously and imports to fall off sharply as a result of whatever price increase is brought about by the tariff. Butter and flaxseed, therefore, are both in a favorable situation for the application of a duty from the standpoint of those who make national self-sufficiency an object. While the increase in price which a duty would entail cannot be computed without a knowledge of the foreign elasticities, there is no reason for supposing that they differ greatly from the domestic, and if not the important part played by American production in world production, gives assurance that the rise in price will be considerably less than the duty.