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## Methodological notes on analyzing the manufactured export performance in less developed countries

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### Methodological Notes on Analyzing the Manufactured Export Performance in Less Developed Countries

by W. G. Tyler

**CONTENTS:**

- Import substituting industrialization has increasingly come under criticism as a strategy for economic growth in the less developed countries. Many economists, in both the developed and less developed countries, have become highly skeptical of the benefits of inward looking development and have advocated outward looking growth, emphasizing the export of manufactures, as a viable growth strategy. In analyzing the manufactured export performance of the less developed countries, a number of methodological questions are raised. This paper, originally prepared as three separate notes, focuses on some usable methodological tools for the economic analyst.
- Chapter I provides a discussion of some of the econometric problems involved in quantitatively estimating the determinants of manufactured export behavior in less developed countries. An ordinary least squares regression model for analyzing manufactured export behavior in the relatively short run is developed and discussed.
- In Chapter II neo-classical microeconomic theory is adapted to the problem of analyzing export behavior of the industrial firm in a less developed economy. Under the assumptions of profit maximizing behavior and economically separate domestic and foreign markets, a micro model of export behavior is developed subject to the constraint of the firm's production function.
- Chapter III presents a methodology for measuring the demand side contribution of import substitution and export expansion as ex post explanations of industrial growth. An alternative, more comprehensive approach to the traditional Chenery and recent Morley-Smith approaches to measurement is developed.

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## Preface

As economists turn their attention to examining the problems of industrialization and manufactured export promotion in the less developed countries, a number of methodological questions are raised. How can the tools of economic theory and quantitative measurement be adapted and employed to analyze the problems of export expansion of those countries? This paper, originally prepared as three separate notes, focuses on some usable methodological tools for the economic analyst. In all cases the idea has been to discuss some of the issues involved in using different tools, and no attempt has been made here to present empirical results of the application of these tools.

Chapter I provides a discussion of some of the econometric problems involved in quantitatively estimating the determinants of manufactured export behavior in less developed countries. In Chapter II neo-classical microeconomic theory is adapted to the problem of analyzing export behavior of the industrial firm in a less developed economy. Finally, Chapter III presents a methodology for measuring the demand-side contributions of import substitution and export expansion as ex post explanations of industrial growth. In reading these notes the reader is advised to treat them as individual units, as they were not written to be published together. There are some minor notational differences and in one instance an overlap in content.

These notes were prepared in conjunction with the research project "Import Substitution and Export Diversification in the Industrialization Process of Selected Less Developed Countries" being undertaken at the Kiel Institute of World Economics (Institut für Weltwirtschaft). As a part of this project case studies are currently under way on Spain, Mexico, Singapore, India, Brazil, Egypt and Taiwan.

In preparing these notes the author is indebted to his colleagues at the Kiel Institute of World Economics. Deserving special mention for their helpfulness and comments are: Ranadev Banerji, Juergen B. Donges, Maurice Girgis, James Riedel, Bernd Stecher and Torsten Tewes. For patiently enduring my abuse in typing the manuscript special thanks go to Lynne Brown.

## Chapter I

### On the Econometrics of Estimating the Determinants of Manufactured Export Behavior

As less developed countries (LDC's) increase their desire to expand exports of manufactured products, it becomes of increasing interest to the policy-makers of those countries to have an appreciation of the effectiveness of different policy instruments in achieving the export objectives. While there is much despair on the part of less developed countries with regard to protectionism on the part of the developed countries and other, largely exogenous influences on export behavior, there is much the LDC's can do to promote industrial exports with their own policies. The problem then is to determine the effectiveness of different strategies. In evaluating the effectiveness of different exogenous policy instruments, it is necessary to have an understanding of the determinants of the behavior of manufactured exports for the country in question. This paper discusses the specification and estimation of an econometric model of such behavior for a less developed country. Although some empirical work along these lines has been done<sup>1</sup>, the author feels that the implicit models in such analyses have never been properly specified. Consequently, the empirical results are frequently misleading. This paper then deals with the methodological problems of undertaking econometric analysis of manufactured export behavior in the relatively short run. Of particular concern from a policy standpoint is the estimation of the effects of exchange rate changes on exports.

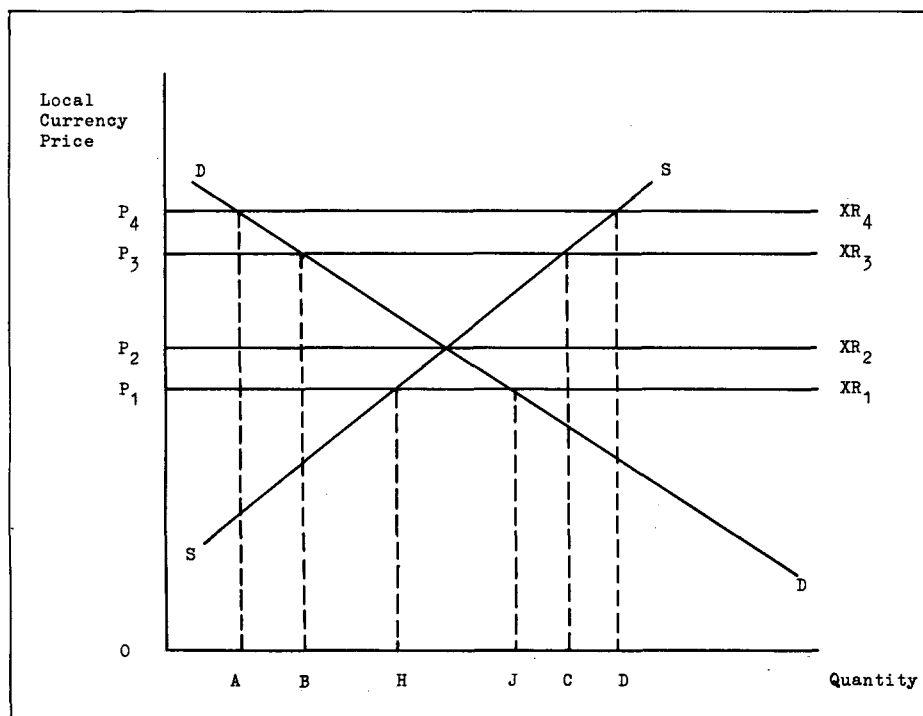
There are two basic difficulties in the econometrics of estimating the determinants of export performance - an identification problem and a difficulty regarding the concept of export supply itself. Discussing the nature of export supply first, it should be observed that the export supply function is neither conceptually distinct nor identical to the aggregate supply function. The amount of a firm's output is simply the sum of its output for the domestic and foreign markets. What is important is the cost function, and, unless a case can be made that the costs of producing for exportation differ from those of producing and selling in the home market<sup>2</sup>, a separate cost function for exports

<sup>1</sup> See J. B. Donges, "Spain's Industrial Exports - An Analysis of Demand and Supply Factors", *Weltwirtschaftliches Archiv* (Review of World Economics), Bd. CVIII, Tübingen, 1972, pp. 191 sqq. - David Felix, "Import Substitution and Industrial Exporting: An Analysis of Recent Argentine Experience", in: *Fiscal Policy for Industrialization in Latin America*, Ed. by David T. Geithman, Gainesville, Florida, forthcoming in 1973. - Henry J. Bruton, "Latin American Exports and Import Substitution Policies", Research Memorandum No. 32, Center for Development Economics, Williams College, Williamstown, Massachusetts, November, 1969, mimeogr. - William G. Tyler, "Manufactured Export Promotion in a Semi-Industrialized Economy: The Brazilian Case", *The Journal of Development Studies*, London, forthcoming. - Idem, "Export Diversification and the Promotion of Manufactured Exports in Brazil", Study Prep. for the Agency for International Development, Rio de Janeiro, August, 1969, mimeogr.

<sup>2</sup> It may of course be that selling in the foreign market is more costly than marketing the firm's products domestically.

is conceptually incorrect. Consider the industry market depicted in Figure I. 1. The industry supply curve is the horizontal summation of the individual firm marginal cost curves above the point  $AVC = MC$ .<sup>1</sup> As usual, domestic demand function is downward sloping and is denoted by DD. A foreign market for the industry's output exists, and it is assumed that any exports of the LDC are insufficient to affect the international market price. In other words, the country is, or would be, a marginal supplier and a price taker. Hence, the foreign demand curve, denoted by XR, is seen as perfectly elastic. A change in the exchange rate alters the domestic currency remuneration for exportation and results in a shift of the external demand curve.

Figure I. 1



In the absence of tariffs and other protection devices, at  $XR_1$ , the industry is a net importer, producing  $OH$  and importing  $HJ$ .<sup>2</sup> At exchange rate  $XR_2$  the industry is neither an exporter nor an importer, while at  $XR_3$  total output is  $OC$  with  $OB$  being consumed domestically and  $BC$  being exported. With a devaluation to  $XR_4$  exports increase not only by  $CD$  but by  $AB$  as well. The exchange rate effect, i. e.,  $\frac{\Delta \text{Exports}}{\Delta XR}$  in Figure I. 1 is equal to  $\frac{AB + CD}{P_3 P_4}$ . As is seen, the exchange rate effect on exports ( $X$ ) is more

powerful than that implied by the elasticity of supply alone. The domestic demand elasticity is also important; ceteris paribus, the more elastic domestic demand, the

<sup>1</sup> The average cost curve ( $AVC$ ) intersects the marginal cost curve ( $MC$ ) at the latter's lowest point.

<sup>2</sup> The  $XR$  curves can be interpreted as external supply curves as well as external demand curves.

greater will be the effect of exchange rate changes on exports. Because of the domestic demand effect, it is impossible to interpret  $\frac{dX}{dXR}$  as the slope of the supply curve.

Therefore,  $\frac{dX}{dXR} \cdot \frac{XR}{X}$  is not the elasticity of the industry supply curve.

For such a situation an export function can be derived. Assume the model:

$$(1) C_D = C_D(P, Y_d) = \alpha_0 + \alpha_1 P + \alpha_2 Y_d \quad \alpha_1 < 0 < \alpha_2$$

$$(2) Q_S = Q_S(P) = \beta_0 + \beta_1 P \quad \beta_1 > 0$$

$$(3) Q_D = C_D + X_i$$

where:

$C_D$  = domestic market demand for the industry's output

$P$  = local currency price, exogenously determined

$Y_d$  = domestic market income

$Q_S$  = quantity supplied

$Q_D$  = quantity demanded

$X_i$  = net exports for the industry.

Equating total demand and supply and solving for  $X$ , we have the export function:

$$(4) X = \beta_0 - \alpha_0 + (\beta_1 - \alpha_1)P - \alpha_2 Y_d$$

from which the export elasticity with respect to a change in the exchange rate can be estimated. It is greater than the supply elasticity. The model could be easily extended to include an export subsidy.

Conceivably one could aggregate such a model over all industries for a total export

function, i. e., for an expression of  $\sum_{i=1}^n X_i$ . However, problems of aggregation and

the nature of the functional form of the supply equation<sup>1</sup> present formidable difficulties in pursuing this approach. What the policy-maker wants to know is what are the effects

<sup>1</sup> If the total cost (TC) function is specified as:

$$TC = aQ^3 + bQ^2 + cQ + d, \quad a, c, d, > 0, \quad b < 0, \quad b^2 < 3ac$$

the supply function is derived by assuming profit maximization ( $MC = P$ ) and expressing  $Q$  as a function of price ( $P$ ).

of policy on exports. An alternative, but similar model focusing on aggregate manufactured exports is posited below.

A second basic difficulty in estimating the determinants in industrial export performance concerns an identification problem. Both demand and supply elements are involved in the estimation. If one observes, as in Figure I. 2, a series of points, where it is known that demand and supply are equal, it is impossible to distinguish the demand and supply relationships unless more is known than that they are both functionally related to price  $P$ . The true relationships might resemble, for example, those depicted in Figure I. 2b or I. 2c.

Figure I. 2

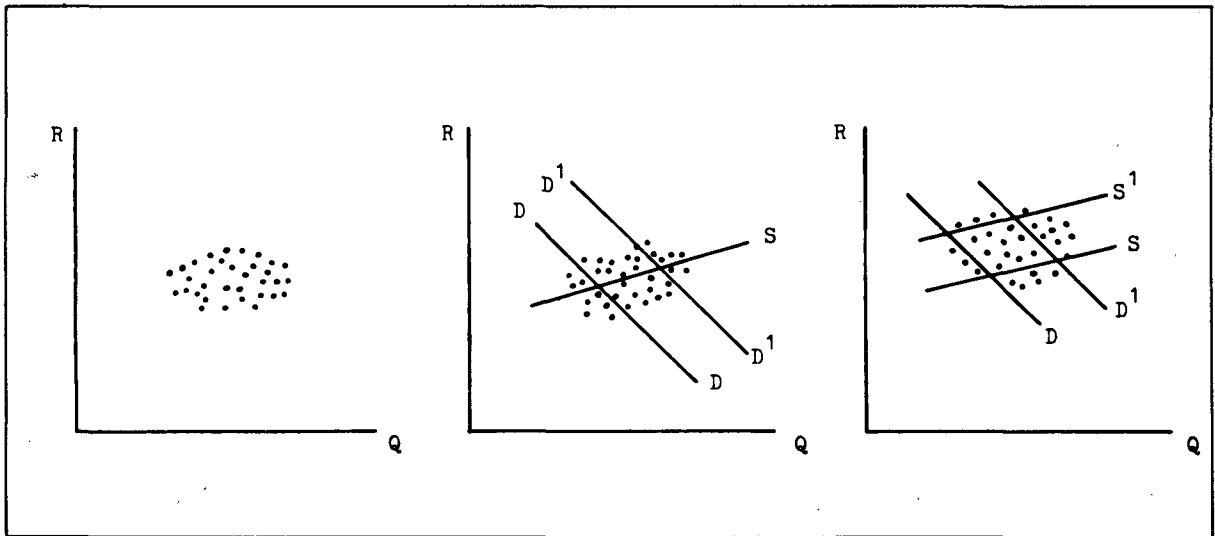


Figure I. 2a

Figure I. 2b

Figure I. 2c

Previous attempts to estimate the determinants of export performance have mixed demand and supply concepts with little regard to identification problems.

Assume the simple demand and supply model for a country's manufactured exports:

$$(5) X_D = X_D(R)$$

$$(6) X_S = X_S(R, B)$$

$$(7) X_D = X_S$$

$$\text{where } \frac{\partial X_D}{\partial R} < 0, \quad \frac{\partial X_S}{\partial R} > 0, \quad \frac{\partial X_S}{\partial B} < 0$$

and where

$X_D$  = quantity of manufactured exports demanded in constant units of foreign exchange (constant dollars)

$X_S$  = quantity of manufactured exports supplied



- R = real exchange rate for manufactured exports (reflecting real local currency remuneration to exporters per real unit of foreign exchange)
- B = capacity utilization.

Capacity utilization has been included as a variable since it seems to have been important in those countries for which studies (cited above) have been done. Slack domestic market conditions and capacity underutilization have been important in expanding industrial exports. In Brazil, for instance, the recession-boom effect has been an important determinant of manufactured export behavior.

In the model (5) - (7), as posited, variables X and R are endogenous, while B is considered exogenous. An econometric model depicting the relationships (5) - (7) might appear as:

$$(8) \quad X_{Dt} = a_0 + a_1 R_t + \epsilon_{1t}$$

$$(9) \quad X_{St} = b_0 + b_1 R_t + b_2 B_t + \epsilon_{2t}$$

where  $a_1 < 0$ ,  $b_1 > 0$ ,  $b_2 < 0$

and where the a's and b's represent parameters, t represents a specific time period (an observation), and the  $\epsilon$ 's are random disturbances. In this model order and rank conditions are satisfied for the exact identification of the structural equation (8)<sup>1</sup>. However, without further information or additional restrictions (9) is underidentified. Since it is the supply relationship that interests us most, a problem appears.

Fortunately, there is a way out of this identification quandry by making a restrictive assumption about (8). Since less developed countries individually are marginal suppliers of manufactured goods in world trade, it is assumed that the external demand curve facing an individual LDC for its manufactures is perfectly elastic, analogous to the market demand curve confronting an individual firm under perfectly competitive conditions. The industrial exporting LDC can not affect international market prices. The parameter  $a_1$  in (8) is then restricted to a value of infinity, and  $a_0$  is determined by the exchange rate policy of the LDC. A real devaluation results in a shift upward of the perfectly elastic external demand curve by the amount of the devaluation. The variable R thus ceases to be an endogenous variable and becomes exogenous in nature, determined by policy-makers. With this assumption about R we can directly estimate the export supply function, in this case (9). Shifts in the perfectly elastic demand curve, owing to exchange rate policy, trace out the aggregate export supply function.

Although one can work with an extension of the linear model in (9), a nonlinear variety may provide a better fit. A basic model can be posited as:

$$(10) \quad X_{St} = \frac{AR_t^{b_1} T_t^{b_3}}{B_t^{b_2}} \quad b_1, b_2, b_3 > 0$$

<sup>1</sup> The estimation of the parameters of (8) would require the transformation of the structural equations (8) and (9) into the reduced form and estimation through indirect least squares.

where A is a constant. The new variable T represents any tax incentives provided for manufactured exports; it can be measured as an index of local currency remuneration for export expressed as a percentage above the domestic market price. For example,  $T = 100$  would indicate no tax incentives, whereas  $T = 125$  would mean that a domestic producer would receive 25 percent more local currency for an export than for a domestic sale - provided of course that he could find a foreign purchaser at that price. What this means is that the local producer could afford to sell the product abroad at 25 percent less than the price in the domestic market. Clearly, changes in T affect local currency remuneration in the same way that changes in R do. While it is possible to combine these two effects as  $R_t^* = R_t \cdot \frac{T_t}{100}$ <sup>1</sup>, it is also possible to separate them by looking at changes in T as a shift in the export supply curve.

The measurement of capacity utilization B may present some problems. Although some data on capacity utilization may be available in some LDC's, one can not normally expect to find such information in any reasonable time series form. In this case a reasonable proxy for B is deviations from a time trend of industrial production. A minus sign deviation indicates a slack in the growth of industrial output and capacity underutilization. Thus, the recession-boom effect implies  $\frac{\partial X}{\partial B} < 0$ . If B however is estimated in this way (the Wharton method), the model specified as (10) can not be fit with OLS because of the negativity of some of B's observations.

The export supply function in (10) is log linear and can be easily estimated with ordinary least squares as:

$$(11) \quad \log X_t = \log A + b_1 \log R_t - b_2 \log B_t + b_3 \log T_t + \epsilon_t$$

As specified, the estimated parameters  $b_1$ ,  $b_2$  and  $b_3$  can be interpreted as elasticities. The disturbance term is  $\epsilon$ , about which the standard assumptions are made<sup>2</sup>.

The time dimension of the model deserves some attention. The model described is essentially static, but a time series must be used to generate the degrees of freedom for the estimation of the parameters. Two problems are apparent with time series estimation. First, annual observations are not adequate. The model should be essentially a relatively short-term one, and a time series protracted enough to provide a large sample of observations may mask certain longer-term changes not dealt with or accounted for in the model. The shorter the time span the better. Also, annual data may hide important happenings within the year. For these reasons at least quarterly observations are highly desirable if not absolutely essential.

A second difficulty in the time dimension deals with time associated shifts in the demand and supply relationships. If the country is undergoing continuing industrial growth, there

<sup>1</sup> It would be also possible to include the changes in tariffs of importing countries in the calculation of R. We could have  $R_t^* = R_t \cdot \frac{T_t}{100} \cdot \frac{D_t}{100}$  where D represents a weighted index of tariffs for importing countries with the base period equal to 100. Anything affecting relative prices could be conceivably included in the R measure.

<sup>2</sup> See Jan Kmenta, *Elements of Econometrics*, New York, London, 1971, pp. 202 sqq.

is implied a rightward shift in the country's aggregate industrial supply curve. *Ceteris paribus* this suggests lower production costs for manufactured exports and thus greater competitiveness. To introduce a shift variable into the export supply function one might include a measure of real industrial output in (10). Similarly, one could incorporate a time trend in the dependent variable as an independent variable.

Still another alternative would be the introduction of auto-regressive elements into the model. A lag in the dependent variable  $X$ , e. g.,  $X_{t-1}$  or  $\frac{X_{t-1} + X_{t-2}}{2}$ , could be introduced as an independent variable. Expectations and attitudes can be expected to be important in the real world. Furthermore, many of the unquantifiable elements of governmental export promotion can be picked up with the inclusion of lagged exports as an independent variable. Also, one may find it propitious to introduce lags in the independent variables. It is reasonable to believe that changes in the real exchange rate or tax incentives will have a delayed impact on export performance. It is a question of the time periods selected for the analysis and the manner of measurement<sup>1</sup>. Spectral analysis offers still another approach to deal with the problems involved with the introduction of the time element. Regarding lags and other variations on the basic regression model, there can be no hard and fast rules. Common sense is one's best guide, while data limitations provide the practical constraints. Only experimentation can find the best fit.

In utilizing quarterly or monthly data possible difficulties may arise with respect to seasonality in the dependent variable. While it is feasible to develop a seasonally adjusted series for manufactured exports, it may be preferable to include explicit seasonal variables in the analysis with seasonally unadjusted data. Assuming linearity and additivity in the seasonal factors, we can rewrite our quarterly version of (11) as:

$$(12) \quad \log X_t = \log A + b_1 \log R_t - b_2 \log B_t + b_3 \log T_t + C_1 F_{1t} + C_2 F_{2t} + C_3 F_{3t} + \epsilon_t$$

where

$$F_{1t} = 1 \text{ in first quarter periods} \\ = 0 \text{ in all other periods,}$$

$$F_{2t} = 1 \text{ in second quarter periods} \\ = 0 \text{ in all other periods,}$$

$$F_{3t} = 1 \text{ in third quarter periods} \\ = 0 \text{ in all other periods.}$$

It may of course be that seasonality is unimportant in a country's manufactured export behavior.

As is the case with time series analysis, the least squares estimation of (11), or its variations, may exhibit serial correlation of the error terms. While autocorrelation alone does not generally yield biased estimates of the regression coefficients, it

<sup>1</sup> One may at least partially avoid the lag problem in the exchange rate by calculating the nominal exchange rate by dividing the local currency export receipts by foreign currency exchange receipts for the period in question. Since such transactions were negotiated previous to their actual export, the calculated exchange rate will already contain a lag element.

seriously biases downward their standard errors - thus rendering illegitimate the use of the standard tests of statistical significance. Consequently, one must test for the presence of autocorrelation; the Durbin-Watson statistic should be estimated.

If autocorrelation is found in the estimation of (11), an alternative approach is to work with a transformation of the model specified to first differences. In addition to writing (11) we can also write:

$$(13) \quad \log X_{t-1} = \log A + b_1 \log R_{t-1} - b_2 \log B_{t-1} + b_3 \log T_{t-1} + \epsilon_{t-1}$$

Subtracting (13) from (11) we obtain

$$(14a) \quad \log X_t - \log X_{t-1} = b_1(\log R_t - \log R_{t-1}) - b_2(\log B_t - \log B_{t-1}) \\ + b_3(\log T_t - \log T_{t-1}) + (\epsilon_t - \epsilon_{t-1})$$

or

$$(14b) \quad \Delta \log X_t = b_1 \Delta \log R_t - b_2 \Delta \log B_t + b_3 \Delta \log T_t + u_t$$

where  $u_t = \epsilon_t - \epsilon_{t-1}$ . If  $u_t$  is a random variable without serial correlation, a serial correlation coefficient of unity in the original disturbances is implied. If this condition holds, the transformation to first differences can be employed to avoid serial correlation.

An alternative way around any possible problems with autocorrelation would be to utilize a cross-section instead of a time series for the analysis. Rather than regressing with a sample over time (t), it is conceptually possible to regress with a sample composed of different industries. Capacity utilization and tax incentives are likely to differ across industries. Furthermore, effective rates of protection could easily be incorporated into the analysis to calculate an implicit exchange rate<sup>1</sup>.

A few final comments should be made regarding the limitations in using econometric analysis to examine the determinants of manufacturing export behavior for a less developed country. In addition to the obvious difficulties imposed by data availability and accuracy, there are other problems as well that have not yet been mentioned. First, a certain minimum level of manufactured exports seems to be required for the analysis to avoid problems imposed by entirely random fluctuations. On the other hand, the econometric model specified may be valid only up to some maximum limit in manufactured exports. Beyond that point, it may be impossible to make the crucial assumption of a perfectly elastic external demand curve confronting the less developed country<sup>2</sup>. Furthermore, the partial equilibrium approach implicit in the model is

<sup>1</sup> Conceivably an aggregate rate of effective protection could be employed in the time series analysis. However, substantial problems in aggregation are apparent in such an approach. For a discussion of implicit exchange rates see Stephen R. Lewis Jr., *Economic Policy and Industrial Growth in Pakistan*, London, 1969.

<sup>2</sup> The point at which a less developed country ceases to face a perfectly elastic external demand curve will depend upon the commodity composition of its industrial exports and the market position for its key exports of manufactures.

justifiable when manufactured exports account for a relatively small percentage of total manufacturing output. However, with a larger share of industrial output being accounted for by exports, exports themselves become a more important factor in the generation of total income. If the model is specified that manufactured exports in part are a function of total manufacturing output, such output ceases to be an exogenous variable when exports are large. A more general model is required than that specified. The partial equilibrium approach no longer remains valid.

Similar problems also exist with respect to aggregation and disaggregation. If manufactured exports are relatively small and one desires to disaggregate these exports by industry, one is liable to have problems in analyzing export behavior in terms of the model specified for the desired industry. Problems of random fluctuations are compounded by the existence of special circumstances not accounted for in the model. Dealing with aggregate industrial exports these problems are not as apparent. Disaggregation is further complicated by index number difficulties. Relative prices are bound to change. Without disaggregated wholesale industrial price indices any disaggregated analysis of manufactured exports with the specified model must be undertaken with extreme caution.

More generally still, since the model is expressed in real magnitudes, the selection of the appropriate deflators must be done with care. The foreign exchange value of manufactured exports should be adjusted for foreign exchange inflation. To the extent that the United States constitutes the major market for the LDC's manufactured exports, the wholesale industrial price index for the United States can be used as a deflator. For the real exchange rate variables both the American and LDC's wholesale industrial price indices should normally be used. All of the problems and statistical inadequacies of these indices will be reflected in the parameter estimation of our model.

Finally, a word about multicollinearity. Problems of statistical estimation preclude the incorporation of many exogenous variables into the model even though they may be important factors influencing export behavior. The government may undertake many measures designed to promote manufactured exports, but to the extent such measures are taken concurrently it may be impossible to separate out the effects of each. Furthermore, the specification of an econometric model provides something of a bias in including those exogenous variables more conducive to quantification and measurement (not to mention those suggested by conventional economic theory). Many of the important determinants of export behavior, such as sales effort, may be omitted.

## Chapter II

### On the Microeconomics of Manufactured Export Promotion

While economists have recently paid growing attention to the problems of export diversification and promotion for the less developed countries, most of the resulting literature has focused on macroeconomic questions. Relatively little attention has been devoted to the microeconomics of export promotion and behavior<sup>1</sup>. Yet in order to generalize about the aggregates one implicitly makes rather crucial assumptions about the behavior of individual producers. In this paper an attempt is made to sketch out the foundations for analyzing export behavior. Some aspects of the neoclassical theory of the firm and production are reviewed and adapted to the context of export promotion and behavior of the less developed countries. It is the purpose of this paper to present some of the issues involved for further discussion. The author does not pretend to have resolved the problems.

The paper is organized in five sections. Section I presents assumptions and a restatement of the theory of the discriminating monopolistic firm, while Section II presents this restatement in graphical terms. Section III is the firm's profit maximizing export supply function under the stated assumptions. In Section IV a more generalized model is developed incorporating a production function constraint. Section V discusses some of the implications of the analysis and presents a few generalized conclusions.

#### I.

In specifying assumptions one would like to approximate conditions present in the less developed countries as much as possible without sacrificing relative simplicity. We shall therefore assume:

1. Profit maximizing behavior on the part of the firm.
2. Imperfectly competitive market conditions in the domestic market. Assume also that the government is unable to limit the exercise of such market power on the part of the firm.
3. Perfectly competitive market conditions in the external market.
4. Economic isolation of the domestic and external markets through domestic import restriction.
5. Excess capacity for the firm.

Before reviewing the theory of the firm - in fact a discriminating monopolist - under such conditions, two comments are in order. First, the objective function of profit maximization is chosen not only for theoretical convenience but in the belief that entre-

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<sup>1</sup> See David T. Geithman and Roger D. Blair, Export Promotion under Imperfect Competition: Devaluation and Subsidization, unpublished paper, 1972, and William G. Tyler, "Export Promotion with Increasing Returns to Scale under Imperfect Domestic Market Conditions", Social and Economic Studies, Vol. XVIII, Jamaica, B.W.I., 1969, pp. 402 sqq.

preneurs in less developed countries, contrary to what some individuals would have us believe, exhibit profit maximizing behavior. Clearly, if they maximize some other objective function, alternative models of behavior must be elaborated.

Second, some remarks on the nature of excess capacity, i. e. , capacity underutilization, are warranted. In many less developed countries attempting to industrialize abundant investment incentives have frequently resulted in building plant and equipment ahead of existing domestic market demand. In Brazil, for example, it has been estimated that in 1968 idle capacity in the automotive industry amounted to 42 percent<sup>1</sup>. While many writers have argued the desirability of exporting for underutilized industries<sup>2</sup>, there is a conceptual problem at the micro level in defining capacity underutilization. Engineers and economists typically differ in their definitions of full capacity. Without being drawn into this argument<sup>3</sup>, for our purposes we shall define capacity underutilization as existing when output is less than that with the lowest short-run average costs.

Given the conditions specified in the above assumptions 1, 2 and 4 the profit function for the firm is<sup>4</sup> :

$$(1) \quad \pi = P_1 Q_1 + P_2 Q_2 - C$$

where the notation is:

$\pi$  = total profits

R = total revenue

C = total costs

Q = total output = total sales

$Q_1$  = sales in domestic market

$Q_2$  = sales in the foreign market

$P_1$  = product price in the domestic market

$P_2$  = product price in the foreign market in local currency

<sup>1</sup> José Almeida, "A Evolução da capacidade de produção da indústria automobilística brasileira no período 1957-1969", Pesquisa e Planejamento Econômico, Vol. II, Rio de Janeiro, No. 1, p. 60.

<sup>2</sup> See, for example: Daniel M. Schydrowsky, "Fiscal Policy for Full Capacity Industrial Growth in Latin America", in: Fiscal Policy for Industrialization in Latin America, Ed. by David T. Geithman, Gainesville, Florida, forthcoming in 1973. - J. B. Donges, "Spain's Industrial Exports - An Analysis of Demand and Supply Factors", Weltwirtschaftliches Archiv (Review of World Economics), Bd. CVIII, Tübingen, 1972, pp. 191 sqq.

<sup>3</sup> For a good discussion of the different concepts of capacity utilization the reader is referred to Almeida, op. cit., pp. 55 sqq. - See also Lawrence R. Klein, "Some Theoretical Issues in the Measurement of Capacity", Econometrica, Vol. XXVIII, New Haven, Conn., 1960, pp. 272 sqq.

<sup>4</sup> The following treatment draws heavily on the standard neoclassical approach appearing in most micro-economic texts. See especially, James M. Henderson and Richard E. Quandt, Microeconomic Theory, A Mathematical Approach, Economic Handbook Series, New York, 2nd Ed., 1971, pp. 215 sqq.

and where:

$$R_1 = P_1 Q_1$$

$$R_2 = P_2 Q_2$$

$$Q = Q_1 + Q_2$$

$$C = C(Q) \quad \frac{\partial C}{\partial Q} > 0$$

$$P_1 = \phi(Q_1) \quad \frac{\partial P_1}{\partial Q_1} < 0$$

$P_2 =$  a constant, determined by exchange rate policy

Since we specify imperfectly competitive market conditions in the domestic market,  $P_1 = \phi(Q_1)$  must be substituted into equation (1) giving us:

$$(2) \quad \pi = \phi(Q_1) \cdot Q_1 + P_2 Q_2 - C(Q)$$

To obtain the first order conditions for profit maximization set the partial derivatives equal to zero and obtain

$$\frac{\partial \pi}{\partial Q_1} = Q_1 \cdot \phi'(Q_1) + \phi(Q_1) - C'(Q) = 0$$

(3)

$$\frac{\partial \pi}{\partial Q_2} = P_2 - C'(Q) = 0$$

Since we know that  $MR_1 = \frac{dR_1}{dQ_1} = R_1'(Q_1) = Q_1 \cdot \phi'(Q_1) + \phi(Q_1)$ ,

$MR_2 = \frac{dR_2}{dQ_2} = R_2'(Q_2) = P_2$ , and  $MC = \frac{dC}{dQ} = C'(Q)$ , by setting the above equations (3)

simultaneously equal to zero we have obtained the familiar first order condition

$$(4a) \quad Q_1 \cdot \phi'(Q_1) + \phi(Q_1) = P_2 = C'(Q)$$

or simply

$$(4b) \quad MR_1 = MR_2 = MC.$$

The marginal revenues of both markets must equal the marginal cost of total output. The equality of the MR's does not imply that the prices in both markets will be equal. In fact, the domestic market price ( $P_1$ ) will exceed the external price ( $P_2$ )<sup>1</sup>.

<sup>1</sup> Substituting, equation (4a) can be rewritten

$$P_2 = Q_1 \cdot \phi'(Q_1) + P_1$$

or

$$P_2 - P_1 = Q_1 \cdot \phi'(Q_1)$$

Since  $Q_1 > 0$  and  $\phi'(Q_1) < 0$ ,

$P_1 > P_2$  for  $P_1, P_2 > 0$ .



To examine the implications of the first order conditions with regard to price behavior, we can express the marginal revenues as a function of price and price elasticity. We can manipulate the expression for marginal revenue to obtain

$$(5a) \quad MR_i = \frac{dR_i}{dQ_i} = \frac{d(P_i Q_i)}{dQ_i} = P_i + Q_i \cdot \frac{dP_i}{dQ_i} = P_i \left( 1 + \frac{dP_i}{dQ_i} \cdot \frac{Q_i}{P_i} \right) = P_i \left( 1 + \frac{1}{\epsilon_{d_i}} \right)$$

where  $\epsilon_{d_i}$  is the point elasticity of demand in the  $i$ th market. Since the elasticity can normally be considered to be negative, we can alternatively express (5) as:

$$(5b) \quad MR_i = P_i \left( 1 - \frac{1}{|\epsilon_{d_i}|} \right) \quad |\epsilon_{d_i}| > 1$$

We can substitute (5b) into the profit maximization first order condition (4b) and obtain

$$(6a) \quad P_1 \left( 1 - \frac{1}{|\epsilon_{d_1}|} \right) = P_2 \left( 1 - \frac{1}{|\epsilon_{d_2}|} \right) = MC$$

Since we have specified perfect elasticity in the foreign market, i. e.,  $\epsilon_{d_2} = -\infty$ , (6a)

can alternatively be expressed as

$$(6b) \quad P_1 \left( 1 - \frac{1}{|\epsilon_{d_1}|} \right) = P_2 = MC$$

This shows that as long as  $\epsilon_{d_1} > -\infty$ , the domestic market price ( $P_1$ ) will be greater than the price in the external market ( $P_2$ ). It also demonstrates that the more inelastic the domestic market demand, the higher will be the domestic market price.

The second order conditions for profit maximization require that  $MC' > MR'$ , or that the marginal cost for output as a whole increases more rapidly than the marginal revenues<sup>1</sup>. Since in our problem the marginal revenues are either falling or are constant, a positively sloped marginal cost function satisfies the second order conditions.

<sup>1</sup> Formally, the principal minors of the Hessian determinant

$$\begin{vmatrix} MR'_1 - MC' & -MC' \\ -MC' & MR'_2 - MC' \end{vmatrix}$$

must alternate in sign starting with the negative sign. Therefore, we must have

$$MR'_1 - MC' < 0$$

and

$$(MR'_1 - MC')(MR'_2 - MC') - (MC')^2 > 0$$

## II.

These familiar results can also be expressed graphically and are depicted in Figure II. 1. Combining the domestic and foreign demand schedules  $AR_1$  and  $P_2$ , the total marginal revenue for the firms is  $ABP_2$ . Assuming a conventional cost function and its resultant cost curves, with  $P_2$  the firm maximizes profits by selling  $OG$  at price  $P_1$  in the domestic market. At  $OG$  output,  $MR_1 = MC$ . No sales are made in the external market because the average variable costs ( $AVC$ ) are greater than  $P_2$ .

A devaluation of the local currency shifts upward the perfectly elastic foreign demand curve. With a devaluation to  $P_2^*$ . The total marginal revenue curve of the firm becomes  $AB^*P_2^*$  and total output grows to  $OL$ . Domestic sales fall to  $OH$  and exportation amounts to  $HL$ . Even though exports by themselves are not profitable, i. e.,  $AC > P_2^*$ , the firm's profits are maximized through exportation. At these levels the profit maximizing conditions  $MR_1 = MR_2 = MC$  are met. The fall of domestic sales is accompanied by a price increase in the domestic market to  $P_1^*$ . With a further devaluation to  $P_2^{**}$ , the firm's exports grow to  $JF$ , while domestic sales decline further to  $OJ$  at the higher price  $P_1^{**}$ .

Now consider the concept of capacity underutilization to which we referred earlier. According to our definition, excess capacity exists when output is less than  $OF$ . Supposing the initial exchange rate implied by  $P_2$ , exchange rate adjustments can be employed to eliminate economically inefficient capacity underutilization. Devaluation to the exchange rate represented by  $P_2^{**}$  has the effect of increasing output at a relatively low resource cost and expanding exports. Note however that with the increases in  $P_2$  via devaluation, there is an unambiguous rise in the domestic price ( $P_1$ ). The actual magnitude of the increase in  $P_1$  depends upon the elasticity  $\epsilon_{d_1}$  as is seen by taking differences in (6b). This unambiguous result seems to contradict the assertion of those who argue that falling domestic prices will result from a policy of export promotion<sup>1</sup>.

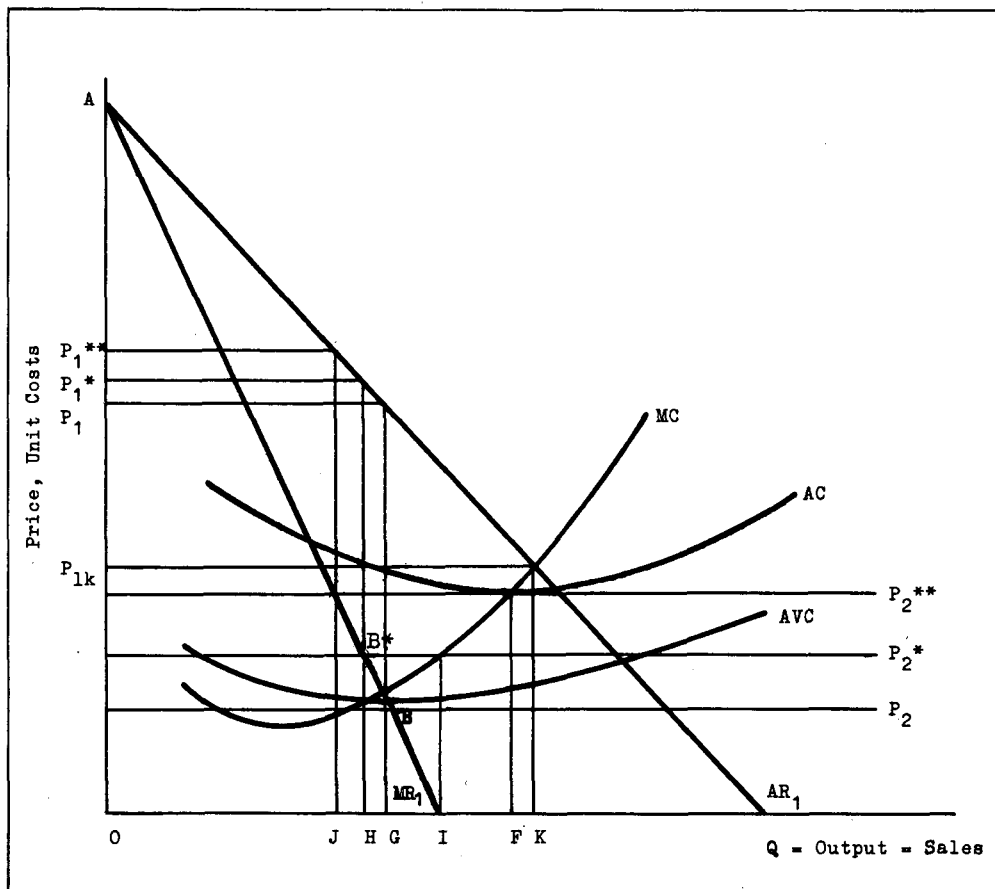
A decrease in costs, on the other hand, will serve to decrease the domestic price as well as increase the amount of exports. Examining Figure II. 1 it is seen that the opposite is true for an increase in costs. Should domestic demand increase the result is also unambiguous; domestic sales and price will increase while exports fall. Total

<sup>1</sup> It should be remembered, however, that our results are predicted on the short run and assume imperfectly competitive conditions in the domestic market. It also should be noted that, if competitive market conditions prevailed and the situation depicted in Figure II. 1 was for an entire industry rather than for one monopolistic firm, total output would be  $OK$  with all of it being sold in the domestic markets at price  $P_{1k}$ . The existence of economic profits would lead to an expansion of productive capacity. Exportation would occur only when  $P_1 = P_2$ .

output will remain the same provided  $P_2 > \min AVC$  and the point where the new  $MR_1 = MC$  is not greater than  $P_2$ . Conversely, a decline in domestic demand will have the effect of decreasing domestic price and sales and increasing exports. Such analysis of the effects of changes in domestic demand on exports may be important in understanding export behavior<sup>1</sup>.

As is seen in Figure II.1, exports not only increase with devaluation (presuming  $P_2 > \min AVC$ ) via a movement along the firm's MC, or supply, curve. Devaluation also increases exports via the effect of reducing domestic market sales. It is this effect of course that also results in the higher domestic market price. It is apparent from Figure II.1 that the changes in domestic quantity demanded (and hence  $MR_1$ ) marginal costs (MC), and  $P_2$  are all important in determining the quantity of export sales. Since demand and costs are both functions of output, exports can be functionally related to  $P_2$  alone. Such an export function would allow us to quantitatively analyze the effects of exchange rate adjustments under the conditions assumed in our model.

Figure II.1



<sup>1</sup> This argument is made in the initial case in R. A. Cooper, and K. Hartley, Assisted by C. R. M. Harvey, *Export Performance and the Pressure of Demand. A Study of Firms*, Studies in Economics, London, 1970.

## III.

To derive the firm's profit maximizing export function, let us first make some specifications as to the mathematical form of the cost and domestic demand functions. Corresponding to Figure II. 1, let us assume

$$(7) \quad C = C(Q) = cQ^3 + dQ^2 + jQ + k \quad c, j, k > 0, d < 0, d^2 < 3jc$$

$$(8) \quad P_1 = \phi(Q_1) = a + bQ_1 \quad a > 0, \quad b < 0$$

The firm's short-run total supply function can be derived from the cost function expressed in (7). We know that

$$\begin{aligned} Q &= Q(P) && \text{for } P \geq \min \text{AVC} \\ Q &= 0 && \text{for } P < \min \text{AVC} \end{aligned}$$

where

$$(9) \quad \text{AVC} = cQ^2 + dQ + j$$

Differentiating (9) with respect to  $Q$  and setting the resultant expression equal to zero to find the minimum average variable cost, we have

$$(10) \quad \frac{d\text{AVC}}{dQ} = 2cQ + d = 0$$

Solving for  $Q$  we obtain the minimum AVC

$$Q = \frac{-d}{2c}$$

which is seen to be positive because  $c > 0$  and  $d < 0$ . Second order conditions are also satisfied because  $c > 0$ . At a price (both  $P_1$  and  $P_2$ ) below  $\frac{-d}{2c}$  the profit maximizing firm will not produce. If  $P_2 < \frac{-d}{2c}$  no exports will occur. Differentiating (7) with respect to  $Q$  we have the marginal cost expression

$$(11) \quad \text{MC} = \frac{dC}{dQ} = 3cQ^2 + 2dQ + j$$

setting  $P$  (only  $P_2$ , in this case because of the domestic market imperfection) equal to MC and solving for  $Q$  we have the total supply function

$$(12a) \quad Q = \frac{-2d + \sqrt{4d^2 - 12cj + 12cP_2}}{6c} \quad \text{for } P_2 \geq \frac{-d}{2c}$$

and

$$(12b) \quad Q = 0 \quad \text{for } P_1 < \frac{-d}{2c}$$

where  $Q = Q_1 + Q_2$

Owing to the monopolistic conditions existing in the domestic market, sales in that market are determined by the condition  $MR_1 = MC$  where  $MR_1 \neq P_1$ . A supply function for sales in the domestic market can be derived by referring back to the domestic demand function (8). Substituting (8) into the identity  $R_1 \equiv P_1 Q_1$  and differentiating with respect to domestic sales we have the following expression for marginal revenue in the internal market

$$(13) \quad MR_1 = a + 2bQ_1$$

Setting  $MR_1 = P_2$  ( $P_2 = MR_2$ ) to satisfy the first order conditions and solving for  $Q_1$  we obtain

$$(14) \quad Q_1 = \frac{P_2 - a}{2b} \quad \text{for } P_2 \geq \frac{-d}{2c}$$

If no exports are profitable, we can set  $MR_1 = MC$  and solve for  $Q_1$  to obtain

$$(14b) \quad Q_1 = \frac{-2(d-b) + \sqrt{(2d-2b)^2 - 12cj + 12ca}}{6c} \quad \text{for } P_1 \geq \frac{-d}{2c} \geq P_2$$

and

$$(14c) \quad Q_1 = 0 \quad \text{for } P_1 < \frac{-d}{2c}$$

Since we know from (6b) that  $P_1 > P_2$ , if  $P_1 < \frac{-d}{2c}$ ,  $P_2 < \frac{-d}{2c}$  also. Therefore, in such a case there is no output.

From the identity  $Q \equiv Q_1 + Q_2$  we can derive export supply function by subtracting the domestic sales equation (14a) from the total supply function (12a). Thus the export supply function is written

$$(15) \quad Q_2 = \frac{-2d + \sqrt{4d^2 - 12cj + 12cP_2}}{6c} - \frac{P_2 - a}{2b}$$

While (15) may be seen unwieldy, if the firm's cost and domestic demand functions are known or can be estimated, it is an easy matter to solve the export supply function (15) - or a similar one based on different functional forms for the cost and domestic demand relations - for the profit maximizing level of exports. Under the conditions we have specified, such a function should accurately predict export sales. Other export supply functions are conceptually incomplete.

The firm's export supply function (15) can be differentiated with respect to  $P_2$  to analyze the effects of exchange rate changes on exports. The first expression on the right hand side of (15) deals with the movement along the MC function as  $P_2$  varies, while the second expression relates to the domestic demand effect. If  $a > P_2$ , as normally expected, the domestic demand effect via devaluation will serve to increase exports by reducing the profit maximizing sales in the domestic market. As apparent, both the price elasticity

in the domestic market and the slope of the marginal cost function are instrumental in determining the export effectiveness of a devaluation. Ceteris paribus the more elastic the domestic demand curve the greater will be the export increase due to a devaluation (or vice versa). Also, the smaller the slope of the MC function the greater the export effect of an exchange rate change. If it is true that the marginal costs in over-expanded firms with substantial excess capacity increase at a very slow rate, a devaluation may prove very effective in promoting exports despite highly inelastic demand conditions in the domestic market. Conversely, under such conditions a fall in the realexchange rate may substantially reduce exports.

## IV.

So far in our discussion it has been assumed that the technical conditions for efficient production have been met. In the next few pages we shall broaden our discussion to include such considerations by developing a model, comprised of a system of simultaneous equations, demonstrating profit maximizing behavior under the preceding assumptions. By subjecting the profit maximizing firm to the constraint of its production function, we can now relax the efficient production assumption and analyze the firm's behavior in the context of neoclassical production theory. Expanding our basic objective function in (1) and subjecting it to the constraint imposed by the general two factor production function,  $Q = f(K, L)$  we have the following Lagrangian objective function:

$$(16) \quad \pi_{\lambda} = P_1 Q_1 + P_2 Q_2 - rK - wL - \lambda [Q_1 + Q_2 - f(K, L)]$$

where

$r$  = rental value for capital

$K$  = capital

$w$  = wage rate

$L$  = labor employed

and where, as before,

$$Q = Q_1 + Q_2$$

$$P_1 = \phi(Q_1)$$

$P_2$  = a constant, determined by exchange rate policy

To attain the first order conditions we set the first partial deviations of (16) equal to zero. We have:

$$(17) \quad \frac{\partial \pi_{\lambda}}{\partial Q_1} = R'_1 - \lambda = 0$$

$$\frac{\partial \pi_{\lambda}}{\partial Q_2} = P_2 - \lambda = 0$$

$$(17) \quad \frac{\partial \pi_\lambda}{\partial K} = -r + \lambda f_K = 0$$

$$\frac{\partial \pi_\lambda}{\partial L} = -w + \lambda f_L = 0$$

$$\frac{\partial \pi_\lambda}{\partial \lambda} = Q_1 + Q_2 - f(K, L) = 0$$

The interpretation of (17) is similar to that of (3) and presents no surprises. The Lagrangian multiplier  $\lambda$  can be interpreted as the firm's marginal cost. Thus, the first two equations of (17) specify that for profit maximization the condition  $R'_1 = R'_2 = C'$  must be fulfilled. The third and fourth equations state that for profit maximization the factor price ratio must be equal to the ratio of the marginal products, i. e.,  $\frac{w}{r} = \frac{f_L}{f_K}$ .

Second order conditions for a profit maximum in (16) are satisfied if  $d^2\pi$  is negative definite. This requires that the principal minors of the relative bordered Hessian determinant

$$|\bar{H}| = \begin{vmatrix} R'_1 - \lambda' & -\lambda' & -\frac{\partial \lambda}{\partial K} & -\frac{\partial \lambda}{\partial L} & -1 \\ -\lambda' & -\lambda' & -\frac{\partial \lambda}{\partial K} & -\frac{\partial \lambda}{\partial L} & -1 \\ f_K \lambda' & f_K \lambda' & \lambda f_{KK} + f_K \cdot \frac{\partial \lambda}{\partial K} & \lambda f_{KL} + f_K \cdot \frac{\partial \lambda}{\partial L} & f_K \\ f_L \lambda' & f_L \lambda' & \lambda f_{LK} + f_L \cdot \frac{\partial \lambda}{\partial K} & \lambda f_{LL} + f_L \cdot \frac{\partial \lambda}{\partial L} & f_L \\ -1 & -1 & f_K & f_L & 0 \end{vmatrix}$$

alternate signs beginning with the negative sign, i. e.,

$$|\bar{H}_1|, |\bar{H}_3|, |\bar{H}_5|, < 0 \text{ and } |\bar{H}_2|, |\bar{H}_4| > 0. \text{ We have}$$

$$|\bar{H}_1| = R'_1 - \lambda' < 0 \text{ if } R'_1 < 0 \text{ and } \lambda' \geq 0$$

also,

$$|\bar{H}_2| = (R'_1 - \lambda')(-\lambda') - (-\lambda')^2 = -R'_1 \cdot \lambda' > 0 \text{ if } R'_1 < 0 \text{ and } \lambda' > 0$$

Thus we see that we must have a positive sloping marginal cost curve at the relevant point. Without further expansion, we assert that convexity in the isoquants of the production function is also necessary to insure profit maximum<sup>1</sup>.

Considering the effects of changes in the parameters in system (17), the first order conditions will be re-established if:

$$\begin{aligned}
 R'_1 + dR'_1 - (\lambda + d\lambda) &= 0 \\
 P_2 + dP_2 - (\lambda + d\lambda) &= 0 \\
 (18) \quad -(r + dr) + \lambda f_K + d\lambda f_K + \lambda(f_{LK}dL + f_{KK}dK) &= 0 \\
 -(w + dw) + \lambda f_L + d\lambda f_L + \lambda(f_{LL}dL + f_{KL}dK) &= 0 \\
 Q_1 + dQ_1 + Q_2 + dQ_2 - \{f(K, L) + f_K dK + f_L dL\} &= 0
 \end{aligned}$$

From the identity  $Q = Q_1 + Q_2$  we can write

$$\begin{aligned}
 (19) \quad Q_1 + Q_2 - Q &= 0 \\
 Q_1 + dQ_1 + Q_2 + dQ_2 - (Q + dQ) &= 0
 \end{aligned}$$

and from the firm's domestic demand function,  $P_1 = \phi(Q_1)$ , recalling that  $\frac{dP_1}{dQ_1} = \phi_{Q_1}$ , we write

$$(20) \quad \phi_{Q_1} \cdot dQ_1 - dP_1 = 0$$

From the first order conditions expressed in (17) - and (4b) - we have

$$\begin{aligned}
 R'_1 - \lambda &= 0 \\
 P_2 - \lambda &= 0 \\
 (21) \quad R'_1 &= P_2 \\
 r - \lambda f_K &= 0 \\
 w - \lambda f_L &= 0
 \end{aligned}$$

We further know from the neoclassical theory of the firm that the value of the marginal products of the factors must equal the factor prices for profit maximization<sup>2</sup>. Therefore, we write

$$(22) \quad P_2 \cdot f_L - w = 0$$

<sup>1</sup> This will be suggested in the development of a somewhat simpler model below.

<sup>2</sup> We would also write  $P_2 f_K - r = 0$ , but it is not necessary to the development of our argument.



We can further extend our argument by the inclusion of the concept of the elasticity of substitution. The elasticity of substitution, defined as

$$\sigma = \frac{d \log \frac{K}{L}}{d \log \frac{f_L}{f_K}}$$

which through substitution and manipulation can be expressed as<sup>1</sup>

$$\sigma = \frac{f_L f_K (f_{LK} K + f_{LL} L)}{KL(2f_{LK} f_L f_K - f_{LK}^2 - f_{LL}^2)}$$

For an homogeneous production function of degree one, Euler's theorem can be utilized and the elasticity of substitution can be expressed as:

$$\sigma = \frac{f_L f_K}{f_{LK} Q}$$

Therefore,

$$(23) \quad \frac{1}{\sigma} = \frac{f_{LK}}{f_L f_K} \cdot Q$$

Combining the equations expressed in (18), (19), (20), (21), (22), and (23) we can represent the resulting system of simultaneous equations in matrix form as

$$(24) \quad \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 \\ f_{KK} & f_{LK} & f_K & 0 & 0 & 0 & 0 & 0 & 0 & f_K & -1 & 0 & 0 & 0 & 0 \\ f_{KL} & f_{LL} & f_L & 0 & 0 & 0 & 0 & 0 & 0 & f_L & 0 & -1 & 0 & 0 & 0 \\ -f_K & -f_L & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & -1 & 0 \\ 0 & 0 & 0 & 1 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \phi_{Q_1} & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -f_K & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -f_L & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & f_K & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \times \begin{bmatrix} dK \\ dL \\ d\lambda \\ dQ_1 \\ dQ_2 \\ dQ \\ dP_1 \\ R_1 \\ P_2 \\ \lambda \\ r \\ w \\ Q_1 \\ Q_2 \\ Q \end{bmatrix} = \begin{bmatrix} dR_1' \\ dP_2' \\ dr \\ dw \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ P_2 \\ 0 \\ 0 \\ 0 \\ \frac{1}{\sigma} \end{bmatrix}$$

<sup>1</sup> See Henderson and Quandt, op. cit., pp. 62, 86.

This provides us with the solution for the system

$$(25) \quad \begin{bmatrix} dK \\ dL \\ d\lambda \\ dQ_1 \\ dQ_2 \\ dQ \\ dP_1 \\ R'_1 \\ P_2 \\ \lambda \\ r \\ w \\ Q_1 \\ Q_2 \\ Q \end{bmatrix} = A^{-1} \begin{bmatrix} dR'_1 \\ dP_2 \\ dr \\ dw \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ P_2 \\ 0 \\ 0 \\ 0 \\ \frac{1}{\sigma} \end{bmatrix}$$

Where  $A$  is the coefficient matrix in (24). This solution enables us to evaluate changes in the employment of productive factors, marginal cost, outputs, and domestic price for given changes in the factor prices and changes in the external price brought about by exchange rate adjustments. The effects of government policy regarding factor prices and the exchange rate can thus be analyzed in terms of such objectives as employment creation and export promotion, bearing in mind of course that such an analytical device as (24) is of an entirely partial equilibrium nature. In the event that we possess quantitative estimates of the firm's production function, its domestic demand function, and its output and input prices, we can quantitatively estimate the effects of such changes in policy.

An alternative approach involves the derivation of a cost function from the production function assuming homogeneity in the production function and convexity in its isoquants. Such a cost function would then be substituted into equation (2). But the cost function will differ according to the specification of the production function. For the Cobb-Douglas production function, the total cost function is derived with relative simplicity<sup>1</sup>.

<sup>1</sup> The derivation presented is that of Henderson and Quandt, *op. cit.*, p. 85.

Allowing for full adjustment, we write the production function, cost equation, and expansion path function (implicit with Cobb-Douglas) as

$$Q = AK^\alpha L^{1-\alpha} \quad 0 < \alpha < 1$$

$$C = rK + wL$$

$$(1 - \alpha)rK - \alpha wL = 0$$

The second and third equations can simultaneously be solved for the most efficient values of K and L giving us

$$K = \frac{\alpha C}{r}$$

$$L = \frac{(1 - \alpha) C}{w}$$

Substituting these values for K and L into the production function, we have

$$Q = A \left( \frac{\alpha C}{r} \right)^\alpha \left[ \frac{(1 - \alpha) C}{w} \right]^{1-\alpha}$$

Solving for C we obtain

$$(26) \quad C = \frac{r^\alpha w^{1-\alpha}}{A \alpha^\alpha (1-\alpha)^{1-\alpha}} \cdot Q$$

which is the total cost function<sup>1</sup>. With the CES production function, the relation between factor prices, output and cost of course is still more complicated, but the total cost function is still linear<sup>2</sup>.

With our system (24) it is apparent that the specification of the production function is important in determining not only the employment of the productive factors given a change in factor prices but the firm's exports as well. The firm's marginal cost will change with a change in factor prices, bringing about a change in exports. Naturally, different production functions will give different results. The generality of (24) and (25) allows us to specify the production function in different ways. To foster generality, we have also incorporated the elasticity of substitution into the system, allowing us to examine the outcome given different elasticities of substitution.

<sup>1</sup> From this expression one can easily see one of the famous properties of the homogeneous, constant returns to scale, Cobb-Douglas, i. e., that marginal cost is constant. An increase in either factor price unambiguously shifts upward the constant marginal cost.

For increasing (decreasing) returns to scale with a Cobb-Douglas production function, the total cost function is nonlinear and increases at a decreasing (increasing) rate. See F. H. Fleck, H. Bortis, und R. Casutt, "Die Kostenfunktion einer Cobb-Douglas-Produktionsfunktion", *Weltwirtschaftliches Archiv*, Bd. CVII, 1971 II, pp. 123 sqq.

<sup>2</sup> See A. A. Walters, "Production and Cost Functions: An Econometric Survey", *Econometrica*, Vol. XXXI, 1963, p. 7.

The limitations of (24) appear quite clear when attempting to introduce a production function into the system. The system (24) purports to deal with a short-run profit maximization problem; yet in selecting a production function it is easy to confuse the problem of short-term maximization and long-run behavior. Production function estimates, no matter what the specification of the production function, generally pertain to full adjustment. In our two factor case, both capital and labor are considered variable. Plugging such a full adjustment function, estimated under those conditions, into (24) then is incorrect. More serious still is the related problem of scale. Linearly homogeneous CES and Cobb-Douglas production functions exhibit constant marginal costs, but second order conditions require that marginal cost increase. To make the system (24) workable one must either make estimates of unconventionally specified short-run production functions or drop the constant returns to scale assumption explicit in equation (23). The latter can be accomplished by eliminating (23) from (24) substituting the equation  $P_2^f K - r = 0$  mentioned in footnote 2 on page 23<sup>1</sup>.

## V.

One should be careful in generalizing from the model presented in (24) and any comparative statics analysis derived from it. The partial equilibrium and static qualifications have been suggested above. Nevertheless, we think that the model can serve as a point of departure for further analysis. Furthermore, it can also serve as a basis for making predictions as to micro behavior. Given the availability of micro-level data, the model can conceivably provide an instrument for making quantitative predictions given changes in certain policy parameters by the government.

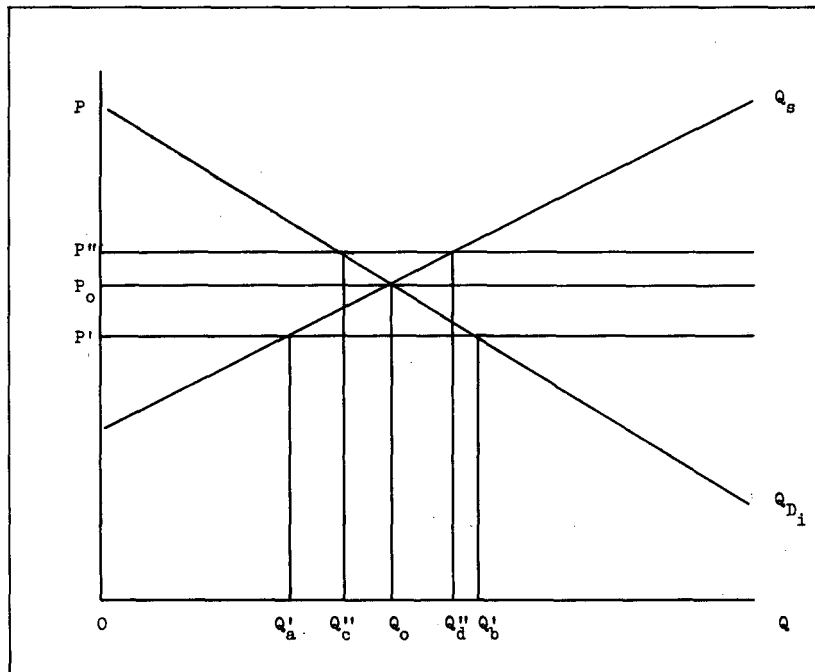
On a more macro level, generalizations are less facile. It is possible that the model presented in (24) can be reworked into a more general equilibrium setting, aggregating individual firm behavior into industries. If the industry acts as a cartel, (24) is applicable. Also, to the extent that an industry may be dominated by a monopolistic firm such as described in this paper, the model will apply in analyzing the behavior of the industry. The estimation of the production function under such conditions, however, becomes difficult. Similarly, if we fit, for example, a CES production function for a particular multifirm industry, it is by no means certain that the estimated function represents that of a "typical" firm.

An alternative, aggregate model can be formulated for a product market, replacing the assumption of imperfect competition with that of a perfectly competitive market. Without market intervention such competitive conditions imply that domestic and external market prices are now the same. Assume the demand and supply relationship shown in Figure II. 2. As before foreign demand and supply are assumed to be perfectly elastic. With the exchange rate implied by the foreign price  $P'$  the external market is willing to absorb or supply unlimited amounts of the product. With  $P'$  without import restrictions amount  $OQ'_a$  would be produced domestically and  $Q'_a Q'_b$  imported. With import restrictions equal in magnitude to  $P' P_0$  no imports would take place and domestic production would be  $OQ_0$  sold at price  $P_0$ .<sup>2</sup> Assume that tariff and/or exchange policy never allow

<sup>1</sup> Another alternative would be to scrap the marginal analysis of (24) and set the problem in a programming framework. Since  $P_1$  is taken to be a declining function of  $Q_1$ , a non-linear program would be required.

<sup>2</sup> For an analysis of import substitution within this general framework the reader is referred to Stephen R. Lewis Jr., *Economic Policy and Industrial Growth in Pakistan*, London, 1969, pp. 23 sqq.

Figure II. 2



imports to occur, i. e., that the effective import price is not permitted to fall below  $P_0$ .<sup>1</sup> The difference between  $P_0$  and  $P'$ , i. e., the spread between the domestic and international prices, presumably could be measured - possibly by the height of the tariff. As long as the local currency foreign price is below  $P_0$ , there will be no exports.

Devaluation raising  $P$  to say  $P''$  will have the effect of promoting exports. In Figure II. 2 increasing  $P$  to  $P''$  results in  $OQ_c'$  domestic sales and  $Q_c'Q_d'$  exported; the price increase in the domestic market reduces domestic sales and frees more output for exportation. The supply curve above  $P_0$  will determine total production, and the division of total output between domestic and export sales will depend upon the elasticities of supply and domestic demand. In addition to being intuitively obvious from Figure II. 2, this can be demonstrated by the specification of a simple model<sup>2</sup>. Assume

$$Q_1 = Q_1(P, Y_d) = \alpha_0 + \alpha_1 P + \alpha_2 Y_d$$

$$Q_S = Q_S(P) = \beta_0 + \beta_1 P$$

(27)

$$Q_D \equiv Q_1 + Q_2$$

$$Q_D \equiv Q_S$$

<sup>1</sup> It is of course possible to relax this rather extreme assumption of zero imports. Such relaxation, however, does not appreciably affect the thrust of our argument.

<sup>2</sup> This is developed in Chapter I.

where

$Q_S$  = quantity supplied

$Q_D$  = total quantity demanded

$P$  = local currency price, exogeneously determined

$Y_d$  = domestic market income

and, as before

$Q_1$  = domestic market sales

$Q_2$  = exports.

Equating total demand and supply and solving for  $Q_2$ , we have the export function

$$(28) \quad Q_2 = \beta_0 - \alpha_0 + (\beta_1 - \alpha_1)P - \alpha_2 Y_d$$

from which the export elasticity with respect to a change in the exchange rate ( $P$ ) can be estimated.

Consistent with the analysis leading to the development of (24) we can specify a supply function for profit maximizing firms. Aggregating all firms producing the product in question, we can still utilize the concept of a profit maximizing profit function subject to the constraint imposed by the industry's aggregate production function<sup>1</sup>. From such a profit function a supply function can be developed which can be incorporated into the model (27) to derive an alternative expression for (28). The Lagrangian expression for industry's aggregate profit function can be written as

$$(29) \quad \pi_\lambda = PQ_S - rK - wL - \lambda [Q_S - f(K, L)]$$

Setting the first partial derivatives equal to zero, as above in (17), we have the first order conditions

$$\frac{\partial \pi_\lambda}{\partial Q_S} = P - \lambda = 0$$

$$(30) \quad \frac{\partial \pi_\lambda}{\partial K} = -r + \lambda f_K = 0$$

$$\frac{\partial \pi_\lambda}{\partial L} = -w + \lambda f_L = 0$$

$$\frac{\partial \pi_\lambda}{\partial \lambda} = Q_S - f(K, L) = 0$$

<sup>1</sup> We do not deny that there are problems of aggregation; for the purposes of building a model for a single product market we have chosen to ignore such problems. We are also assuming the identity of a product market and an industry. A discussion of the aggregation problem is available in Henri Theil, *Linear Aggregation of Economic Relations*, Contributions to Economic Analysis, 6, Amsterdam, 1954.

where, as before,  $\lambda$  is interpreted as marginal cost. The second order conditions for a profit maximum require increasing marginal costs and convexity in the isoquants of the production function<sup>1</sup>. The specification of a production function along with its quantitative estimation would allow us to express  $Q_S$  in terms of  $P$ . This supply function can be substituted into (27), enabling us to re-estimate the export supply function (28). Again, provided we have estimates of the domestic demand function, we predict export response to changes in the exchange rate when the new  $P > P_0$ . Introducing small changes into our first order conditions it would be possible to develop a system similar (and simpler) to (24).

As with (24) the problems are the same. The second order conditions require increasing marginal costs and convexity in the isoquants of the production function. The rising marginal cost criteria can not be satisfied by the constant returns to scale, Cobb-Douglas or CES production functions. As before, there is also the problem of distinguishing between the short and long term.

In applying (24) or an alternative aggregated model a few generalizations can be made. The degree to which capital and labor can be substituted will determine the shift of the firm's marginal cost curve given a change in factor prices. Generally and under ceteris

<sup>1</sup> Formally, second order conditions for a profit maximum require that the principal minors of the relevant bordered Hessian determinant alternate in sign beginning with the negative. The bordered Hessian is:

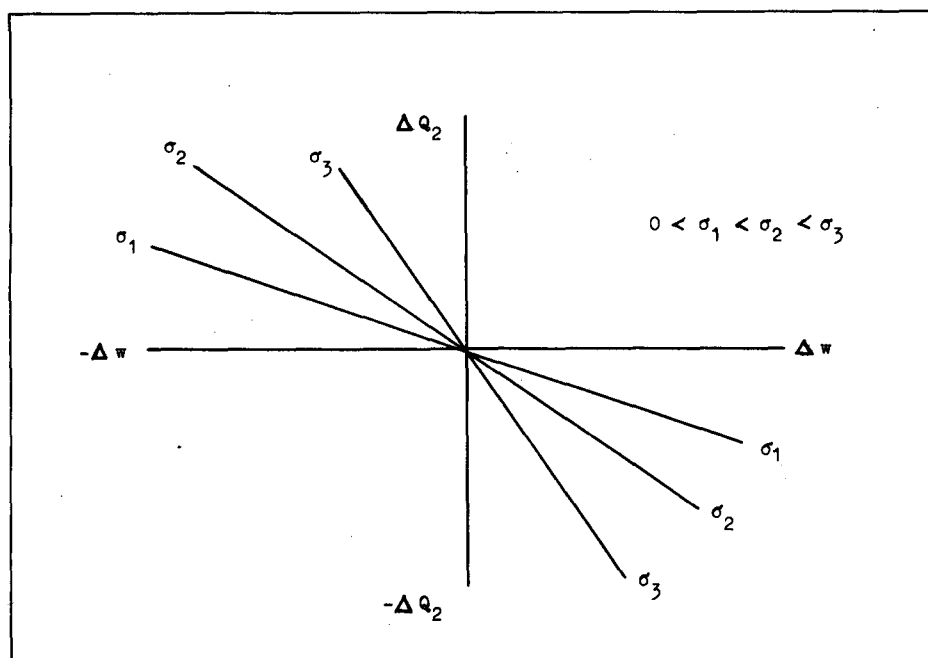
$$|\bar{H}| = \begin{vmatrix} -\lambda' & -\frac{\partial \lambda}{\partial K} & -\frac{\partial \lambda}{\partial L} & -1 \\ \lambda f_{KK} + f_K \lambda' & \lambda f_{KK} + f_K \cdot \frac{\partial \lambda}{\partial K} & \lambda f_{KL} + f_K \cdot \frac{\partial \lambda}{\partial L} & f_K \\ \lambda f_{LL} + f_L \lambda' & \lambda f_{LK} + f_L \cdot \frac{\partial \lambda}{\partial K} & \lambda f_{LL} + f_L \cdot \frac{\partial \lambda}{\partial L} & f_L \\ -1 & f_K & f_L & 0 \end{vmatrix}$$

To assure  $d^2\pi$  is negative definite it is required that  $|\bar{H}_1|$ ,  $|\bar{H}_3| < 0$  and  $|\bar{H}_2|$ ,  $|\bar{H}_4| > 0$ . An examination of the first principal minor  $|\bar{H}_1| = -\lambda'$  indicates that marginal cost must be increasing at the relative maxima. Expanding the second principal minor we have

$$\begin{aligned} |\bar{H}_2| &= -\lambda' (\lambda f_{KK} + f_K \cdot \frac{\partial \lambda}{\partial K}) - (-\frac{\partial \lambda}{\partial K}) (\lambda f_{KK} + f_K \lambda') \\ &= -\lambda' \lambda f_{KK} + \lambda f_{KK} \cdot \frac{\partial \lambda}{\partial K} \end{aligned}$$

For  $|\bar{H}_2| > 0$  it can be seen that it is required that  $\frac{\partial \lambda}{\partial K} > \lambda'$ . Without further expansion we assert without proof that the production function must be strictly concave at the point where the first order conditions are satisfied. For the proof of a somewhat simpler case see Henderson and Quandt, op. cit., p. 68.

Figure II. 3



paribus conditions, the larger the elasticity of substitution ( $\sigma$ ) the greater will be the increase in exports given a decrease in the wage rate (or the interest rate), for instance. This relationship is presented in Figure II. 3. One complicating factor is that the elasticity of substitution is most likely to be lower in the short run than during a longer period in which fuller adjustment can be made. Assuming the acceptance of the strong factor intensity thesis across industries<sup>1</sup>, ceteris paribus with a wage rate decrease the most labor intensive industries will experience the largest decreases in their marginal costs, enabling them to expand their exports relative to the more capital intensive industries. Differences in elasticities of substitution, however, can offset this relative advantage for the labor intensive industry.

The incorporation of factor price changes into the system (24) is particularly relevant given the factor market distortions that seem to accompany import substituting industrialization in the less developed countries. Policies in those countries, designed to spur industrialization, frequently have the effect of increasing the wage rates for unskilled labor and reducing the interest rate. Interest rate subsidies are especially high for certain privileged activities, which in turn are generally capital intensive in nature. The increase in the  $\frac{w}{r}$  factor price ratio has effects not only on the employment of labor but on the amount of exports as well, as can be seen in our static model of profit maximizing behavior for an individual monopolistic firm.

<sup>1</sup> The strong factor intensity argument is not necessarily inconsistent with factor substitutability (and therefore the use of the CES production function where  $\sigma > 0$ ). Much depends upon where the economic boundaries of the isoquants are drawn. Some support for the strong factor intensity argument is provided by a comparison of the U. S. and Brazilian industrial sectors. Ranking the industries of each country by value added per employee - a proxy for capital intensity- the resulting Spearman rank correlation coefficient was .84. The ranking is quite comparable despite far greater absolute levels of capital intensity in American industries. See William G. Tyler, "Factor Proportions in Brazilian Industrial Exportation", *Revista Brasileira de Economia*, Vol. XXIV, Rio de Janeiro, 1970, No. 1, pp. 129 sqq.



The distortion in factor prices (an increase in  $\frac{w}{r}$ ) has several overall effects for a less developed, industrializing economy. First, it results in more capital intensive production in all industries, thereby hampering the absorption of labor. Second, it favors those industries that are inherently more capital intensive. Third, the artificial cheapening of capital tends to result in inefficient capacity underutilization<sup>1</sup>. Fourth, factor market distortions have a tendency to affect the country's export of manufactured goods. Such resource misallocation may affect the pace of development (as well as its nature). The first three of these effects of the policy-induced factor market distortions are well known, but the fourth has not been widely commented upon<sup>2</sup>. Distortions which increase the relative price of labor ( $\frac{w}{r}$ ) serve to penalize those industries producing more labor intensive commodities and favor those producing more capital intensive goods. Export promotion measures, e. g., a real devaluation, will be most successful in promoting the more capital intensively produced goods. To attain a certain increase in export ( $Q_2$ ) given the factor market distortions, a devaluation, i. e., an increase in  $P_2$ , will have to be larger than that required in the absence of the factor market distortions.

The tendency of factor market distortions, given the artificial cheapening of capital, to generate excess capacity also has an effect on the commodity composition of exports, reinforcing the direct factor market distortion effect on exports. Some recent empirical work has provided support for the belief that capacity underutilization is an important determinant of export behavior in developing, semi-industrialized economies<sup>3</sup>. To the extent that capacity underutilization is positively associated with capital intensity in production<sup>4</sup>, excess capacity in its influence in promoting export activity changes the commodity composition of industrial exports to one more capital intensive in nature.

One might do well to also ponder the growth of exports with factor market distortions. If the country's factor intensity in its manufactured exports is more capital or skill intensive than that predicted by a Heckscher-Ohlin notion of its comparative, its exports may grow at a slower rate than if the country's exports were more consistent with its comparative advantage. Thus, indirectly factor market distortions may affect the growth of exports through their effect on the factor intensity of exports. It is indeed plausible that the slow growth of labor intensive manufactured exports from the countries having pursued vigorous import substituting industrialization is at least partially due to the factor market distortions accompanying the industrialization process.

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<sup>1</sup> See Gordon C. Winston, "Capital Utilization in Economic Development", *The Economic Journal*, Vol. LXXXI, London, 1971, pp. 36 sqq.

<sup>2</sup> William G. Tyler, "Trade in Manufactures and Labor Skill Content: The Brazilian Case", *Economia Internazionale*, Vol. XXV, Genova, 1972, pp. 314 sqq.

<sup>3</sup> See Donges, op. cit. - David Felix, "Import Substitution and Industrial Exporting: An Analysis of Recent Argentine Experience", in: *Fiscal Policy for Industrialization in Latin America*, op. cit. - William G. Tyler, "Manufactured Export Promotion in a Semi-Industrialized Economy: The Brazilian Case", *The Journal of Development Studies*, London, forthcoming.

<sup>4</sup> Unfortunately, I can produce no systematic evidence supporting this assertion. Data on capacity utilization is scarce in less developed countries, and I can find no reasonable inter-industry cross-section. The only evidence, other than theoretical reasonableness, that I can offer is casual empiricism based on interviews with Brazilian manufacturers.

To the extent that the country's growth is dependent upon export growth, factor market distortions take on an added dimension. The elimination of factor market distortions would change the commodity composition of the country's industrial exports to one more labor intensive in character. Presumably, *ceteris paribus* the elimination of these distortions would also result in a larger amount of exports, owing to the larger relative reduction in marginal costs for the producers of the more labor intensive goods than for the makers of capital intensive goods.

Generally, it is assumed that the more capital intensive industries will be associated with a lower elasticity of substitution, and there is some evidence from the United States to support this view<sup>1</sup>. Nevertheless, the generality of these findings has been challenged in empirical production function estimation with Brazilian data, where a positive (albeit weak) association between capital intensity and the elasticity of substitution was found<sup>2</sup>. If there is indeed such a positive association, then there are some rather important implications for the less developed countries. First, there will be a tendency for industrial exports to be still more capital intensive given factor market distortions. The greater ease of the capital intensive industries to substitute capital for labor will result in the commodity mix of manufactured exports changing to one as a whole more capital, or skill, intensive.

Second, the gap between the so-called modern and traditional industries can be expected to become greater. With distortionary increases in the relative price of labor ( $\frac{w}{r}$ ), the more capital intensive industries are more capable of substituting capital for labor, tending to accentuate still further the existing productivity differentials. Third, output growth is likely to be affected as well. Assuming greater relative capital accumulation, it has been argued that with an increase in the elasticity of substitution ( $\sigma$ ) the output rate rises<sup>3</sup>. If more capital intensive industries possess higher, and increasing, elasticities of substitution then it is to be expected that they should grow faster<sup>4</sup>.

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<sup>1</sup> Murray Brown and John S. de Cani, "Technological Changes in the United States, 1950-1960", *Productivity Measurement Review*, No. 29, Paris, 1962, pp. 26 sqq.

<sup>2</sup> William G. Tyler, "Labor Absorption with Import Substituting Industrialization: An Examination of the Elasticities of Substitution in the Brazilian Manufacturing Sector", *Kieler Diskussionsbeiträge (Kiel Discussion Papers)*, 24, October, 1972, p. 8. The estimated Spearman Rank correlation coefficient was + .25.

<sup>3</sup> Murray Brown, *On the Theory and Measurement of Technological Change*, Cambridge, 1966, pp. 24 sq.

<sup>4</sup> By this standard it could be argued that the less developed countries should therefore concentrate on capital and skill intensive industries. However, there is some question as to what extent growth is high because the  $\sigma$ 's are high and to what extent the  $\sigma$ 's are high because growth is high.

## Chapter III

### On the Measurement of Import Substitution and Export Expansion as the "Sources" of Industrial Growth

In a well known article<sup>1</sup> Hollis Chenery presented a measure of import substitution from which an identity measure of the "sources" of growth for an industry can be derived. This identity is

$$(1) \quad \Delta X_i = \frac{X_i^1}{Z_i^1} \cdot \Delta D_i + \frac{X_i^1}{Z_i^1} \cdot \Delta E_i + \left( \frac{X_i^2}{Z_i^2} - \frac{X_i^1}{Z_i^1} \right) Z_i^2$$

where

$X_i$  = industry's total output

$M_i$  = imports

$Z_i = X_i + M_i$  = total available supply

$D_i$  = domestic intermediate and final demand

$E_i$  = exports

and where the superscripts indicate two different time periods. Dividing (1) through by  $\Delta X_i$ , the "sources" of industrial growth can be estimated<sup>2</sup>. The first and second terms on the right hand side of (1) indicate growth attributed to domestic demand growth and to export expansion, while the third term represents a proportional measure of import substitution ( $IS_i$ ).

<sup>1</sup> Hollis B. Chenery, "Patterns of Industrial Growth", *The American Economic Review*, Vol. L, Menasha, Wisc., 1960, pp. 624 sqq.

<sup>2</sup> Utilizing this measure are a number of recent studies. See Jaleel Ahmad, "Import Substitution and Structural Change in Indian Manufacturing Industry 1950-1966", *The Journal of Development Studies*, Vol. IV, London, 1968, pp. 352 sqq. - Hollis B. Chenery, Shuntaro Shishido, and Tsunehiko Watanabe, "The Pattern of Japanese Growth, 1914-1954", *Econometrica*, Vol. XXX, New Haven, Conn., 1962, pp. 98 sqq. - J. B. Donges, "Shaping Spain's Export Industries - Experience, Problems, Prospects", unpublished paper. - George Fane, "Import Substitution and Export Expansion. Their Measurement and an Example of Their Application", *The Pakistan Development Review*, Vol. XI, Karachi, 1971, pp. 1 sqq. - Donald Huddle, "Postwar Brazilian Industrialization: Growth Patterns, Inflation, and Sources of Stagnation", in: *The Shaping of Modern Brazil*, Ed. by Eric N. Baklanoff, Baton Rouge, 1969, pp. 86 sqq. - Steven R. Lewis Jr., and Ronald Soligo, "Growth and Structural Change in Pakistan's Manufacturing Industry, 1954-1964", *The Pakistan Development Review*, Vol. V, 1965, pp. 94 sqq. - D. Steuer and C. Voivados, "Import Substitution and Chenery's Patterns of Industrial Growth, A Further Study", *Economia Internazionale*, Vol. XVIII, Genova, 1965, pp. 47 sqq.

In a more recent contribution Morley and Smith have demonstrated that the Chenery import substitution measure is likely to understate the actual amount of import substitution owing to the failure of the measure to adequately account for the intermediate effects<sup>1</sup>. This is especially the case for a semi-industrialized country, like Brazil, that exhibits substantial industrial interdependence. To reflect the effects of intermediate demand Morley and Smith have devised an alternative measure, which can be written as

$$(2) \quad IS_i^* = \left( \frac{X_i^2}{Z_i^{2*}} - \frac{X_i^1}{Z_i^{1*}} \right) Z_i^{2*}$$

where in matrix notation

$$\mathbf{Z}^* = \mathbf{X} + \mathbf{M}^*$$

$$\mathbf{M}^* = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{M} = \text{a vector of redefined imports}$$

$$\mathbf{A} = \text{matrix of technical coefficients } a_{ij}$$

The vector of redefined imports  $\mathbf{M}^*$  can be interpreted as necessary domestic production that would be required to completely substitute for imports if final demands were to remain constant.

Just as the neglect of the intermediate effects of import substitution of the Chenery measure tends to understate the growth attributed to import substitution, the use of (1) may also understate that growth accounted for by export promotion. In that export expansion is clearly of importance to less developed countries, inclusion of an adequate measure of its contribution to growth is highly desirable. A modification of the Morley-Smith framework provides such a measure. In matrix notation we have the identity

$$(3) \quad \mathbf{X} + \mathbf{A}\mathbf{X} = \mathbf{H} + \mathbf{E} - \mathbf{M}$$

where  $\mathbf{H}$  is a vector of final domestic demand. From (3) we derive

$$(4) \quad \mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{H} + (\mathbf{I} - \mathbf{A})^{-1} \mathbf{E} - (\mathbf{I} - \mathbf{A})^{-1} \mathbf{M}$$

Similar to the expression for redefined imports,  $\mathbf{M}^* = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{M}$ , we can speak of redefined exports  $\mathbf{E}^*$  where

$$\mathbf{E}^* = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{E}$$

The vector  $\mathbf{E}^*$  represents that total amount of production attributed to exports<sup>2</sup>. Combining the Chenery and modified Morley-Smith approaches we have

<sup>1</sup> Samuel A. Morley and Gordon W. Smith, "On the Measurement of Import Substitution", *The American Economic Review*, Vol. LX, 1970, pp. 728 sqq.

<sup>2</sup> A similar reformulation for redefined domestic demand is unnecessary, since domestic demand  $\mathbf{D}$  already comprises both final and intermediary demand. In other words,

$$\mathbf{H}^* = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{H} = \mathbf{D}$$

$$(5) \quad \Delta X_i = \frac{X_i^1}{Z_i^{1*}} \cdot \Delta D_i + \frac{X_i^1}{Z_i^{1*}} \cdot \Delta E_i^* + \left( \frac{X_i^2}{Z_i^{2*}} - \frac{X_i^1}{Z_i^{1*}} \right) Z_i^{2*}$$

The term for domestic demand  $D$  in (1) and (5) can be considered a residual. The upward bias in growth attributed to domestic demand growth in (1) is eliminated in (5) with the introduction of the Morley-Smith measure of import substitution and our adjustment for export promotion. Clearly, for the economy as a whole, changes in export composition as well as in export volume will be important in determining the contribution of export expansion to the economy's overall industrial growth. In other

words, the sum of redefined exports  $\sum_j E_i^*$  may undergo a change with a constant  $\sum_j E_i$  with a change in export composition. For example, a shift in the export composition to one of greater intermediate effects can conceivably play an important role in growth from the demand standpoint.

It should be born in mind that the Chenery identity (1) and its modifications (5) are descriptive measures of an *ex post* nature on the demand side. They provide more in the way of a description as to what happened than analyzing why it happened. Furthermore, any such measures neglect secondary income effects. Increases in income are spent in part on domestically produced manufactured products. The greater the level of industrialization and domestic output as a percentage of total supply (however defined) the greater will be the tendency to attribute the secondary income effects to domestic income growth. Export expansion or import substitution increase domestic incomes but the expenditure of these incomes on domestically produced manufactures is reflected as an expansion of the internal market. Nothing is said about what enabled incomes to expand initially. Thus, in both (1) and (5) the growth "attributable" to domestic market expansion is overstated and that "accounted for" by either export promotion or import substitution understated.

For the aggregated industrial sector (but not for individual sectors) the secondary income effects can be incorporated by the use of Keynesian multiplier concepts. Assume an income multiplier  $k$ , i. e.,

$$k = \frac{1}{1 - (1 - t)(c - m)}$$

where  $t$ ,  $c$ , and  $m$  respectively represent the economy's marginal propensities to tax, consume, and import. Redefining  $c$  and  $m$  to represent the marginal propensities to consume and import only manufactured goods, we have a redefined, smaller multiplier  $k^*$ . We can write

$$(6) \quad k^* = \frac{1}{1 - (1 - t)(c^* - m^*)}$$

where  $c^*$  and  $m^*$  are the redefined marginal consumption and import propensities as related to manufactures. The redefined multiplier  $k^*$  can be interpreted as the income multiplier for industrial output. From (6) it is apparent that countries with lower  $m$ 's, as a result of previous substitution or other factors, will possess larger

$k^*$ 's than more open economies with larger  $m$ 's. Incorporating  $k^*$  into aggregated (5) and dividing through by the change in total industrial output  $\Delta X$  we have

$$(7) \quad \frac{\Delta X}{\Delta X} = \frac{X^1}{Z^{1*}} \cdot \frac{\Delta D'}{\Delta X} + \frac{X^1}{Z^{1*}} \cdot k^* \cdot \frac{\Delta E^*}{\Delta X} + \left( \frac{X^2}{Z^{2*}} - \frac{X^1}{Z^{1*}} \right) \cdot k^* \cdot \frac{Z^{2*}}{\Delta X}$$

where  $\Delta D'$  is the modified domestic increase, calculated as a residual, and where, to avoid double counting in the aggregation,  $X$  and  $Z^*$  are now defined in value added terms. Using (7) to identify the "sources" of industrial growth can help avoid consigning the secondary income generation effects of export promotion or import substitution to the growth of the domestic market<sup>1</sup>. Conceivably, by closing the input-output system one could use a modification of (7) to measure the effects of export promotion and import substitution in each sector<sup>2</sup>.

While it is of course preferable to have two comparable (and good quality) input-output tables for both the early and later periods, it is clear that such ideal conditions are not generally available for the researcher. In this case the later input-output table would seem to be preferable. Implicit in the use of a single input-output table to measure redefined imports and exports in two time periods involves a number of familiar assumptions. Changes in product mix, the technical coefficients, and factor prices are all ruled out by assumption. The longer the period under examination the less likely it is that such conditions will prevail.

The basic open input-output framework can also be utilized to examine the employment effects of import substituting and export promoting activities where labor is considered abundant and labor absorption an important policy objective. Employment increases can be thought to proceed *pari passu* with output growth. If, for example, import substitution in a particular industry accounts for, say, 20 percent of output growth during a certain time period, import substitution can also be considered to account for 20 percent of the observed employment increase. Direct use of the input-output framework, however, can provide additional insights into the employment effects of growth. The required labor intensity to produce one unit of final demand is given by

<sup>1</sup> A simple illustration can be used to indicate the magnitude of  $k^*$ . Assume

$$\begin{aligned} t &= .2 \\ c &= .9 \\ m &= .1 \end{aligned}$$

The normal income multiplier  $k$  is then equal to 2.78. Further assume that one half of all increases of consumption expenditures go for manufactured goods. Thus,  $c^* = .5 \times .9 = .45$ . Assuming all increases of imports are for manufactured goods, we have  $m^* = m = .1$ . The redefined income multiplier  $k^*$  is then calculated to be 1.39. Under such reasonable assumptions this indicates that failure to consider the secondary income effects emanating from either export expansion or import substitution can substantially underestimate their contributions as "sources" of industrial growth.

<sup>2</sup> The contribution of export expansion to industrial growth may still be understated for another reason. To the extent that the growth of industrial production is constrained on the supply-side by an import constraint, the generation of foreign exchange through export expansion alleviates such a constraint.

$$r_{Lj} = \sum_i l_j r_{ij}$$

where

$$l_j = \frac{L_j}{X_j} = \text{sector's labor output ratio (direct use of primary factor L in sector j)}$$

$$r_{ij} = \text{total direct and indirect use of commodity i by sector j (element in inverse Leontief matrix derived from a domestic transactions matrix).}$$

In matrix notation we have

$$\mathbf{r}_L = [(\mathbf{I} - \mathbf{A})^{-1}]^T \mathbf{l}$$

or

$$\mathbf{r}_L = \mathbf{l}(\mathbf{I} - \mathbf{A})^{-1}$$

The resultant  $\mathbf{r}_L$  vector represents the total direct and indirect labor requirements to produce a unit of final product for each sector. Each  $r_{Lj}$  is an employment multiplier. The employment effect is obtained by multiplying the sector's final demand change by the relevant  $r_{Lj}$ . Using such a methodology one can analyze the comparative employment effects of import substitution and import promotion. Also, the effects of changes in import and export composition can be examined. Since the interrelatedness of the economy affects the magnitude of  $r_{Lj}$ , it is not at all clear that the export expansion of labor intensive manufactures will have the greatest employment effects.