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# Disequilibrium Estimation of Developing Country Exports*

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## Summary

The major objective of this paper is to investigate export flows of developing countries, taking into account both supply behavior and the possibility of market disequilibrium. Previous estimates of export flows have usually focused on demand rather than supply relationships, on the grounds that the price elasticities facing any individual country are infinite, and these estimates have been based on the assumption of market equilibrium. Once this assumption is dropped, each observation may be regarded as reflecting equilibrium, excess demand, or excess supply. The estimation technique utilized in this context, based on the assumption that the short side of the market determines the quantity transacted, allows us to estimate a model for data in which some of the observations are on the export supply function of the developing country and some observations are on the export demand function of the partner countries.

The disequilibrium model is estimated for the exports of seven developing countries and for the group of non-oil developing countries. The coefficient estimates are fairly well-determined, and the empirical results offer evidence in support of the hypothesis that the export market is not in continuous equilibrium. In agreement with earlier studies, it is found that exports are price elastic. The coefficients of the income variables are statistically significant, but there are considerable differences in income elasticities across countries. The model estimates the probability that a given data point is generated by an excess demand or excess supply regime. For the seven developing countries, as well as for the group of non-oil developing countries, there were episodes of both excess supply and excess demand in the sample period. Such information is useful for addressing policy issues, including quantitative restrictions on exports and macroeconomic adjustment under price rigidities.

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## I. Introduction

This study represents the first attempt to estimate elasticities of supply and demand for developing country exports, taking into account the possibility of market disequilibrium. In sharp contrast to the traditional econometric analysis of developing country export behavior that uses single equation models, the model presented here consists of simultaneous supply, demand, and market rationing relationships. An important advantage of the disequilibrium approach is that consistent estimates of elasticities are obtained for export markets that do not clear. Another advantage of this approach is that it permits estimation of the probability that a given data point is generated by excess demand or excess supply.

In equilibrium models, the observed quantities are at the intersection of supply and demand schedules, whereas some of the most interesting policy problems arise because markets do not clear. A model that assumes equilibrium obviously cannot be used to test whether there has been any excess demand or excess supply. Once the assumption of continuous market equilibrium is dropped, each observation reflects either equilibrium or excess demand. 1/ If supply and demand are not always equal, and the short side of the market determines the quantity transacted, then we need to utilize the techniques developed in disequilibrium econometrics to estimate the structural parameters. An application of disequilibrium econometrics to the supply and demand for developing country exports is provided in this paper. The estimation technique allows us to estimate a model for data in which some of the observations are on the export supply function of the developing country and some observations are on the export demand function of the partner countries.

The disequilibrium model was estimated for the exports of seven developing countries and for the group of non-oil developing countries. In agreement with earlier studies, it is found that exports are price elastic. The coefficients of the income variables are statistically significant but there are considerable differences in income elasticities across countries. The empirical results support the hypothesis that the export market is not in continuous equilibrium. The disequilibrium model also sheds some light on the issue of nontariff barriers in industrial countries and the exports of developing countries.

The paper is organized as follows. Section II contains a brief discussion of the market for exports of the developing countries. Section III discusses the nonclearing market hypothesis for developing country exports. Section IV presents the results of the estimation,

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1/ Excess supply can be represented as negative excess demand.

while Section V provides a discussion of the results and their policy implications. Finally, Section VI presents some concluding observations and suggestions for future research. Appendix I discusses the estimation technique, and Appendix II provides a description of the data base.

## II. Supply and Demand for Developing Country Exports

Previous empirical models of developing country exports have estimated the export supply side of the market separately from the export demand side. One strand of research has emphasized the supply-side determinants of developing country exports, such as the growth of gross domestic product, domestic prices, taxes, and subsidies. The other strand of research has emphasized the demand-side determinants of exports, such as income growth in industrial countries and the relative price of exports. There has been no research on developing country exports comparable to the simultaneous equation models for industrial country exports by Magee (1970), Goldstein and Khan (1978), and Dunlevy (1980). 1/

Contributions to the literature on the relationship between developing country exports and supply-side variables include: Balassa (1978a, 1978b), Bhagwati (1978), Krueger (1978), Teigeiro and Elson (1973) and Tyler (1981). These studies are concerned in one way or another with price competitiveness in the exporting countries and the volume of exports. They argue that low growth rates for exports are due primarily to domestic supply problems, often induced or aggravated by incorrect domestic policies, rather than to lack of external demand. Both the time series econometric work and the country studies show that exchange rates explain at least a part of export growth rates. While the supply response may be weak in the short run, these studies show a significant and substantial long-run positive supply response. The major limitation of these studies is their neglect of the demand-side determinants of exports, such as demand for imports in industrial countries or prices in competitor countries. The argument advanced for neglecting the demand-side variables is that the typical developing country is small and faces an infinitely elastic demand for its exports, so that changes in foreign demand influence exports only through world prices.

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1/ Although work by Chu and Morrison (1985) is suggestive in this regard. Their model traces the historical movements of commodity prices fairly closely, and indicates that industrial production and domestic prices, adjusted for exchange rate changes, have been major factors undelying commodity price fluctuations since the early 1970s. Their study analyzes short-term supply-side factors--such as changes in domestic prices and exchange rates of exporting countries--as well as demand side variables--such as changes in economic activity, domestic prices and exchange rates of importing countries.

Studies that have examined the relationship between developing country exports and demand-side variables include: Rhomberg (1968), Deppler and Ripley (1978), Houthakker and Magee (1969), and Khan (1974). The results of these studies suggest that real income in importing countries and price competitiveness in exporting countries are the principal determinants of developing country exports. In these studies, price elasticities of demand have generally been estimated under the assumption of infinite price elasticities of supply. This assumption is justified by arguing that when exporters are operating at less than full capacity, changes in output occur without changes in price. An exporter will not raise prices in an expanding market until capacity has been reached by its competitors, because this will price it out of the market. On the other hand, when demand slackens, exporters reduce production rather than price because they fear the reaction of their competitors.

The assumption that the price elasticity of export supply is infinite has been frequently criticized in the literature. As far back as 1950, Orcutt demonstrated that price elasticities in trade relationships can be seriously biased by simultaneity between prices and quantities. Since the relationship between prices and quantities may be due to supply factors or to demand factors, the estimated price elasticity by ordinary least squares method would be a weighted average of a negative demand elasticity and a positive supply elasticity. When the price elasticity of export supply is not infinite, the single equation estimation of the demand elasticity is biased toward zero.

Bond (1985) estimated a model of export quantity flows from the non-oil developing countries to importing countries that specifies the effects of both the level of world economic activity and domestic pricing policies on export growth. Export volume flows were modeled for groups of exporting non-oil developing countries and groups of importing countries. The results of this study indicate that growth in the importing countries is in general the most important determinant of exports from non-oil developing countries, but that exchange rate policies can also be used to increase exports. Although this study contains both demand- and supply-side determinants of exports, the structural equations were not estimated by simultaneous equation methods. The estimated parameters were those of a reduced-form equation that is overidentified, and the estimates of neither demand nor supply price elasticities can be obtained. This model was constructed to answer more broadly-based policy questions relevant for groups of deveoping coountires than would be possible from a model based on an individual developing country. Examples of the type of policy questions that can be answered from Bond's model are: by how much does devaluation by a group of exporting countries increase their exports; and by how much do changes in aggregate demand in importing countries affect the exports of groups of non-oil developing countries. This paper, by focusing on export market disequilibrium for an individual developing country, can be viewed as a complement to Bond's study.

It will be helpful first to describe the simultaneous-equations equilibrium model of exports that is referred to in the trade literature as the imperfect substitutes model. The demand specifications in this model are based on the assumption that traded goods produced domestically are imperfect substitutes for those produced in other countries. The disequilibrium counterpart of this model is considered in the following section. The simple imperfect substitutes model for developing country exports to the industrial countries is specified in equations (1) through (4). The equations include industrial country demand for developing country exports, the supply of exports by developing country, the market-clearing equilibrium condition, and the relative price equation.

$$(1) \quad X^d = f_1(Y^*, PX^*, P^*)$$

$$(2) \quad X^s = f_2(Y, PX, P)$$

$$(3) \quad X^d = X^s$$

$$(4) \quad PX^* = e(1+t)PX$$

The variables are $X^d$, the quantity of developing country exports demanded by the industrial country; $X^s$, the quantity of exports supplied by the developing country; $PX^*$, the price of developing country exports facing demanders in the industrial country; PX, the export price received by suppliers in the developing country; $Y^*$, the income or activity variable in the industrial country; $P^*$, the price of substitutes in the industrial country; Y, the gross domestic product in the developing country, which is a proxy for productive capacity; P, the price of goods sold in the developing country; e, the foreign exchange rate (industrial country currency/developing country currency); and t, the proportional tariff rate which also includes transport costs, insurance, and other differences between the price received by the developing country supplier and the price paid by the demander in the industrial country.

The scale or activity variable that is often used in export supply and demand functions is gross national product. Gross domestic product and the manufacturing production index series have also been used in previous research. Since these variables move so closely together over time, no important difference in results is obtained by using one or the other. In this study, gross domestic product was used for the developing countries and the manufacturing production index for the industrial countries. However, in the empirical measurement of the relative price variable in the

export supply and demand functions, the well-known aggregation problem was encountered. The only export prices that were available for the developing countries studied were unit value series. Since aggregation takes place in the computation of unit values, this series is consistent over time only if the composition of exports remains the same over the sample period or if the net effect of such changes is insignificant. Otherwise, the unit value errors would be inversely correlated with the errors for export volumes, because the volume of exports index is obtained by deflating total values by unit values. This aggregation problem is discussed in detail in Section IV, where the estimation results are reported.

## III. The Market for Developing Country Exports in Disequilibrium

In the imperfect substitutes model that was discussed in the previous section, the observed quantity of exports is given by the intersection of the supply and demand schedules. The endogenous variables are the observed quantity of exports, which is equal to both supply and demand, and the relative price of exports, which is the market equilibrating variable. However, there is some evidence that prices are slow to adjust to their market-clearing levels and exports fluctuate a great deal over the business cycle. The high variability of exports occurs in both industrial and developing countries and is due to variations in demand as well as supply. When export prices are relatively slow to adjust in the short run, then nonprice rationing, trade credit terms, discounts, and relative waiting times become important determinants of exports. Several studies have attempted to incorporate the short-run rationing devices into empirical export equations. These studies have been confined to industrial country experiences, probably because of data availability.

In an early paper, Steuer et al. (1966) showed that independent of relative prices, the relative waiting time between the export order and delivery was a significant variable in the machine tool industries of United States, United Kingdom, and Germany. Artus (1973) investigated the export production behavior of machinery industries, providing further evidence for delivery delays. With regard to the effect of cyclical swings on the demand for exports, Gregory (1971) estimated U.S. import equations that capture the impact on U.S. imports of changes in supply conditions. These equations included nonprice rationing variables that are not adequately represented in price movements. He was expressly interested in the proposition that, in the short run, producers do not adjust their prices to meet fluctuations in demand but use waiting times, credit terms, and other nonprice methods to make fluctuations in demand correspond to their supplies. Gregory's estimation results support the hypothesis that the allocation of resources between domestic and foreign goods is responsive to variations in the nonprice rationing variables.

Gregory modifies the standard export demand equation by treating the price of exports as a vector possessing many dimensions, of which one is the actual quoted price and others are short-run rationing devices such as waiting time, trade credit terms, and rebates, etc. The major difficulty with this approach is that not all of the elements of the augmented price vector are observable. In some instances, such as the relative waiting time, the elements are measurable in principle but data series are frequently not available. In other instances, such as the general enthusiasm on the part of sellers for new orders, the elements are not directly observable. Therefore, proxy variables are needed to take account of these variables in the estimation procedure. But the relationships between the various elements of the augmented price vector may be too complex for their variation to be approximated by proxy variables.

When the export supply is rationed through techniques such as longer order-delivery lags and tighter customer credit conditions, the quantity demanded is lower. If the estimated export demand equation does not include the rationing factor, then the quantity movements caused by both factors will be attributed to the price variable alone. This leads to an overstatement of the price effect and an upward bias in the estimated price elasticity of export demand. The bias equals the true coefficient of the omitted variable multiplied by the regression coefficient of the excluded variable on the included variable. Furthermore, the bias will not disappear even if the sample is increased, so that the omission of a variable from the true model will also yield inconsistent parameter estimates. The only case in which the bias and inconsistency will disappear occurs when the omitted variable is uncorrelated with the included independent variable; but export prices and nonprice rationing are correlated.

In this section, the disequilibrium model for developing country exports is formulated. In the model that is specified, either buyers or sellers may encounter quantity constraints. When prices do not adjust quickly enough to equate the demand for and the supply of exports in period t, then it is assumed that the quantity sold is given by the minimum of supply and demand (the "min condition"). The min condition derives its justification from the principle of voluntary exchange; that is, no buyer can be forced to buy more than he demands, nor can any seller be forced to sell more than he wishes to sell. This formulation has the advantage of permitting simultaneous estimates of export demand and supply functions for developing countries. Since the structural equations are estimated directly, estimates of both the demand and supply elasticities are obtained. Moreover, in contrast to earlier studies, the formulation takes explicit account of the possibility of market disequilibrium. The econometric model is the following:

$$X_t^d = \alpha' x_{1t} + \varepsilon_t \tag{5}$$

$$X_t^s = \beta' x_{2t} + \eta_t \tag{6}$$

$$X_t = \min (X_t^d, X_t^s) \tag{7}$$

The $X_t^d$ term denotes the demand in period t for the developing country export volume, $X_t^s$ is the real supply in period t of developing country exports, and $X_t$ is the actual quantity transacted. The vector of explanatory variables in the export demand equation is $x_{1t}$ and in the export supply equation is $x_{2t}$, and $\varepsilon$ and $\eta$ are stochastic error terms, where $(\varepsilon_t, \eta_t) \sim N(0,\Sigma)$ and are drawn independently with respect to t. The variance-covariance matrix $\Sigma$ is assumed to be diagonal.

Economic theory provides little guidance on either the appropriate functional forms of the export demand and supply functions, or whether lagged values of the variables should be included. Hence the precise specification of export demand and supply equations is largely an empirical issue, and there are numerous papers addressing the issues involved in determining an appropriate specification. 1/ Double-logarithmic equations in this paper have been used because of their generally superior fit in previous studies and their ease of interpretation.

The export demand equation used is of the following form:

$$\log X_t^d = \alpha_o + \alpha_1 \log(Y_t^*/P_t^*) + \alpha_2 \log(PX_t^*/P_t^*) + \alpha_3 \log(X_{t-1}) + \varepsilon_t \tag{8}$$

where $\varepsilon_t$ is a random error term that is independent and normally distributed. Since the equation is specified in terms of logarithms, $\alpha_1$ and $\alpha_2$ represent the short run or "impact," real income and relative price elasticities of export demand, respectively. The parameter $\alpha_1$ is expected to be positive, because an increase in income in the industrial countries raises their demand from all sources, including from the

1/ The issues involved in answering these questions and attempt to solve them have been surveyed in Leamer and Stern (1970), Magee (1975), and more recently, Goldstein and Khan (1985).

developing countries. The parameter $\alpha_2$ is expected to be negative, because when developing country export prices increase faster than import prices from other sources for the industrial countries, then there will be substitution away from developing country exports. 1/

The export supply equation that we estimate is specified as a log-linear function of the relative price of exports (i.e., the ratio of export prices to domestic prices) and of an index of the real gross domestic product of the developing countries (a proxy for productive capacity).

$$\log X_t^s = \beta_0 + \beta_1 \log(Y_t/PY_t) + \beta_2 \log (PX_t/PY_t) + \beta_3 \log(X_{t-1}) + \eta_t \quad (9)$$

In equation (9), $Y_t$ is an index of GDP of the developing countries, $PX_t$ is an index of the export prices of the developing countries in domestic currency, and $PY_t$ is an index of the GDP deflator of the developing countries. The parameters $\beta_1$ and $\beta_2$, which measure the elasticity of export supply with respect to an increase in productive capacity and the relative price of exports, respectively, are expected to be positive.

For greater insight, the effects of factors of production on export supply should be modeled directly rather than via total output as a proxy variable for domestic capacity. This would be more in keeping with the theory of international trade, which relates trade movements to factor movements and relative prices. Thus, export supply could be postulated to be a function of relative prices, capital stock, labor force, and imports. The reason for including imports as a factor of production is that intermediate goods, machinery, and spare parts are a major component of the import bill in many developing countries. The maintenance imports are necessary to keep existing capacity fully utilized, and imports of capital goods are needed for the expansion of industries. However, the developing country data do not provide all the information needed for estimating an export supply equation based on factors of production. The data for capital stock series are especially weak.

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1/ It is customary to express the price of exports and their substitutes in ratio form. But the homogeneity assumption embodied in the price ratio variable has been questioned in some articles. This procedure constrains the influence of the two price variables to be equal in magnitude but opposite in sign. Despite its theoretical justification, this constraint could well be inappropriate in pratice when the index for export unit values and the price index for substitutes are constructed with different weights and/or different formulas. See Murray and Ginman (1976).

The lagged dependent variable occurs in both equations due to intertemporal spillover effects. For example, there are adjustment costs to firms when they alter their production plans. These costs include conventional hiring costs such as acquiring information about the quality of workers, investment in training new workers, and potential loss of goodwill or the cost of breaching an implicit contract. Furthermore, a firm maximizing expected present value does so conditional upon the inherited production position and its expectations concerning the states of all markets in which it trades in the current period and in the future. If there are errors in the expectations-generating mechanism, as well as in carrying out plans, the model should reflect these, as is done in the partial adjustment and adaptive expectations models. Another reason for including the lagged dependent variable is the existence of inventories and considerations of stock and flow interactions. Finally, the export data refer to deliveries and not to production or orders. As a result, the data-generating mechanism inevitably implies lags in the export equations.

Lags are estimated in the Koyck form, even though this form is more restrictive than the general lag structure. In the Koyck form, both the income and price lags must be identical in length and shape, with the weights declining geometrically over time. The Koyck form achieves a major simplification in that only one parameter in relation to the lagged dependent variable is estimated instead of a string of coefficients for lagged independent variables. The Koyck form has also been employed in most previous studies, and this makes it easier to evaluate the disequilibrium modification to the export model that is introduced in this paper.

The econometric problem is to estimate the coefficients of the demand and supply functions for developing country exports. When demand is greater than supply, the observed quantity of exports is on the supply function; whereas when demand is less than supply, the observed quantity of exports is on the demand function. Even if it is known which observation belongs to the demand function and which to the supply function, these equations cannot be estimated by ordinary least squares. The residuals in these truncated samples do not have zero means and they are correlated with the exogenous variables of the model, so that the OLS estimates will be biased. The disequilibrium estimation techniques are discussed in detail in Appendix I.

It is often assumed in models of a market in disequilibrium that there is an equilibrating tendency, but it does not operate with sufficient speed to equate demand and supply within the unit period. Sometimes the Walrasian price adjustment mechanism, where price change is an increasing function of excess demand with a finite speed of adjustment, is added as an explanatory variable to a model of the structure (5)-(7). If there is excess demand, the price rises, and if there is excess supply, the price falls. However, the price $p_t$ does not adjust to equate supply and demand but reacts partially to the market disequilibrium as follows:

$$p_t - p_{t-1} = \gamma_1 (D_t - S_t), \quad \gamma_1 > 0 \text{ if } D_t > S_t$$

$$p_t - p_{t-1} = \gamma_2 (D_t - S_t), \quad \gamma_2 > 0 \text{ if } D_t < S_t \qquad (10)$$

In this formulation, different speeds of price adjustment for periods of excess demand and excess supply are permitted, so that $\gamma_1$ and $\gamma_2$ are not necessarily equal. This procedure has important advantages, because any observable variable that depends in a known manner on excess demand adds valuable information for sample separation; i.e., for determining the probability that a given observation came from a regime of excess demand. 1/ In our context, however, adding a price adjustment equation would not be suitable, because there is no obvious single indicator of excess demand for developing country exports. As mentioned above, there are serious problems with using export unit values as the relative price variable. Furthermore, a poor choice of indicator will give a poor sample separation, and such misspecification will be transmitted to the supply and demand equations.

There are many reasons why export prices differ in equilibrium from domestic prices, including tariffs, subsidies, and transport costs. But stochastic shocks, exchange restrictions, and price controls can cause the actual wedge between domestic and export prices to diverge from the equilibrium. Although this creates supplier arbitrage that would restore the equilibrium, inflation inertia may be strong so that domestic prices are slow to adjust. For example, the "implicit contracting" literature has provided several reasons as to why prices might be rigid in particular circumstances. 2/ The implicit contracting models are rich in institutional details, particularly with respect to transaction costs such as mobility costs for laborers, recruiting costs for firms, etc., upon which many of the results rest.

Some of the more important factors contributing to export market disequilibrium are business cycles in the industrial countries, price rigidities, trade restrictions by industrial countries, and inappropriate financial and exchange rate policies pursued by the developing countries. In particular, trade restrictions by industrial countries can have serious consequences for the exports of the developing countries, because these countries depend on a narrow range of products, and their exports are small relative to the size of markets in the industrial countries. When a successful exporter faces restrictions in his markets, other exporters are discouraged from rapid expansion of sales in those markets because they face the prospect of restrictions if their supply grows too large.

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1/ See Goldfeld and Quandt (1975).
2/ See Baily (1974) and Azariadis (1975).

It is very difficult to quantify nontariff barriers because of their varying forms. The latter include: import licensing arrangements that might be applied with different degrees of restrictiveness; quantitative restrictions in the form of outright prohibitions, import quotas, and voluntary export restraint arrangements; and internal taxes that may discriminate against imports. A further difficulty in assessing the incidence of nontariff measures is that changing supply and demand conditions can over time increase or reduce the restrictiveness of a given nontariff barrier. Experience seems to indicate that perhaps the most important factor influencing the willingness of governments to adopt restrictive trade measures is the cyclical downturn in economic activity and the associated rise in unemployment. 1/ In periods of high unemployment, protectionist pressures tend to increase as industries and workers seek government action to insulate sectors of the economy from import competition. But the stance of trade policies is not always symmetrical in relation to the phases of the business cycle. Protection granted through restraint on imports during periods of rising unemployment is, in practice, difficult to dismantle speedily when economic activity takes an upturn, because industries and workers resist an erosion of existing privileges. 2/ Thus, when the period of recovery is not sustained over relatively long periods, there is a tendency for a ratchet effect in protection. Since the estimation technique employed here permits identification of periods of excess supply for the exports of the developing countries, these periods can be compared with episodes of weak economic activity in the industrial countries in the persistence of excess supply in the developing country export market.

## IV. Estimation Results

The disequilibrium model was estimated by maximum likelihood methods. The likelihood functions of this model are quite complex and are nonlinear in their parameters. Reasonable specifications based on single-equation ordinary-least-squares (OLS) were estimated for the supply and demand functions over the entire sample period, and the parameters for the OLS estimation were used as starting values for the disequilibrium estimation (see Table 1). As was noted earlier, some observations might not lie on either the demand or the supply schedule, and excess demand or supply can therefore be properly observed only when the complete model--consisting of a demand function, a supply function, and the min condition--is estimated by disequilibrium techniques. If observed exports are the minimum of demand and supply, some observations will lie only on the supply

1/ See Clifton (1985).

2/ The reader is referred to Anjaria, et al. (1982) for a discussion of this aspect of protection.

Table 1. Ordinary Least Squares Estimates 1/

| Export Demand | | | | | | Export Supply | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Elasticity | | Lagged | | | | Elasticity | | Lagged | |
| Constant | Income | Price | Exports | $\bar{R}^2$ | Country | Constant | Output | Price | Export | $\bar{R}^2$ |
| 1.23 | 0.20 | -0.26 | 0.79 | 0.95 | Brazil | 1.46 | 0.29 | -0.15 | 0.54 | 0.95 |
| (1.47) | (2.34) | (1.77) | (8.28) | | | (2.65) | (3.65) | (1.76) | (3.67) | |
| 0.84 | 0.20 | -0.01 | 0.61 | 0.82 | El Salvador | 1.45 | 0.40 | -0.16 | 0.42 | 0.84 |
| (0.67) | (1.14) | (0.05) | (3.23) | | | (1.78) | (2.22) | (0.89) | (2.24) | |
| 0.23 | 0.50 | -0.24 | 0.69 | 0.98 | Greece | 0.54 | 0.31 | -0.18 | 0.74 | 0.98 |
| (0.21) | (2.53) | (0.98) | (5.53) | | | (0.44) | (1.94) | (0.83) | (7.09) | |
| 3.57 | 0.17 | -0.42 | 0.49 | 0.89 | India | -1.41 | 0.51 | 0.41 | 0.38 | 0.91 |
| (2.69) | (2.54) | (2.30) | (2.97) | | | (1.95) | (4.00) | (2.89) | (2.32) | |
| -7.95 | 2.91 | -0.64 | 0.51 | 0.99 | Korea | 0.24 | 0.15 | -0.10 | 0.91 | 0.99 |
| (3.84) | (4.78) | (3.19) | (5.31) | | | (0.33) | (2.39) | (0.69) | (27.96) | |
| 2.34 | 0.61 | -0.48 | 0.36 | 0.98 | Philippines | -0.07 | 0.65 | 0.002 | 0.35 | 0.98 |
| (3.82) | (4.19) | (4.14) | (2.59) | | | (0.21) | (3.43) | (0.02) | (2.00) | |
| 1.74 | 0.48 | -0.54 | 0.69 | 0.97 | Thailand | -3.79 | 0.69 | 0.63 | 0.53 | 0.98 |
| (0.93) | (2.79) | (1.40) | (5.15) | | | (3.08) | (4.40) | (2.72) | (4.37) | |
| 0.40 | 0.89 | -0.48 | 0.51 | 0.98 | Non-oil developing countries | 0.51 | 0.42 | -0.07 | 0.53 | 0.98 |
| (0.67) | (5.42) | (4.17) | (6.02) | | | (1.39) | (4.65) | (2.34) | (5.56) | |

1/ t-values are in parentheses.

function and others only on the demand function, with a "knife-edge" set of equilibrium points lying on both. The preliminary OLS estimation on the entire data set for each country was done merely to obtain starting values for the disequilibrium estimation.

The results of the disequilibrium estimation of the export supply and demand equations are presented in Table 2. To make the reporting of the results more convenient to the reader, the table focuses on the parameter estimates and the probability of observing an excess demand or excess supply regime. The estimation was performed for countries selected largely on the basis of data availability; these were Brazil, El Salvador, Greece, India, Korea, the Philippines and Thailand. Other countries were omitted because certain essential series were missing or were not continuously available for a sufficient number of years.

The table also includes the results of the estimation for the group of non-oil developing countries. 1/ However, there are many reasons for caution in the presentation of the aggregate group results. When data are aggregated over similar economic units, then an aggregate function taking the same general form as the individual functions does not introduce an unacceptably high aggregation error. But some of the greatest disparities among economic units are those created by national boundaries, because the nature and timing of economic policies differ markedly across countries. For example, developing countries have intervened in their export markets both directly through controls on trade and investment and indirectly through taxes, subsidies, and other measures affecting the prices of factor and product markets, and reliance on direct controls has been more pervasive in some countries than in others. In this respect, an elasticity calculated on the export data for the group of non-oil developing countries combines wide variations among the responses of different countries to changes in market conditions. For these reasons, the income and price elasticities for the group of non-oil developing countries are merely illustrative and should not be interpreted as precise estimates.

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1/ Quarterly data were available only for Korea and for the group of non-oil developing countries. The quarterly data were not seasonally adjusted because it is unlikely that the demand and supply equations would follow the same seasonal adjustment patterns. However, these equations were estimated with seasonal adjustment dummies but this did not improve the estimation results and they are not reported. A dummy variable for the two rounds of oil price increases was included in all of the equations. The dummy variable was zero for all years except 1973, 1974, 1979, and 1980.

Table 2. Maximum Likelihood Estimates 1/

| Export Demand | | | | | | Export Supply | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Elasticity | | | | | | Elasticity | | | |
| Constant | Income | Price | Lagged Exports | Variance of Error Term | Country | Constant | Output | Price | Lagged Export | Variance of Error Term |
| 2.03 | -0.13 | -0.28 | 1.00 | 0.003 | Brazil | 1.94 | 0.40 | -0.20 | 0.37 | 0.015 |
| (0.86) | (0.13) | (0.15) | (0.11) | (0.001) | | (0.85) | (0.12) | (0.12) | (0.23) | (0.005) |
| 0.69 | 0.03 | 0.04 | 0.36 | 0.018 | El Salvador | -2.05 | 2.23 | -0.30 | -0.24 | 0.002 |
| (1.26) | (0.19) | (0.26) | (0.25) | (0.006) | | 0.89 | 0.21 | 0.13 | 0.11 | (0.001) |
| 2.83 | 0.43 | -0.76 | 0.77 | 0.009 | Greece | -2.36 | 1.70 | 0.10 | -0.31 | 0.001 |
| (1.49) | (0.21) | (0.34) | (0.14) | (0.003) | | (1.26) | (0.27) | (0.20) | (0.19) | (0.001) |
| 4.43 | 0.04 | -0.68 | 0.73 | 0.005 | India | -1.92 | 0.85 | 0.65 | -0.08 | 0.003 |
| (1.82) | (0.09) | (0.25) | (0.26) | (0.002) | | (0.75) | (0.16) | (0.16) | (0.20) | (0.001) |
| -11.77 | 4.67 | -1.24 | 0.25 | 0.02 | Korea | -8.48 | 0.97 | 1.33 | 0.60 | 0.007 |
| (2.46) | (0.78) | (0.25) | (0.12) | (0.004) | | (1.27) | (0.12) | (0.23) | (0.05) | (0.002) |
| 16.88 | 0.36 | -2.40 | -0.62 | 0.002 | Philippines | -0.78 | 0.68 | 0.16 | 0.33 | 0.003 |
| (3.86) | (0.19) | (0.52) | (0.31) | (0.001) | | (0.27) | (0.17) | (0.07) | (0.15) | (0.001) |
| 20.16 | 1.34 | -4.23 | -0.49 | 0.002 | Thailand | -7.15 | 0.94 | 1.22 | 0.48 | 0.011 |
| (2.35) | (0.16) | (0.49) | (0.16) | (0.001) | | (1.77) | (0.17) | (0.33) | (0.13) | (0.003) |
| 0.01 | 1.58 | -0.77 | 0.21 | 0.001 | Non-oil developing countries | 1.19 | 0.45 | -0.11 | 0.40 | 0.0001 |
| (0.82) | (0.27) | (0.17) | (0.13) | (0.0003) | | (0.26) | (0.05) | (0.02) | (0.06) | (0.00005) |

1/ Asymptotic standard errors are in parentheses.

Inspecting the country equations, the full information maximum likelihood estimates of the activity or income variable in the supply and demand equations are found to be generally significant, and the numerical magnitudes are plausible. The sign of the income coefficient in the empirical export demand equation is usually specified as being positive, but the theoretical possibility exists that the relationship may be negative. 1/ Even though most empirical studies have obtained positive coefficients for income elasticities, Magee (1975) has observed that this may be due, among other things, to the reluctance on the part of researchers to report such findings. In our sample, we obtained a negative coefficient for income only for Brazil and it is statistically insignificant. The income coefficients for India and El Salvador appear to be very small but those too are statistically insignificant.

The issue of unequal income elasticities of export supply and demand has attracted considerable attention in the trade literature. It can be seen from Table 1 that the export demand and supply elasticities are different for most of the countries. Even after excluding Brazil, El Salvador and India, there are a few highly significant differences. The most striking of these is Korea. The income elasticity of foreign demand for Korea's exports is 4.67, while the output elasticity on the supply side is 0.97. This may be due in large part to the successful diversification of Korea's exports. The only other country in the sample with a demand elasticity that is much larger than the supply elasticity is Thailand. The contrary is true for Greece and the Philippines, where the supply elasticities are considerably larger than the demand elasticities faced by these countries.

Concerning the influence of relative prices on the export supply and demand of the developing countries, the results are more clear-cut in the demand equation than in the supply equation. All but one of the price elasticities for demand are negative and most of them are statistically significant. The price elasticity of demand for exports from the group of non-oil developing countries is also negative and statistically significant. The price variables in the export supply equations do not perform nearly as well, with some insignificant estimates and a few negative coefficients. A common explanation of such counter-intuitive results is

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1/ The theoretical possibility of the negative income coefficient comes from the perfect substitutes model of exports, where the demand for exports is the excess of domestic consumption over domestic production. If the increases in domestic production were greater than the increases in domestic consumption, then the coefficient for the income variable would be negative. However, the disequilibrium model estimated in this paper is based on the imperfect substitutes model of exports which seems to be more relevant for the developing countries.

that the export unit value data are inadequate. Unit values tend to be correlated with quality, since goods are not homogeneous within the trade headings from which they are calculated. For example, if two categories of shoes are exported, one of better quality and higher price than the other, then a shift in sales from the low quality shoes to the high quality shoes would cause the unit value of shoe exports to rise, even though neither category of shoes had changed in price. In this situation, therefore, the increase in unit value does not imply any increase in profitability. 1/

Another explanation for the negative price elasticity of export supply is due to the consumption patterns and the government policy reaction functions of certain developing countries. The price elasticity of export supply depends not only on the price elasticity of domestic production but also on the price elasticities of domestic consumption and inventory accumulation as well. In the case of the perfect substitutes model of exports, if domestic demand is more price elastic than output supply, then the supply of exports would be inversely related to the price of exports. Even if the domestic consumption of most exportables is small in the developing countries, the holdings of inventories in these countries may be substantial. If the price elasticity of inventory accumulation of exportables is positive, so that a lower level of inventories is held when the price is relatively low, then this will also reduce the export supply elasticity. This would be the case if governments or buffer stock agencies attempt to stabilize the incomes of the producers; they buy or sell exportables as soon as their world market prices fall to a predetermined miminum or rise to a certain maximum. Thus, the price elasticity of inventory accumulation would be opposite to the price elasticity of exportables production. In this respect, several country studies have emphasized that many developing country exports are determined more by government domestic policies (e.g., agricultural policies) and direct public interventions in the export market than by the world market price of exports. 2/

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1/ Domestic wholesale price indexes and GNP deflators have been used as substitutes for export unit values in previous research, but they are unreliable as an indicator of price competitivenss. The domestic price indexes include prices of imports and nontradables as well as exportables, and the weighting and commodity composition of these indexes may be very different from the composition of exports. Since domestic price indexes encompass a range of different goods, they do not adequately capture export price competitiveness.

2/ See the country studies undertaken for the research project on exchange control, liberalization, and economic development sponsored by the National Bureau of Economic Research and co-directed by Bhagwati and Krueger. See Bhagwati (1978) and Krueger (1978).

We now turn to the problem of testing the hypothesis of excess demand or supply in the developing country export market. The specification of the disequilibrium model itself defines the probabilities with which each observation belongs to the demand equation, and the mathematical details are provided in Appendix I. The probability that $D_t < S_t$ can be computed from the estimated model because the disequilibrium likelihood function allocates sample observations to excess demand and excess supply regimes. Although each data point contains some information about both regimes, the weights in the likelihood function are associated with the probability of observing excess demand or supply. If these weights indicate a high probability of one particular regime, a low weight is given to the alternative regime. In equilibrium $D_t = S_t$ and the estimated $Pr\{D_t < S_t\}$ will be approximately 0.5. When there is excess demand, then $Pr\{D_t < S_t\}$ will be close to one, and when there is excess supply, the probability will be close to zero. The classification of the sample observations into the two regimes is of considerable interest and perhaps of even greater importance from the point of view of the policymakers than the analysis of the coefficient estimates. Such a classification could help policymakers in identifying markets where there is disequilibrium, and might suggest what steps the authorities could take in order to avoid the rigidities in that market.

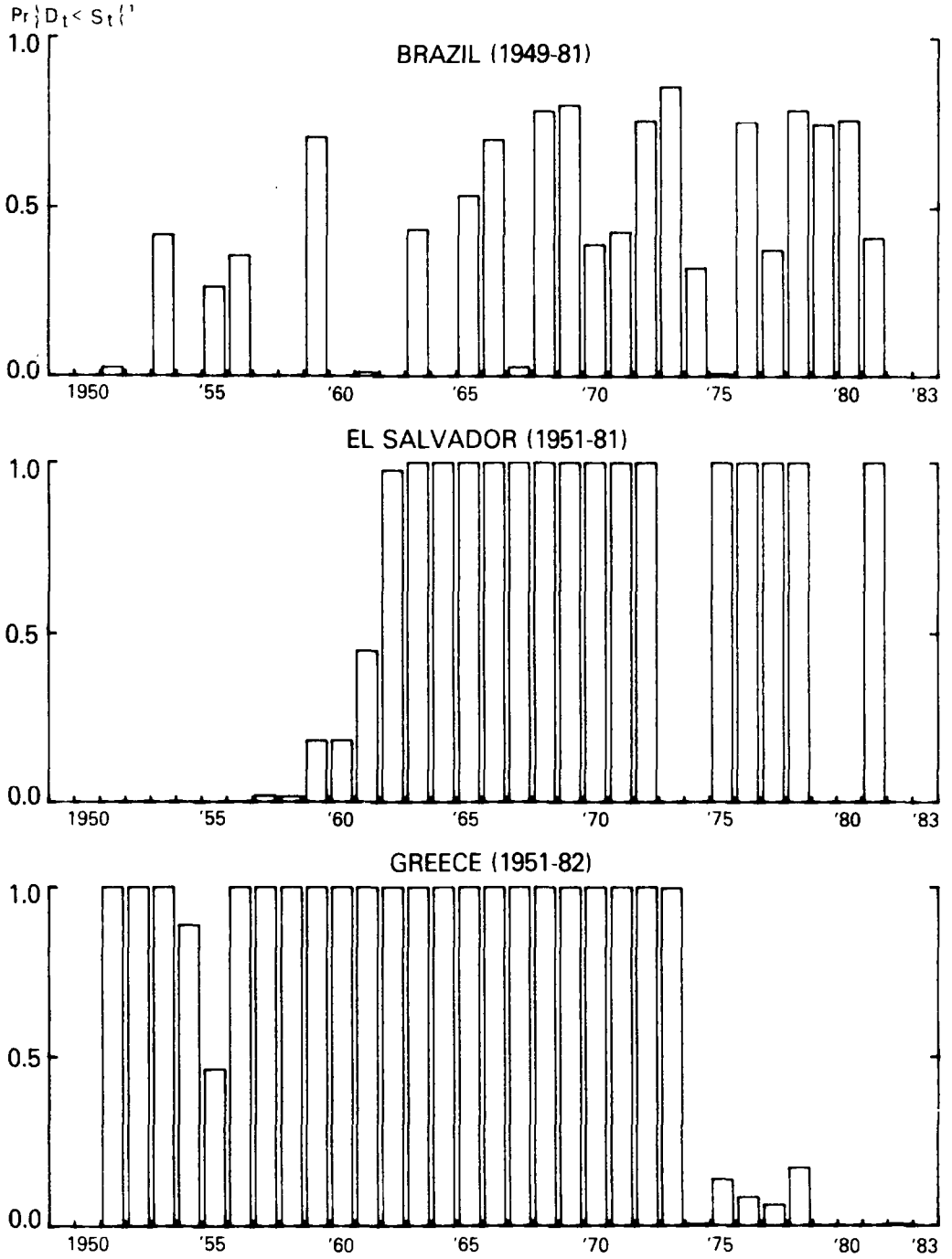
It is perhaps easiest to discuss the test for the hypothesis of market disequilibrium by referring to the estimated classification probabilities shown in Chart 1. The chart depicts the probabilities that the industrial country demand for developing country exports is less than supply. The chart includes the probability estimates for each of the seven developing countries as well as for the group of non-oil developing countries. We believe that the evidence here justifies rejecting the hypothesis of sustained excess supply in the market for developing country exports. Although excess supply appears to be the dominant regime for most of the countries, there are also periods of excess demand. For the Philippines and Thailand there are long periods of excess supply in the earlier years of the sample, while for Greece and Korea the same phenomena are observed in the later years of the sample.

## V. Export Market Disequilibrium: Explanations and Implications

The above analysis offers evidence in support of the market disequilibrium hypothesis for developing country exports. For the seven developing countries as well as for the group of non-oil developing countries, there were episodes of both excess supply and excess demand in the sample period. However, it is necessary to add that results based on aggregate data, such as those presented here, need to be interpreted with due caution. In the specification and estimation of the disequilibrium model for developing country exports, it was assumed that the aggregate quantity

CHART 1

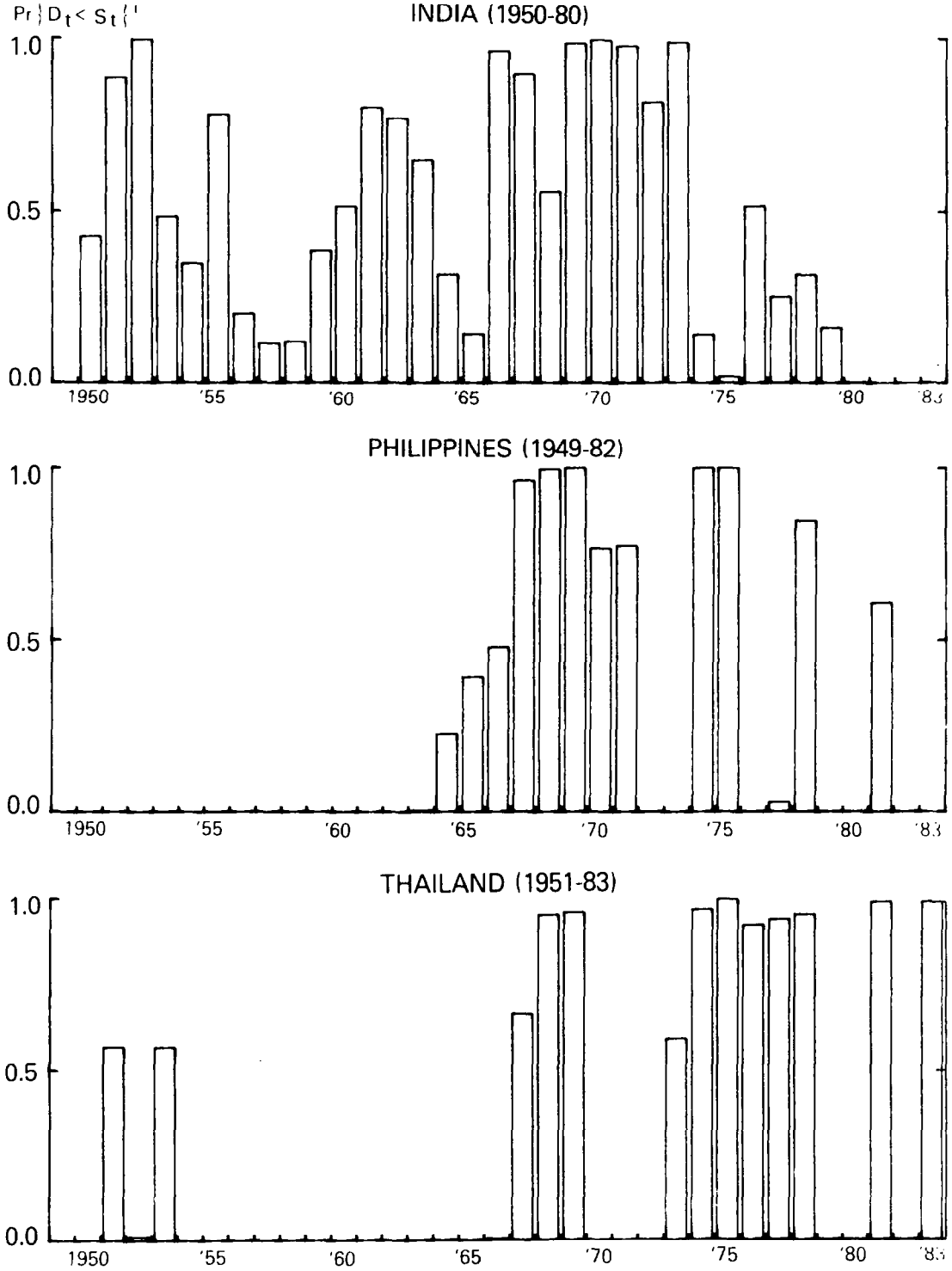
# DISEQUILIBRIUM CLASSIFICATION PROBABILITIES




[1] Pr{Dt< St} is the probability that export demand is less than export supply.

CHART 1 (continued)

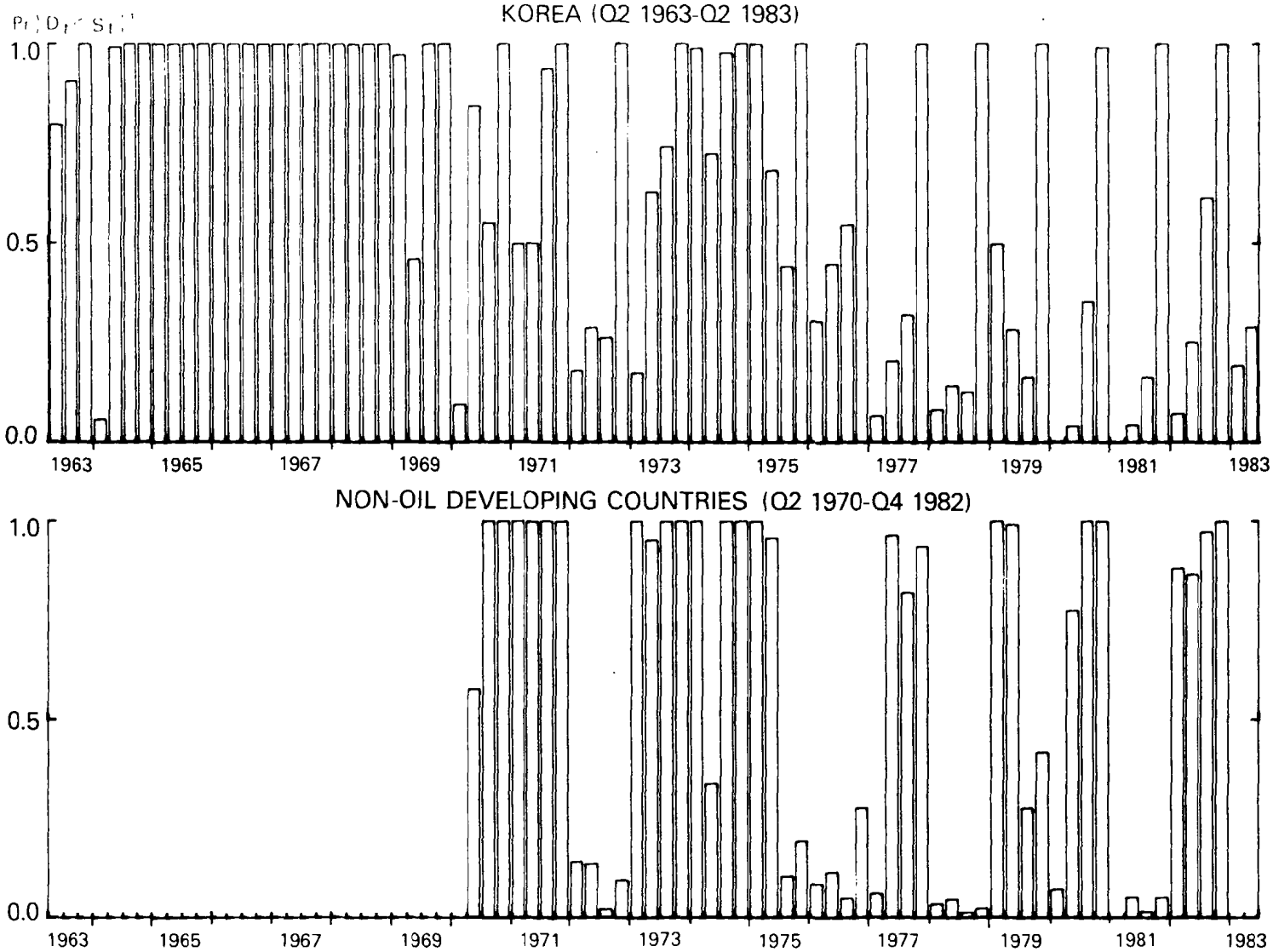
# DISEQUILIBRIUM CLASSIFICATION PROBABILITIES




[1] $Pr\{D_t < S_t\}$ is the probability that export demand is less than export supply.

CHART 1 (concluded)

# DISEQUILIBRIUM CLASSIFICATION PROBABILITIES




[1] $Pr\{D_t < S_t\}$ is the probability that export demand is less than export supply

transacted switches in discrete steps between being on the aggregate supply curve and on the aggregate demand curve. But at each point in time, there is likely to be continuity in the market for total exports, because some microeconomic markets will be in excess supply whereas others are in excess demand. If disaggregated data were available, it would be useful to estimate the disequilibrium model for particular sectors or industries. Another problem with estimating the disequilibrium model for developing country exports is that the time series are generally too short, at least on an annual basis.

In this section, we briefly consider three potential explanations of disequilibrium in the export market for a developing country. These are stochastic demand shocks, economic policies pursued by the developing countries, and protectionism in the industrial countries. Needless to say, the purpose of this discussion is to suggest a number of issues requiring further research rather than to provide final answers.

Export market disequilibrium is sometimes explained as a consequence of stochastic demand shocks. Suppose the economy exports several different types of products to a number of countries and there is a certain degree of market segmentation. Stochastic demand shocks occur constantly in these markets. If prices were sluggish downwards when negative shocks occurred, then some of these disaggregated export markets would be out of equilibrium and excess supply would be observed. In markets where positive shocks are received, excess demand will be observed if prices are sluggish upward, otherwise equilibrium will be restored immediately at higher prices. If prices are more likely to be sluggish downwards than upwards, as is commonly assumed, then one might expect to see excess supply in several different categories of exports. Nonetheless, while this type of formulation affords an explanation of excess supply within a year, it gives less convincing reasons for persistent excess supply in the export market.

Another explanation of export market disequilibrium focuses on the economic policies pursued by the developing economies. Frequently, proponents of this view attribute the excess supply of developing country exports to inappropriate government policies, notably including those with respect to interest rates, exchange rates and relative prices. It is argued that the wide variety of controls employed by governments in developing countries tends to isolate producers from the world price structure, thereby weakening competitive pressures operating in the supply side of the export market. Distortions of this type are often compounded by the varying degrees of effective protection extended to different industries. The extensive use of import quotas is another important reason for the highly divergent relative gap between domestic and world prices across industries. The distortions are especially

harmful to import-substituting industries that have been protected and are attempting to produce for the export market. Hence, policies result in a highly distorted domestic price structure, which may in turn lead to severe rigidities in the supply of exports that cause market disequilibrium.

Export market disequilibrium is also sometimes explained as a consequence of protectionism in the industrial countries. In recent years, protectionism has relied heavily on nontariff barriers to trade. Such barriers--of which the two most common types are government adjustment subsidies and voluntary export restraint arrangements--interfere with the operation of the market mechanism and create situations where supply exceeds demand. Government adjustment subsidies are intended to reduce the impact of market forces on factor rewards in import-competing industries. In the case of voluntary export restraint arrangements, the onus of enforcement of the arrangement is on the exporting country, but it is the importing country that selects the commodities to be put under voluntary export restraint. This choice is not taken at random and it is those commodities that most threaten import-competing firms and are close substitutes for domestically produced commodities that are selected by the industrial countries. As a result of such arrangements, which may apply to a broad commodity group such as cotton textiles or to narrower categories such as woven fabrics of cotton, excess supply is created by the developing country being forced to export less than it wishes to at the given price.

Each of the explanations for export market disequilibrium discussed here has some plausibility, but there is only limiting empirical evidence to aid in choosing among them. There is perhaps no developing country whose experience can be neatly pigeonholed into one of these categories. Major disturbances have affected world trade on both the demand and supply side, especially during the 1970s. Furthermore, these disturbances tend to be correlated with one another. For instance, the intensification of protectionist practices in the industrial countries tend to be associated with periods of low economic activity. This is because the adjustment costs borne by import-competing sectors are higher in stagnant than in fast-growing economies. The low periods of economic activity magnify the extent of the required adjustment by necessitating an actual reduction on the part of the import-competing sector rather than only a lower rate of future expansion. Moreover, the prospects of alternative employment are limited for the adversely affected factors of production. But the slowdown of economic activity and increased protectionism in the industrial countries will cause exports of a developing country to decline. Other things being equal, the current account deficit will widen and if the developing country does not have sufficient international reserves, then there will be a need for macroeconomic adjustment. If the current account deficit is controlled by imposing restrictions on imports, then this may create problems in the domestic production process and adversely affect the supply of

exports. In this case, therefore, both the supply and the demand side contribute to the market disequilibrium. The simple disequilibrium model presented is illustrative, but a full statistical evaluation of the different factors that influence export market disequilibrium remains to carried out.

## VI. Conclusion

We have specified and estimated a simple aggregate disequilibrium model of the developing country export market. The simple disequilibrium model seems to fit reasonably well the export experience of the developing countries studied. The coefficient estimates are fairly well-determined and the estimated variances of the error terms are acceptable. The empirical analysis offers evidence in support of the hypothesis that the export market is not in continuous equilibrium. However, rather than summarize in more detail the results of the analysis, it may be worth ending with some observations relating to the limitations of the analysis in this paper.

Major among these limitations is the aggregation error pertaining to the discrete switching rule applied to the aggregate exports. In the specification and estimation of the disequilibrium model for developing country exports, it was assumed that aggregate exports switch in discrete steps between being on the supply function and on the demand function. It was assumed that traders on the short side of the market realize their demands or supplies and that there cannot be both rationed buyers and rationed sellers in the same market. However, there is likely to be some continuity in the market for total exports when some microeconomic markets are in excess supply, whereas some others are in excess demand. If disaggregated data are available, then it would be useful to estimate the disequilibrium model for particular export categories. Furthermore, the formulation and estimation of a smoothed version of the disequilibrium model, probably along the lines of Muellbauer and Winter (1980), would be desirable. Their disequilibrium estimation technique is based on a theory of aggregation over markets in which the aggregate min condition does not hold. Their point is that even when the min condition holds in each micromarket, there may in the aggregate be both rationed buyers and sellers. However, data on several other variables would be required, because in the Muellbauer-Winter technique intermarket influences are important. At the present time, the major drawback for estimating the smoothed version of the disequilibrium export market is the lack of relevant time series with the requisite number of observations for developing countries.

Disaggregation could be pursued by breaking down the exports of a developing country according to major commodity flows. Particular export flows could then be related to more specific determinants. For example, exports of consumer goods could be related to disposable income in the importing countries and the relative price of close substitutes, whereas exports of intermediate goods and raw materials could be related to the index of manufacturing production. A further breakdown of export flows would be required when there are significant changes in the structure of demand. In particular, changes in the intensity of quantitative restrictions on developing country exports are not uniform across the various commodity flows or trading partners. The disaggregated elasticity estimates and the probabilities of market disequilibrium would be useful for determining the impact by sector or industry due to differential changes in the imposition or lowering of trade barriers.

To conclude, our empirical analysis has shed light on some interesting issues but we cannot draw strong, unambiguous policy conclusions from the work reported here. Our results are limited because the sample sizes are relatively small. Furthermore, the min condition generates aggregation problems in a macroeconomic context. Nonetheless, it seems likely to us that as more data become available, progress will be made in further attempts to develop and test implications of the disequilibrium model for the developing countries.

## Estimation of the Disequilibrium Model

This appendix provides a brief discussion of the statistical problem of estimating the parameters of the disequilibrium model. Disequilibrium econometrics, as the name suggests, is concerned with estimating models for markets in which the quantities demanded and supplied are not always equal because prices do not adjust quickly to excess supplies or demands. When economic activity is attempted at sticky prices, it is the adjustment of quantities that leads to a short run or temporary equilibrium. In a market where the price fails to adjust, the "short" side of the market determines the actual amount transacted, and the "long" side is rationed. Such markets raise a number of interesting problems of model specification and estimation. The study of disequilibrium econometrics was initiated by Fair and Jaffee (1972) in their treatment of the market for housing starts and was subsequently considered, among others, by Maddala and Nelson (1974) and Goldfeld and Quandt (1975).

The major point of an econometric investigation is the estimation of an economic relationship supposedly reflected by a particular set of observed data. The econometrician estimates a model that explains the determination of variables in a given framework, and this framework is based on the conditions of the observed data. In an equilibrium supply-demand model for a commodity, the observed quantity is given by the intersection of the supply and demand curves. The endogenous variables are the observed quantity of the commodity, which is equal to both supply and demand, and the price of the commodity, which is the market equilibrating variable.

$$D_t = \alpha_1 P_t + \beta_1' X_{1t} + u_{1t} \quad \text{(demand function)} \qquad (A.1)$$

$$S_t = \alpha_2 P_t + \beta_2' X_{2t} + u_{2t} \quad \text{(supply function)} \qquad (A.2)$$

$X_1$ and $X_2$ are sets of exogenous variables determining demand and supply, respectively. $D_t$ denotes the quantity demanded during period t, $S_t$ the quantity supply during period t, and $u_{1t}$ and $u_{2t}$ are the normal errors that are assumed to be independently distributed with variances $\sigma_1^2$ and $\sigma_2^2$. In the equilibrium model,

$$Q_t = D_t = S_t \qquad (A.3)$$

and equations (A.1) and (A.2) form a simultaneous-equations system and this system of equations can be estimated by the usual simultaneous-equations methods, provided they are identified.

In the disequilibrium model, however, it is assumed that prices or other potential equilibrating variables do not adjust enough to equate demand and supply in period t. The quantity sold is given by the minimum of demand and supply. In the disequilibrium model, the equation (A.3) is replaced by the equation

$$Q_t = \min(D_t, S_t) \qquad (A.4)$$

If $D_t > S_t$, then the observed quantity $Q_t$ is on the supply function, and if $D_t < S_t$, then the observed quantity is on the demand function. The justification for the "min condition" specified in equation (A.4) is the principle of voluntary exchange; that is, no buyer can be forced to buy more than he demands, nor can any seller be forced to sell more than he wishes to sell. The econometric problem is to estimate the parameters of the model specified in equations (A1), (A.2), and (A.4); i.e., $\alpha_1$, $\alpha_2$, $\beta_1'$, $\beta_2'$, $\sigma_1^2$, and $\sigma_2^2$. But even if the econometrician knows which observa-

servations of $Q_t$ belong to the demand function and the supply function, these equations cannot be estimated by ordinary least squares. The residuals in these truncated samples do not have zero means and they are correlated with the exogenous variables of the model.

The disequilbrium model estimated in this paper considered the price $P_t$ as exogenous, and we shall include it in the list of exogenous variables. In other words, $X_{1t}$ and $X_{2t}$ now denote the variables that influence demand and supply, respectively, and $P_t$ is included in these variables. As noted earlier, only $Q_t$ is observed in the specification of the disequilibrium model; $D_t$ and $S_t$ are not always observed. The econometric problem is to derive the probability density function (pdf) of $Q_t$ from the joint pdf of $D_t$ and $S_t$. From the specification of the model, the probability that observation t belongs to the demand function is

$$\Pr(D_t < S_t) = \Pr(u_{1t} - u_{2t} < \beta_2' X_{2t} - \beta_1' X_{1t}) \qquad (A.5)$$

Denoting by $f(Q_t | D_t < S_t)$ the conditional pdf of $Q_t$ given $D_t < S_t$, then the unconditional density of $Q_t$ is:

$$h(Q_t) = f(Q_t | D_t < S_t)\Pr\{D_t < S_t\} + f(Q_t | D_t > S_t)(1 - \Pr\{D_t < S_t\}) \qquad (A.6)$$

It can be proved using formulae for conditional probabilities, that the unconditional density of $Q_t$ is:

$$h(Q_t) = \int_{Q_t}^{\infty} g(Q_t, S_t)dS_t + \int_{Q_t}^{\infty} g(Q_t, D_t)dD_t, \qquad (A.7)$$

where $g(Q_t, S_t)$ is the joint pdf of $D_t$ and $S_t$ with $Q_t$ replacing $D_t$. In the two terms, either $Q_t = D_t$ and S is integrated out over $Q < S$, or $Q_t = S_t$ and D is integrated out over $Q < D$.

Expressions for the two terms in $h(Q_t)$ can be rewritten as follows:

$$h(Q_t) = f_1(Q_t) \cdot F_2(Q_t) + f_2(Q_t) \cdot F_1(Q_t), \qquad (A.8)$$

where

$$f_1(Q_t) = \frac{1}{\sqrt{2\pi}\sigma_1} \exp\left[-\frac{1}{2\sigma_1^2}(Q_t - \beta_1' X_{1t})^2\right], \qquad (A.9)$$

$$f_2(Q_t) = \frac{1}{\sqrt{2\pi}\sigma_2} \exp\left[-\frac{1}{2\sigma_2^2}(Q_t - \beta_2' X_{2t})^2\right], \qquad (A.10)$$

$$F_1(Q_t) = \frac{1}{\sqrt{2\pi}\sigma_1} \int_{Q_t}^{\infty} \exp\left[-\frac{1}{2\sigma_1^2}(D_t - \beta_1' X_{1t})^2\right] dD_t, \text{ and} \qquad (A.11)$$

$$F_2(Q_t) = \frac{1}{\sqrt{2\pi}\sigma_2} \int_{Q_t}^{\infty} \exp\left[-\frac{1}{2\sigma_2^2}(S_t - \beta_2' X_{2t})^2\right] dS_t. \qquad (A.12)$$

The likelihood function of the model is

$$L = \prod_t h(Q_t) \qquad (A.13)$$

The maximization of the likelihood function gives the maximum likelihood estimates of the parameters of the model. The asymptotic standard errors of the estimates are computed by taking the square root of the diagonal elements of the negative inverse Hessian matrix of the loglikelihood function. Once the parameters in the model have been estimated, then these parameters can be used to compute the conditional probability that an observation is on the demand function or the supply function. The likelihood that the particular observation ($Q_t$, $X_{1t}$, $X_{2t}$) did come from the demand regime is

$$\Pr\,(D_t < S_t | Q_t,\ X_{1t},\ X_{2t}) = \frac{f_1\ F_2}{f_1\ F_2 + f_2\ F_1} \qquad \text{(A.14)}$$

It is these conditional classification probabilities that are used for the charts in this paper. Since the estimated parameters of the model are used for calculating the probability that a particular observation comes from one of the two regimes and the parameter estimates are maximum likelihood, the estimated probabilities are also maximum likelihood.

APPENDIX II

## Data Sources and Variables

The data base for estimating the export supply and demand equations are from the International Financial Statistics tapes and data files of the Research Department of the IMF.

## Definitions of the Variables in the Model

X Volume of developing country exports to industrial countries.

$Y^*$ Manufacturing production index for the industrial countries.

$P^*$ GDP deflator for industrial countries.

$PX^*$ Export unit value index of developing countries in U.S. dollars.

PX Export unit value index of developing countriies in domestic currency.

Y Gross domestic product of developing countries.

PY GDP deflator of developing countries.

All the series used in the estimation were converted into indexes with 1980=100.

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