Imports under a Foreign Exchange Constraint

Cristian Moran

To assess proposed macroeconomic adjustment programs, policymakers must estimate import demand relative to the foreign exchange available. Traditional models estimate import demand as a function of relative prices (the real exchange rate) and income (gross domestic product) but omit changes in foreign exchange. In the 1980s, however, declines in foreign lending and the terms of trade and increased debt service costs reduced foreign exchange availability in most developing countries and limited import capacity.

In this article two import models are presented which incorporate both the traditional variables and indicators of import capacity—foreign exchange inflows and international reserves. The first model assumes that import prices are exogenous, but in the second model import prices are endogenous—allowing for government attempts to reduce import demand by increasing the domestic import price. The models are estimated using data for twenty-one developing countries for 1970–83. The results suggest that the import model presented here does a better job of explaining import behavior than do the traditional model (which excludes changes in foreign exchange) and the Hemphill model (which excludes relative import prices and income).

Trade models have been important tools in the analysis of policy packages to deal with macroeconomic imbalances, and such models have received prominent attention in the economic literature (see Goldstein and Khan 1985 for a good survey of this literature). Although the traditional import model, which links imports to domestic output and relative import prices, has worked well for industrial countries that are unconstrained by foreign exchange, it has not proven useful in explaining the recent slump in the imports of developing countries which are short of foreign exchange (Mirakhor and Montiel 1987).

For most developing countries the availability of foreign exchange declined in the early 1980s, as foreign lending cutbacks, interest rates increases, and declining commodity prices forced them to make significant macroeconomic adjustments. As a consequence, merchandise import volumes for all non-oil-exporting developing countries remained stagnant from 1981 to 1986, compared with annual increases of more than 6 percent from 1965 to 1981. Countries in Sub-Saharan Africa and Latin America, unable to adjust rapidly to the

The author is an economist in the Country Economics Department of the World Bank. He is grateful to Sarma Jayanthi, Abdel Semlali, and Sheila Fallon for their assistance, and to Riccardo Faini, Heywood Fleisig, and Mohsin Khan for helpful comments on an earlier draft.

new external circumstances and with a much higher level of external debt relative to their export earnings than other developing countries, faced a sharp reduction in imports. As imports declined, investment deteriorated, and per capita output stagnated or dropped.

In response to these changes, policymakers have struggled to devise strategies that promote growth without a significant deterioration in their trade balances. To do so, they must be able to predict the response of imports to external and domestic shocks in the presence of foreign exchange constraints. Although different models have been proposed to analyze this problem, the approach suggested by Hemphill (1974) and extended later by Chu, Hwa, and Krishnamurty (1983), Winters and Yu (1985), and Sundararajan (1986) seems to be well grounded in the literature. In his model of the Indian economy, for instance, Sundararajan argues that the value of import licenses granted by economic authorities "varied with the tightness of the balance of payments situation, and also reflected the authorities' reaction to the prevailing [desired] import demand and their ability to finance them" (p. 83). A simple rationalization of this approach is used here to interpret the interaction of the variables affecting import demand and the capacity to import. This procedure expands Hemphill's approach by incorporating the traditional variables (relative prices and domestic income) with the variables introduced by Hemphill (foreign exchange receipts and international reserves). This expanded approach avoids biases due to the omission of relevant variables, or due to the simultaneity of import volumes and relative import prices. (The terms relative import prices and real exchange rate are used interchangeably throughout this paper.)

Section I discusses the theoretical models developed in the present study. The general import model (with exogenous prices), which is presented first, contains the traditional and the Hemphill models as special cases. Then an alternative model is derived which presents two separate equations: the traditional import demand equation, and the equation describing the country's import capacity (the Hemphill model). In this alternative model, import volumes and the real exchange rate are determined endogenously. Section II presents the empirical estimates of both models using pooled cross-section time series data. Section III summarizes the main conclusions and suggestions for future research are summarized in section IV. An appendix gives a formal definition of the variables and describes the data sources.

I. IMPORT MODELS

A General Import Model with Exogenous Prices

The first import model developed here assumes that the volume of imports is determined by an explicit optimization problem that balances two objectives: (i) the desire to minimize the deviations of current imports in the presence of foreign exchange constraints, from the long-run equilibrium import level, and
(ii) the desire to minimize the deviations of actual imports from the short-run desired import level. The economic authorities are presumed to grant import licenses in a flexible manner in order to minimize the costs of deviating from both the long-run and short-run desired levels. Following Hemphill (1974), I use an explicit quadratic cost function to capture these costs:

\[ C_t = \beta_1 (m_t - m^*_t)^2 + \beta_2 (r_t - r^*_t)^2 + \beta_3 (m_t - m_{t-1})^2 + \beta_4 (m_t - m^*_t)^2 \]

where \( m_t \) is the actual volume of imports at time \( t \); \( m^*_t \) is the long-run import volume; \( r_t \) is the current and \( r^*_t \) the long-run level of real international reserves; \( m^*_t \) is the short-run notional or desired level of import volumes; and the \( \beta \)s are all expected to be positive. Because we are interested in the determinants of real imports, all nominal variables are deflated by the import price. In conditions of long-run stationary equilibrium (that is, as \( t \) approaches infinity) \( m^*_t = f^*_t = m^*_t = m_t \), where \( f^*_t \) is the long-run level of foreign exchange receipts (equal to export earnings plus net capital inflows). In the short run, however, the last two equalities may not hold because of the presence of past or current shocks.

In the import decisionmaking process assume, first, that the economic authorities minimize the costs of adjustment to the long-run import level, \( m^*_t \), by using reserves to smooth imports. The long-run level of international reserves is assumed to be positively related to the long-run import level. This relation is reflected in a simple linear function:

\[ r^*_t = \gamma_0 + \gamma_1 m^*_t, \quad 0 \leq \gamma_1 \leq 1. \]

In the short run, however, both variables are linked through the balance of payments identity:

\[ \Delta r_t = f_t - m_t \]

where \( \Delta \) is the first difference operator and \( f_t \) is the current level of (real) foreign exchange receipts.

The short-run desired import demand curve, \( m^d_t \), can be written as a simple linear function of relative import prices and real gross domestic product (GDP):

\[ m^d_t = \alpha_0 + \alpha_1 (PM/P)_t + \alpha_2 y_t; \quad \alpha_1 \leq 0; \quad \alpha_2 \geq 0 \]

where \( PM_t \) is the level of import prices (inclusive of domestic taxes reflecting tariff and nontariff barriers); \( P_t \) is an aggregate price index of domestic goods (the GDP deflator); \( y_t \) is a real scale variable (real GDP); and \( \alpha_1 \) and \( \alpha_2 \) are the price and income semi-elasticities of import demand, respectively.\(^1\)

Finally, to close the model, an explicit assumption is needed about the long-

\(^1\) Since imports are equal to domestic consumption minus domestic production, the theoretical income semi-elasticity \( \alpha_2 \) can attain negative values. This would occur if domestic production is more income-elastic than domestic consumption (see Magee 1975, p. 189, for a formal statement of this condition). Empirical evidence for this possibility is scant, however.
run level of foreign exchange receipts, \( f_r^* \). Initially I adopted Hemphill’s assumption:

\[
(5) \quad f_r^* = f_r + \lambda \Delta f_r = (1 + \lambda) f_r - \lambda f_{t-1}
\]

where \( \lambda \) indicates how changes in foreign exchange receipts are perceived. If the changes are perceived to be permanent, \( \lambda \) is positive, and the changes are extrapolated. If the changes are perceived to be transitory, \( \lambda \) is negative, and they are discounted. In the empirical estimation, however, it was found that \( \lambda \) could not be properly identified. To simplify the presentation, therefore, I take \( \lambda = 0 \). That is, I take the current level of foreign exchange receipts as a proxy for the long-run level. (A similar assumption was adopted by Sundararajan 1986.)

By substituting equations 2 and 4 into equation 1, and recalling that \( m_t = -\) ft, the import equation can now be derived by minimizing equation 1 subject to the constraint imposed by available foreign exchange (equation 3), to obtain:

\[
(6) \quad m_t = b_0 + b_1 f_t + b_2 r_{t-1} + b_3 m_{t-1} + b_4 (PM/P)_t + b_5 y_t
\]

where \( b_1 = \beta_1' + \beta_2' (1 - \gamma_1) \geq 0; b_2 = \beta_2'; b_3 = \beta_3'; 0 \leq b_2, b_3 \leq 1; \)

\[
b_4 = \beta_4' \alpha_1 \leq 0; b_5 = \beta_4' \alpha_2 \geq 0; \beta_4' = \beta_4 / \Sigma \beta_2' \Sigma \beta_1' = 1.
\]

Equation 6 constitutes the basic import model with exogenous prices, which extends Hemphill’s model by explicitly incorporating relative import prices and domestic income into the import decision.

This equation incorporates, as special cases, the import models commonly used in the literature. The traditional import model (which ignores the presence of foreign exchange constraints) for example, can be obtained by making \( b_4 = b_5 = 0 \) (or alternatively, \( b_4 = b_5 = 0 \)):

\[
(7) \quad m_t = a_0 + a_1 (PM/P)_t + a_2 y_t + a_3 m_{t-1}; a_1 \leq 0, a_2 \geq 0, 0 \leq a_3 \leq 1
\]

where \( a_1 \) and \( a_2 \) are now the short-term price and income semi-elasticities of import demand, and \( a_1/(1-a_3) \), \( a_2/(1-a_3) \) are the corresponding long-run semi-elasticities. (See Moran 1987 for a derivation and detailed discussion of the assumptions underlying this equation.)

The Hemphill model, which ignores relative prices and domestic income, can be obtained by making \( b_4 = b_5 = 0 \) (or alternatively, \( b_4 = b_5 = 0 \)):

\[
(8) \quad m_t = b_0 + b_1 f_t + b_2 r_{t-1} + b_3 m_{t-1}
\]

where \( b_1 = \beta_1' + \beta_2' (1 - \gamma_1) \geq 0; b_2 = \beta_2'; b_3 = \beta_3'; 0 \leq b_2, b_3 \leq 1. \)

Instead of estimating equations 6–8 directly, however, I estimated the equations in log-linear form. Thus the general import model, equation 6, was written in the form:

\[
(9) \quad \ln m_t = b_0 + b_1 \ln f_t + b_2 \ln r_{t-1} + b_3 \ln m_{t-1} + b_4 \ln (PM/P)_t + b_5 \ln y_t
\]
and similarly for equations 7 and 8. This seemed justified for two reasons: (i) previous empirical studies estimating the traditional import equations found the log-linear specification to be appropriate (see Khan and Ross 1977 and Thursby and Thursby 1984); (ii) the log specification greatly simplifies the interpretation of the estimated coefficients—as they now represent elasticities.

Note that the structural parameters of the general import model presented here are not uniquely identified. Apart from the constant terms, there are seven structural parameters—$\beta_j^i$, $\gamma$, $\alpha_1$, $\alpha_2$—although only six of them are linearly independent, and five reduced-form coefficients, $b_i$ ($i = 1, \ldots, 5$). Thus, even though the reduced-form equation, 9, can be estimated by ordinary least squares, there is no way of getting unconditional estimates of the structural parameters. This is not a serious problem, particularly if the interest is in the response of imports to a unit change in prices or income after due account is taken of the foreign exchange constraint, since in this case the reduced form multipliers, $b_i$, are the relevant elasticities. Moreover, it is also possible to fix one of the structural coefficients and then obtain estimates of the remaining structural parameters conditional on that coefficient. I have not pursued this procedure here, however. Instead, I consider below an alternative specification that explicitly introduces foreign exchange constraints, but allows the structural parameters of the model to be recovered.

**An Alternative Derivation of the General Import Model with Exogenous Prices**

In the discussion above, government policy was restricted to minimizing the costs of a shortage of imports, given available foreign exchange and the demand generated by income and relative prices—using a quadratic cost function. A similar equation will now be derived without using an explicit cost function. Trade policies and trade taxes will be explicitly introduced, however, and the government will be assumed to use these policies to reduce the level of desired imports in response to an increased tightening of the foreign exchange constraint.

In an extension of the traditional import model (equation 7), import prices are decomposed into a component reflecting the value of imports at border prices (expressed in domestic currency), $PM^*_t$, and another component reflecting policy-induced price changes such as taxes, tariffs, and nontariff trade barriers, $Z_t$. To simplify the presentation, I write this equation in log-linear form:

\[
\ln m_t = a_0' + a_1'y_t + a_2'\ln m_{t-1} + a_3'\ln P_t,
\]

with $a_1' = -a_2' \leq 0$; $a_2' \geq 0$; $0 \leq a_3' \leq 1$ and

\[
\ln PM_t = \ln PM^*_t + Z_t,
\]

where $Z_t = \ln (1 + t_{it})$, and $t_{it}$ is the tariff equivalent of all tariff and nontariff barriers at time $t$.\]
Now assume that trade barriers are increased in response to a tightening of
the foreign exchange constraint, so that $Z_t$ is negatively correlated with foreign
exchange inflows and international reserves. This relation can be expressed in
log-linear form:

$$Z_t = c_0 + c_1 \ln f_t + c_2 \ln r_{t-1}; \; c_1 \leq 0; \; c_2 \leq 0.$$  

Then, the prior import model, equation 9, can be obtained by substituting
equations 11 and 12 into equation 10, with an obvious identification of param-
ters. (Note, however, that border prices, $PM^* \_t$, now replace domestic import
prices, $PM_\_t$.)

**A General Import Model with Endogenous Prices**

Consider now a different version of the general model in which real import
prices are endogenous to the import decision. In this model, the Hemphill
equation determines import supply, or import capacity, an assumption that
seems particularly appropriate when the foreign exchange constraint is binding.
Import prices and aggregate output do not appear explicitly in this equation,
but they still influence import volumes through their effect on the import
demand curve.

The complete import model contains two independent structural equations:
an import-supply curve which is infinitely inelastic with respect to price, and a
normal downward-sloping demand curve:

$$\ln m^d_t = a_0 + a_1 \ln (PM/P)_t + a_2 \ln y_t + a_3 \ln m_{t-1} + u_t$$

$$\ln m^s_t = b_0 + b_1 \ln f_t + b_2 \ln r_{t-1} + b_3 \ln m_{t-1} + v_t$$

where $m^d_t = m^*_t = m_t$ in equilibrium, and $(PM/P)_t$, and $m_t$ are the endogenous
variables. Note that these equations have been written in log-linear form, and
that demand and supply shocks—$u_t$ and $v_t$—have been added. These shocks
are assumed to be normally distributed random variables, but may be contem-
poraneously correlated. This latter assumption has important implications for
the interpretation of the model, because it implies that import volume and
import prices are determined simultaneously—with both the supply and de-
mand equations playing important roles in the determination of the two endog-
enous variables. Two remarks need to be made. First, note that both the
demand and supply equations are relevant in the process of adjustment to the
long-run equilibrium position. To see this, assume that a temporary equilibrium
is disturbed by a supply shock (for example, official capital flows are drastically
reduced because of budgetary considerations in donor countries), a situation
which reduces the supply of foreign exchange, $f_t$. In the short run, import
volumes are determined by the import demand curve and exceed foreign ex-
change availability, as the country uses reserves to smooth imports. The ad-
justment process then involves a policy reaction from the authorities that
changes domestic import prices, $(PM/P)_t$,—via changes in the exchange rate
and/or changes in tariffs and nontariff barriers—as the country moves along the import demand curve to the position determined by the new long-run import supply curve. Note also that, during the adjustment process, changes in import volumes also change the import demand curve because of the presence of the term \( m_{t-1} \) in equation 13.

Second, note that in this version of the model all structural parameters \( (a_i, b_i; i = 1, 2, 3) \) are identified, and can be easily estimated. The import supply equation (14) in particular, can be directly estimated by ordinary least squares (OLS), to yield consistent and asymptotically efficient estimates. Import demand equation 13, however, cannot be estimated by OLS, as this would yield biased and inconsistent estimates of the relevant elasticities, since \( (PM/P) \) is endogenous, and hence correlated with the demand shock, \( u_t \). Consistent estimates of the demand elasticities can be obtained by using a simultaneous equation procedure, such as two-stage least squares.\(^2\)

II. Estimation of the Models

The estimation of the import models used pooled cross-section time-series data for twenty-one developing countries over the 1970–83 period. Import behavior was estimated for all developing countries and for four country groups—low-income countries, major exporters of manufactures, nonfuel primary commodity exporters, and oil exporters. (The countries are listed in the appendix; category criteria are discussed in World Bank 1986).

Before estimating the pooled cross-section time series model I used Bartlett’s test for the presence of heteroskedasticity, assuming homoskedastic errors for each country, but allowing for heteroskedastic errors across countries. For two regions (oil exporters and major exporters of manufactures) a correction for heteroskedasticity was needed, which I made before proceeding to estimate the model.\(^3\) Country-intercept dummies were added to each equation, but I assumed that the slopes were similar for all countries in each group. This model is known in the literature as a “fixed effects” model. It is also a dynamic model, because of the inclusion of a lagged dependent variable (see Nickell 1981 and Anderson and Hsiao 1982 for a discussion of this model in the econometric literature).

Table 1 presents the results of the general import models and the two special cases, the Hemphill and the traditional models. Consider first the estimates of

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2. Note that under the added assumption that the import supply and demand shocks are uncorrelated \( (Eu_n \sim 0) \), the system formed by equations 13 and 14 becomes recursive. In this case, the demand curve can be renormalized to express \( (PM/P) \) as a function of \( m_t \), and the resulting equation estimated by ordinary least squares (see Thurman 1986 for a discussion of this procedure). I have not pursued this procedure here, however.

3. I also tested for the presence of autocorrelation in the estimates for five individual countries. In most cases (fifteen out of twenty) the results did not show any evidence of autocorrelation (see Moran 1987, table 2), so I ignored it in the estimates for the pooled sample.
Table 1. Estimates of the General Import Models, the Hemphill Model, and the Traditional Model, 1970–83

\[ \ln m_t = b_0 + b_1 \ln f_t + b_2 \ln r_{t-1} + b_3 \ln m_{t-1} + b_4 \ln \left( \frac{PM}{P} \right)_t + b_5 \ln y_t + \sum c_i D_i \]

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<th>( b_0 )</th>
<th>( b_1 )</th>
<th>( b_2 )</th>
<th>( b_3 )</th>
<th>( b_4 )</th>
<th>( b_5 )</th>
<th>( R^2 )</th>
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286
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<td>2.18 (5.03)</td>
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<td>-3.98 (-3.98)</td>
<td>-3.98 (-3.98)</td>
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<td>(1.000)</td>
<td>703.1960 (249)</td>
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</table>

- Not applicable.

Note: <sup>m</sup>,<sup>n</sup> = imports of goods and nonfactor services; <sup>f</sup>,<sup>P</sup> = foreign exchange receipts; <sup>r</sup>,<sup>P</sup> = end-year stock of international reserves; <sup>PM</sup>,<sup>f</sup> = import prices; <sup>P</sup>,<sup>B</sup> = domestic prices; <sup>y</sup>,<sup>B</sup> = gross domestic output (GDP); <sup>D</sup>,<sup>c</sup> = country dummy. Figures in parentheses are t-values except in the column showing R<sup>2</sup>'s, in which they are the corresponding F values. The method of estimation is ordinary least squares, except for the general import model with endogenous prices which uses two-stage least squares. Instrumental variables are <sup>f</sup>,<sup>r</sup>,<sup>-</sup>,<sup>i</sup>,<sup>y</sup>,<sup>B</sup>, and <sup>mt</sup>,<sup>s</sup>.  

a. Sum of squared residuals. 

b. Degrees of freedom. 

c. Regressions corrected for heteroskedasticity. 

Source: Full definitions, countries, and data sources are detailed in the appendix.
the general import model with exogenous prices (text equation 9). Note that all the parameters have the expected signs and that the coefficient associated with the variable measuring foreign exchange receipts \((b_1)\) is quite significant, and higher for low-income countries than for the other country groups. Relative prices and domestic income also play an important role in these equations, but their significance, measured by the corresponding \(t\)-values, is generally smaller than the significance of foreign exchange receipts and international reserves. The short-run income elasticity estimates oscillate around 0.2, with two out of five estimates being statistically significant at the 1 percent level, and two other estimates significant at the 5 and 10 percent levels (one-tailed test), respectively. The short-run price elasticity estimates oscillate around -0.1, and they are significant in three out of five cases (with one estimate being significant at the 1 percent level, and the other two at the 5 and 10 percent levels, respectively). Long-run elasticities are somewhat higher in absolute value: income elasticities range between 0.2 and 0.4, and price elasticities range between -0.4 and -0.3 (table 2).

Now consider the estimates for the two special cases, the Hemphill and traditional models (text equations 7 and 8, with all variables expressed in logs). Again, all the coefficients have the expected signs, and they are usually statistically significant (at the 1 percent level). Estimates of the foreign exchange and reserve elasticities \((b_1 \text{ and } b_2)\) in the Hemphill model oscillate around 0.5-0.6 and 0.1, respectively. Foreign exchange elasticities \((b_1)\) in the Hemphill model are generally higher than the corresponding elasticities in the general import model, but not by much. By contrast, price and income elasticities \((b_4 \text{ and } b_5)\) in the traditional model are generally much higher than the corresponding elasticities in the general import model. For example, estimates of \(b_4 \text{ and } b_5\) are -0.64 and 1.11 for oil exporters in the traditional model, compared with estimates of -0.23 and 0.20 in the general model. This is what one would expect: when foreign exchange constraints are explicitly considered, imports are likely to be less responsive to variations in the real exchange rate because import restrictions dampen the transmission mechanism of relative prices.

To compare the explanatory power of the general model with the two special cases, I used the conventional \(F\) test. This comparison shows that the general model dominates the traditional model quite strongly in all cases. It also dominates the Hemphill model in two of the four country groups considered (oil exporters and major exporters of manufactures), as well as in the estimates for all developing countries. (The corresponding \(F\)-values are reported in Moran 1987, table A-4.) In no case is the general import model dominated by either the Hemphill or the traditional model (because the former contains as special cases the latter two models). The conclusion is that the general model should be preferred to either the Hemphill or the traditional model. As a consequence, import equations that do not incorporate variables capturing the stringency of foreign exchange constraints \((f_r, r_{-1})\), or relative prices and income \((PM_t/Pr_t, y_t)\) are likely to produce biased estimates due to the omission of relevant
Table 2. Estimates of Long-Run Import Elasticities

<table>
<thead>
<tr>
<th>Country group</th>
<th>General import model with exogenous prices</th>
<th>General import model with endogenous prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Import elasticities (OLS estimates)</td>
<td>Import demand elasticities</td>
</tr>
<tr>
<td></td>
<td>( \varepsilon_i )</td>
<td>( \varepsilon_p )</td>
</tr>
<tr>
<td>Low-income countries</td>
<td>0.83</td>
<td>0.07</td>
</tr>
<tr>
<td>Major exporters of manufactures</td>
<td>0.51</td>
<td>0.13</td>
</tr>
<tr>
<td>Nonfuel primary commodity exporters</td>
<td>0.68</td>
<td>0.06</td>
</tr>
<tr>
<td>Oil exporters</td>
<td>0.71</td>
<td>0.15</td>
</tr>
<tr>
<td>All developing countries</td>
<td>0.68</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Note: \( m_i \) = imports of goods and nonfactor services; \( f_i \) = foreign exchange receipts; \( r_i \) = end-year stock of international reserves; \( P_i \) = import prices; \( P_d \) = domestic prices; \( y \) = gross domestic output (GDP); \( D_i \) = country dummy. The long-run elasticities were calculated as \( \varepsilon_i / (1 - \varepsilon_i) \), or, as \( a_i / (1 - a_i) \), for \( i = f, r, y, p \); except as noted.

- a. In \( m_i = b_0 + b_1 \ln f_i + b_2 \ln r_{i-1} + b_3 \ln m_{i-1} + b_4 \ln (PM/P)_i + b_5 \ln y_i \) (equation 9) estimated by ordinary least squares (OLS).
- b. In \( m_i = a_0 + a_1 \ln (PM/P)_i + a_2 \ln y_i + a_3 \ln m_{i-1} \) (equation 13) estimated by OLS.
- c. Equation 13, estimated by two-stage least squares (2SLS).
- d. Estimates of \( a_1 \) (\( a_3 \) was not statistically significant at conventional significance levels).
- e. Estimates of \( a_2 \) (\( a_3 \) was not statistically significant at conventional significance levels).

Source: Full definitions, countries, and data sources are detailed in the appendix.
variables. The main weakness of these models, however, is that they implicitly assume that the real import price is exogenous, an assumption corrected in the second model.

The second general model, formed by equations 13 and 14, assumes that import volumes and relative import prices are both endogenous. Since import prices do not appear explicitly in equation 14, consistent estimates of this equation can be obtained by ordinary least squares. The import supply equation 14 is identical to the Hemphill model 8 (with all variables expressed in logs), the estimates of which are shown in table 1 and were already discussed. The OLS estimates of the import demand equation 13, however, are biased and inconsistent if $(PM/P)_t$ is endogenous. In this case, consistent estimates of the import demand equation can be obtained through the use of an instrumental variable estimator, such as two-stage least squares (2SLS)—reported in the last set of regressions for each country group in table 1. Observe that the price and income elasticity estimates of this model changed significantly when compared with the OLS estimates of the traditional model (equation 7). For example, the new estimate of the price elasticity for oil exporters is $-1.41$, compared with a previous estimate of $-0.64$. These results suggest that the OLS bias in the price elasticity of import demand may be substantial.

A formal Wu-Hausman test was used to test for the implicit bias in the OLS estimate of the price elasticity of import demand $(a_1)$ in equation 13 (see Thurman 1986 for a discussion of this test). The results of this test suggest that the bias in the estimate of $a_1$ is substantial, except for low-income countries. In sum, the results of an import model which allows for endogenous prices (and an explicit role for foreign exchange receipts), suggest that the traditional price and income elasticity estimates of import demand obtained by OLS are likely to be subject to significant biases.

III. SUMMARY AND CONCLUSIONS

In the 1980s, imports in developing countries have been constrained by shortages of foreign exchange. Government policy in response to these shortages has included changes in the exchange rate and the imposition of tariffs and other barriers that affect the domestic price of imports and thus also affect import demand. These factors should be incorporated in models developed to estimate the level of import demand: without them, the results will be biased due to the omission of relevant variables, or due to the simultaneity of import volumes and relative import prices.

Two main import models were developed to account for these factors. The first model introduced two sets of explanatory variables: relative prices and domestic output; and foreign exchange receipts and international reserves. The reduced form estimates obtained from this model produced long-run foreign exchange elasticities that ranged between 0.5 and 0.8, reserve elasticities that
oscillated around 0.1, price elasticities that ranged between −0.3 and −0.04, and income elasticities that ranged between 0.2 and 0.4 (table 2). This general import model contains as special cases the models normally adopted in the estimation of import equations—the traditional and Hemphill models. A simple $F$ test was then used to determine whether this general model dominated each of the two submodels. The general model dominates strongly the traditional model in all cases. It also dominates the Hemphill model in two of the four country groups considered and in the estimates for all developing countries. Thus the elasticities obtained from either of the two submodels are likely to be biased due to the omission of relevant variables. The main concern with these results, however, is that the real import price is assumed to be exogenous in the estimation of these models.

The second import model developed here assumes that import volumes and relative import prices are both endogenous, and allows explicit testing of the latter assumption. This second model includes two independent structural equations: an infinitely inelastic import-supply curve, and a normal downward sloping demand curve. Two implications of this model were noted. First, if one is unwilling to make special assumptions about the cross-correlation of error terms in these two equations, both endogenous variables are determined simultaneously. Second, the import demand curve cannot be estimated by ordinary least squares since this will produce biased and inconsistent estimates of its parameters. To test for the implicit bias in the OLS estimates (or, for the endogeneity of the real import price), the Wu-Hausman test was performed, a test that compares formally these estimates with those obtained with a consistent procedure, such as two-stage least squares. This test showed that the OLS estimates of the import demand curve are subject to significant biases, a result that again confirms the importance of foreign exchange constraints in the analysis of import behavior in developing countries. The long-run price and income elasticity estimates of import demand for each of four country groups, using OLS and 2SLS, are reported in the last four columns of table 2. In all cases, the 2SLS estimates—which use foreign exchange receipts and international reserves as instruments—are much higher in absolute value than the corresponding estimates obtained with OLS.

Two main conclusions emerge from the present study. First, although price and income effects are important in the analysis of import behavior in developing countries, foreign exchange constraints also play a critical role in determining imports—as they strongly affect import volumes. Second, since governments are likely to increase domestic prices of imports in the face of these constraints, import demand estimation should also account for the endogeneity of these prices. Import models that neglect either of these factors will yield biased estimates for developing-country imports.

An important implication of these results is that policymakers willing to increase imports in developing countries should look to a broader set of policies
than those traditionally considered (fiscal and monetary policies that affect income, or exchange rate policies that affect relative prices). Those broader policies should focus on increasing available foreign exchange.

IV. AREAS OF FUTURE RESEARCH

This article presents a model of import behavior for developing countries which, I believe, captures the important elements of import response in a manner most amenable to analysis for policy decisions in developing countries. In particular applications, however, analysts will need to take a careful look at some of the key assumptions underlying this approach. I briefly mention three areas in which more sophisticated techniques would enrich the analysis and may have a significant effect on the results discussed here.

The first area concerns the simplicity of the dynamic structure in the models presented. The second area concerns the economic rationale underlying both the Hemphill and the general import models. The third area concerns the exogeneity assumption of foreign exchange receipts and domestic output in these models.

Consider first the dynamic structure. Only one lagged dependent variable was introduced to capture adjustment costs, that is, to capture the costs of changes in the level of imports from one period to the next, due to changes in the exogenous variables. The implicit dynamic structure of this model, known in the literature as the "partial adjustment" model, has been criticized as being too simple to capture the interaction between past and current levels of import determinants. Instead, Hendry and others (1986) have proposed the use of a general dynamic structure, which in the case of the Hemphill model can be written in the following way:

\[ \psi(L)m_t = \theta_1(L)f_t + \theta_2(L)r_{t-1} + \epsilon_t \]

where \( \psi(L) \), \( \theta_1(L) \) and \( \theta_2(L) \) are polynomials in the lag operator \( L \), and \( \epsilon_t \) is a random noise process. To facilitate its implementation, they have proposed a set of tests to obtain a parsimonious representation. (See Hendry and others 1986 for the details of this procedure. In Moran 1987, I discuss how the general dynamic structure proposed by Hendry and others can be incorporated in the import models discussed here.) Once the implicit dynamics are captured adequately, the resulting equation can then be used for predictive purposes.

Another area of concern is the economic rationale behind the optimization function used by Hemphill, and its generalization (equation 1). Despite its intuitive appeal, this optimization function is somewhat ad hoc. An alternative scheme with a clear theoretic economic rationale has been developed by Sachs (1981, 1982) and Dornbusch (1983). In these studies, imports are derived from

4. Hemphill (1974) also considers one lagged value of foreign exchange receipts, but the coefficient associated with that variable did not prove significant in this study.
an intertemporal utility maximization problem, in which expectations of future events and wealth are central determinants of import response. This scheme is clearly more appealing from a theoretical standpoint than the approach adopted here, but it is difficult to implement empirically.

Winters (1987) developed two empirical versions of these models (which he labeled "equilibrium" and "disequilibrium" versions) and found that the results, although promising, are not without problems, and that the empirical estimates do not appear much better than other simpler alternatives, such as the Hemphill model. More important, however, is the fact that the intertemporal models developed by Sachs and Dornbusch assume perfect capital markets (the country can borrow unlimited amounts at a constant interest rate), an assumption that may not be appropriate for most developing countries, particularly in the 1980s. Thus, although Winters' results clearly vindicate the simple Hemphill model, and its generalization, the general import model developed here, there is obviously scope for improvement in the theoretical basis and specification of these models.

Finally, consider the exogeneity assumption about foreign exchange receipts, $f_t$, and total value added, $y_t$. In section 1, I assumed that $f_t$ and $y_t$ are exogenous to the current import decision. A problem arises, however, if we believe that governments respond to foreign exchange shortages by increasing external borrowing, making $f_t$ endogenous. It would then be necessary to redefine $f_t$ by excluding the endogenous component of net capital inflows. Hemphill (1974) and Winters and Yu (1985) have discussed the difficulties of this distinction. The problem may be complicated further. For example, a sudden shortfall in imports due to a cutback in foreign lending may have an effect on exports or on total value added (GDP) in the same period, as essential imported inputs are curtailed. Reserves can be used to cut this contemporaneous link, but this possibility is available only for a limited time. In short, the exogeneity of $f_t$ and $y_t$ should be tested rather than assumed, using tests such as those proposed by Granger and Sims (see Geweke 1986 for a recent survey of this literature). If these tests show any sign of feedback, a more general model—where $f_t$, $y_t$, and $m_t$ are simultaneously determined—will have to be developed. This general model could then be estimated simultaneously, or the appropriate reduced form for imports derived and then estimated.

APPENDIX

The Data

$m_t = \text{Imports of goods and nonfactor services (GNFS) in U.S. dollars, obtained from the World Bank's balance of payments data base, deflated by PM}_t.$

5. I used $PM_t$ as the appropriate deflator because there is no deflator for imports of GNFS at the country level derived with a comparable methodology (the implicit national accounts deflator will not be appropriate for this purpose).
PMt = Merchandise import deflator in U.S. dollars, calculated by the World Bank (based on disaggregated import data at the country level).
Pt = GDP deflator in U.S. dollars, obtained from the World Bank’s national accounts data base.
Yt = GDP at market prices in constant dollars, obtained from the World Bank’s national accounts data base.
r = End-year stock of international reserves, obtained from the World Bank’s balance of payments data base, deflated by PMt.
f = Foreign exchange receipts = exports of goods and nonfactor services + net factor income + net transfers + capital inflows (including direct private investment, long- and short-term loans, plus errors and omissions), obtained from the World Bank’s balance of payments data base, deflated by PMt.

Country Classification

The countries were chosen to represent each of the main groups distinguished in World Bank (1986): Low-income countries: India, Kenya, Pakistan, Senegal, Sudan. Major exporters of manufactures: Argentina, Brazil, Republic of Korea, Portugal, Thailand, Yugoslavia. Nonfuel primary commodity exporters (= other oil importers): Chile, Colombia, Côte d’Ivoire, Morocco, Turkey. Oil exporters: Algeria, Indonesia, Mexico, Nigeria, Peru.

REFERENCES


6. I also used a narrower definition of foreign exchange receipts which excluded short-term borrowing. The results obtained with the broader definition, however, were consistently better.


