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by

Jaime Marquez
Caryl McNeilly

ABSTRACT

Interest in income and price elasticities for international trade has increased recently because of the debt crisis that many developing countries are experiencing. Estimates of income elasticities of import demand, however, range from a low of 1.3 to a high of 4.7. Such differences have important implications for debtor and creditor countries alike. Using quarterly data for the period 1973-1981, this paper estimates income and price elasticities for non-oil imports of five major industrial countries from non-OPEC developing countries. The empirical results suggest that the income elasticity is closer to 1 than to 4.

Can Debtor Countries Service Their Debts? Income and Price Elasticities for Exports of Developing Countries

Jaime Marquez
International Finance Division
Federal Reserve Board
Washington, D.C. 20551

and

Caryl McNeilly
Woodrow Wilson School of Public and International Affairs
Princeton University
Princeton, N.J. 08544

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Interest in income and price elasticities for international trade has increased recently because of the debt crisis that many developing countries are experiencing. Estimates of income elasticities of import demand, however, range from a low of 1.3 to a high of 4.7. Such differences have important implications for debtor and creditor countries alike. Using quarterly data for the period 1973-1981, this paper estimates income and price elasticities for non-oil imports of five major industrial countries from non-OPEC developing countries. The empirical results suggest that the income elasticity is closer to 1 than to 4.

This paper is part of a larger modeling effort of trade and financial relations between major industrial countries and developing countries for the Multi-Country Model of the Federal Reserve Board. The work of McNeilly was completed while she was at the Board. We have benefited from the comments of F. Gerard Adams, William Cline, Russell Cooper, Vittorio Corbo, Jonathan Eaton, Neil Ericsson, Mike Gavin, Peter Hooper, Mohsin Khan, Cathy Mann, Marc Noland, Charles Siegman, and Ralph Tryon. Woodrow Bellamy provided helpful research assistance. This paper has been presented in seminars at the Federal Reserve Board and the World Bank. This paper represents the views of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or other members of its staff.

Introduction

This paper estimates income and price elasticities of non-oil imports of major industrial countries from developing countries. Besides their traditional role in analyses of international linkages and trade policies, knowledge of these elasticities is crucial to designing policy responses to the existing debt crisis.[1] From the debtors' standpoint, both stabilization policies and debt rescheduling agreements hinge on balance of payment projections that are crucially dependent on the choice of elasticity estimates. Moreover, whether these countries will, in general, be able to service their external debt depends on the response of their exports to growth in industrial countries, a response that is ultimately determined by income and price elasticities.

Knowledge of these elasticities is also relevant for policymaking in industrial countries. A restrictive monetary policy stance in the United States makes it more difficult for debtor countries to service their debt. Both the increase in interest rates and the induced contraction in U.S. imports reduce the debt-servicing capacity of debtor countries, a reduction that might feed back to the United States as declines in exports and disruptions in financial markets. An important component in determining the magnitude of these feedback effects is the income elasticity for industrial-country imports from developing countries.

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[1]See the studies of Cline (1984, 1985), Dooley et. al. (1983), Adams et. al. (1983), Dornbusch (1985), Riedel (1984), Goldstein and Khan (1982), and Bond (1985). For the debate on the policy implications of different elasticity estimates for the United States, see the testimonies of William Cline and Rudiger Dornbusch before the Joint Economic Committee, March 28, 1984. See also the exchange between Cline and Dornbusch in the Brookings Papers No.2, 1985.

Despite the increased attention given to these elasticities, an examination of the more influential studies reveals a lack of consensus regarding their values. Dornbusch (1985) states that

> **"...the elasticity estimate of LDC export growth with respect to OECD growth cannot be pinned down. ... At this stage there is certainly no firm finding, here or in the literature, regarding the elasticity."** (p. 336-37)

Unsatisfactory as it may be, Dornbusch's characterization is quite accurate. Existing estimates of the income elasticity for non-oil exports of developing countries range from 1.3 (Goldstein and Khan 1982) to 4.7 (Dornbusch 1985). Differences this large in elasticity estimates need to be addressed because of their importance for policy design in both debtor and creditor countries.

To place the analysis in perspective, section 2 reviews the more influential papers in this area. This review reveals that existing elasticity estimates are subject to biases arising from the omission of relevant variables, country aggregation, and simultaneity, all of which limit the applicability of existing estimates to practical problems. Section 3 describes the import demand model used to estimate income and price elasticities of non-oil imports of Canada, Germany, Japan, the United Kingdom, and the United States from non-OPEC developing countries. Econometric estimation of these elasticities requires a fair amount of sensitivity analysis coupled with hypothesis testing. This paper tests the maintained assumptions for the error term (normality, serial independence and homoskedasticity), the structural stability of parameter estimates, the homogeneity of degree zero in prices, and the dynamic specification.

A second contribution of this paper is the construction of quarterly time series for non-oil imports for the above five countries from non-OPEC developing countries. To our knowledge, this kind of information is not publicly available and thus section 4 describes the methodology used to construct the data. Section 5 presents our empirical estimates for income and price elasticities for each of the five countries and uses them to examine the relation between OECD growth and interest rates consistent with sustainable debt servicing by developing countries. The main findings are that the OECD-aggregate income elasticity varies between 1.3 and 1.6, and that sustainable debt servicing requires a 1/2 percent increase in OECD growth for every 1 percent increase in interest rates. Section 6 summarizes the paper and suggests avenues for further research.

2. Review of Existing Studies

Table 1 lists the more salient features of several studies of developing countries' exports. An examination of these features reveals important limitations that limit the applicability of their findings to practical questions. First, the own-price elasticity of import demand is commonly assumed to be zero. In addition to being unrealistic, this assumption might induce a bias in the estimate of the income elasticity and thus be responsible for much of the controversy about its magnitude.

Second, importers are generally treated as if they were small economies, a tenable assumption for countries with little participation in international trade, but an untenable one for most of the countries considered here, either separately or when they are treated as a bloc.

Higher growth in industrial countries is certain to increase non-oil imports from developing countries with a corresponding impact on their price. Although the small country assumption might be relaxed by using two-stage least squares, many studies in this area rely on ordinary least squares for parameter estimation.[2]

Third, an examination of the nature of the data used in previous studies suggests that available elasticity estimates are not strictly comparable to each other. On the one hand, Cline (1984) focuses on multilateral non-oil imports of the bloc of industrial countries, which include non-oil imports of OECD countries from themselves.[3] On the other hand, Dornbusch examines multilateral non-oil exports of developing countries, which include non-oil exports of developing countries to themselves. It is immediately clear that neither of these two measures of multilateral trade are suitable for estimating the income response of imports of industrial countries from developing countries. Furthermore, changes in the country composition of multilateral trade flows might be responsible for the erratic

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[2]Grossman's (1982) analysis does not suffer from the limitations mentioned above, but it only applies to 0.7 percent of U.S. imports. (The 1978 value of U.S. imports from developing countries in Grossman's paper is $1.2 billion, whereas U. S. total imports in 1978 were $183 billion, $42 billion of which were imports from non-oil developing countries (IMF, Direction of Trade, Yearbook 1981, p. 380).) This study makes it possible to establish the extent to which Grossman's findings extend to a non-oil commodity aggregate and the degree to which they apply to other industrial countries.

[3]This point has already been observed by Dornbusch (1985). Note that according to IMF data (Supplement on Trade Statistics, 1982, p.80), only 16 percent of total imports of the OECD region come from non-oil developing countries. This share is even lower for non-oil imports. Similarly, according to IMF data only 57 percent of exports of developing countries flow to industrial countries.

behavior of the aggregate elasticity estimates noted by Dornbusch (1985).[4]

Finally, almost all of these studies rely on import relations between country blocs. From a policy standpoint, aggregation across countries allows us to study how exports of developing countries fluctuate in response to the business cycle of all industrial countries. But unless all importing countries are identical, the resulting elasticity estimates are not helpful for analyzing the effects on trade of developing countries of stabilization policies of a particular importing country. From an econometric standpoint, the chief drawback of country aggregation is the potential for aggregation biases.

To emphasize these biases, table 2 presents income elasticities estimated using data at different levels of aggregation: data for our five countries (Canada, Germany, Japan, the United Kingdom, the United States) considered as one bloc, data at the country level, and a pooled sample of our five countries. The elasticity estimates are based on a linear regression of the growth rate of non-oil imports on the GNP growth rate, which is the specification used by Cline (1984). The elasticity estimated with data aggregated across countries is 2.9, which is relatively close to the estimate of Cline (1984). However, the elasticity estimates using individual country data range from -1.2 for Japan to 5.9 for the United States. To determine whether these

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[4]The use of multilateral trade flows might bias the price elasticity. For example, Bergsten and Cline (1983) do not allow for price effects in their estimating equation. However, empirical tests using their published data reveal that prices exert a negative, but insignificant, influence on imports. This apparent absence of price effects might be the result of a negative price elasticity for imports from non-OECD countries being offset by a positive price elasticity for OECD exports to themselves, which Bergsten and Cline include in their import data.

differences in country elasticities are significant, they are estimated with a pooled sample of our five countries (fixed effects). With an F-test for the hypothesis of equal elasticity across countries, the evidence suggests that such differences are indeed significant. The results of table 2 also suggest that the behavior of U.S. imports might be the dominant force in explaining the behavior of aggregate imports and thus largely responsible for the differences in estimates due to country aggregation. This last possibility is empirically supported by F-tests rejecting the null hypothesis of equality between the U.S. income elasticity and any other country's income elasticity.

Several conclusions emerge from this review and from the results of table 2. First, growth in non-oil exports of developing countries is inadequately explained by growth of importers alone. Failure to account for price effects and dynamic adjustments could result in biased and erratic income elasticities. Second, estimation methods need to recognize that ordinary least squares do not capture general equilibrium effects, which might be responsible for a simultaneity bias. Finally, reliance on multilateral trade flows aggregated across countries might impart a certain instability to parameter estimates. Changes in the country composition of an aggregate trade flow could lead to changes in the aggregate elasticity estimate even if the elasticities at the country level remain unchanged.

3. Empirical modeling of import demand

3.1 The imperfect substitute model

This analysis assumes that domestically produced goods are imperfect substitutes for non-oil imports from developing countries, and that these imports are separable with respect to oil purchases. As a result, the demand for these imports can be expressed as

$$M_t = F(Y_t, P_t, Q_t), \quad (1)$$

where $F_y > 0$, $F_p < 0$, $F_q \gtrless 0$,

- M_t = quantity of non-oil imports from developing countries,
- Y_t = importer's real income,
- P_t = price of imports relative to the price of domestic goods; $= (P_{xt}/E_t)/P_{yt}$;
- P_{xt} = dollar price for non-oil exports of developing countries;
- E_t = exchange rate, dollar/foreign currency;
- P_{yt} = GDP deflator for the importer;
- Q_t = price of imports relative to price of developed countries; $= P_{xt}/Q_{xt}$;
- Q_{xt} = dollar price for exports from developed countries.

According to (1), increases in either domestic income or domestic prices raises non-oil imports from developing countries. In addition, (1) allows imports from developed countries to be either complements ($F_q > 0$) or substitutes ($F_q < 0$) to non-oil imports from developing countries.

3.2 Econometric Specification and Hypothesis Testing

For empirical applications, economic theory provides generally little more than the selection of relevant variables and their anticipated effects. As a result, pinning down elasticity estimates requires a significant amount of hypothesis testing. This paper tests for the functional form of (1), for the maintained assumptions of the error term (normality, homoskedasticity, and serial independence), for the parameter restrictions imposed in the dynamic specifications, for parameter constancy, and finally, for price homogeneity.[5] Appendix 1 tests these hypotheses when the income elasticity is allowed to vary over the business cycle.[6]

The results from Box-Cox tests (presented in appendix 1), provide partial support for a log-linear formulation:[7]

$$(2)\ \ln M_t = \alpha_0 + \sum_\ell \alpha_{1\ell} L^\ell \ln Y_t + \sum_\ell \alpha_{2\ell} L^\ell \ln P_t + \sum_\ell \alpha_{3\ell} L^\ell \ln Q_t + \delta \ln M_{t-1} + \sum_i \phi_i S_i + \theta D + u_t ,$$

where L is the lag operator, S_i is a seasonal dummy for the ith quarter, D is a dummy for one-time events (e.g., dock strikes), and u is a white noise random term. Besides being the more commonly used formulation, the choice of (2) allows the parameters to be interpreted as elasticities, which facilitates the computation of the test-statistic for the hypothesis of price homogeneity.

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[5]The above tests are performed with the GIVE computer software developed by David Hendry. With the exception of normality and homoskedasticity, Thursby and Thursby (1984) test for these hypotheses as well as for the independence between residuals and predetermined variables. Because this paper uses two-stage least squares for parameter estimation, such independence is not being assumed here.

[6]This possibility has been examined by Marston (1971), Khan and Ross (1975), and Haynes and Stone (1983), among others. In the present context, such distinction might be useful to determine the long-run prospects for the balance of payments of developing countries.

[7]The Box-Cox tests of Khan and Ross (1977) for total multilateral imports suggest a log-linear formulation. For non-oil imports from non-oil developing countries, the Box-Cox tests provide only partial support for a log-linear formulation because the log-likelihood function is very flat. In turn, this flatness is due to a relatively constant import-GDP ratio throughout the sample (see data appendix). Although this constancy suggests that the elasticity estimates are invariant to a choice between a logarithmic or a linear specification, this invariance does not apply to the properties of the error term, a point stressed by Seaks and Layson (1983). The Box-Cox tests performed here check for serial correlation, homoskedasticity, and normality, the last of which is the fundamental basis for standard Box-Cox tests.

The error term is generally assumed to satisfy the assumptions needed for classical inference -- namely, serial independence, normality, and homoskedasticity. While serial correlation is usually tested, the other two assumptions are taken as valid. This paper follows the suggestion of Thursby and Thursby (1984) to examine the possibility of serial correlation of order greater than one, in addition to the Durbin-Watson statistic. To this end, we test the null hypothesis that all the coefficients of an AR(4) for the residual are equal to zero.

The hypothesis that the residuals behave according to the normal distribution is tested with the Jarque-Bera statistic (Jarque and Bera 1980), denoted here as JB:

$$(3) \qquad JB = T\left(\mu_3^2/(6\mu_2^3) + (1/24)(\mu_4/\mu_2^2 - 3)^2\right) \sim \chi^2(2),$$

where T is sample size and μ_j is the jth central moment of the distribution of the estimated residuals, $\hat{u}$. The first term of (3) measures the skewness of the distribution of $\hat{u}$ whereas the second term measures the departure of the estimated kurtosis from the kurtosis associated with the normal distribution. The test for homoskedasticity is based on the work of Engle (1982) on autoregressive conditional heteroskedasticity (ARCH). Based on the following model

$$(4) \qquad E(\hat{u}^2;\hat{u}_{t-1}) = \gamma_0 + \gamma_1 \hat{u}_{t-1}^2 ,$$

the null hypothesis of homoskedasticity cannot be rejected if $\gamma_1=0$, which is tested with a t-statistic.

The response of imports to changes in either income or prices is generally subject to some delay. Contracts, delivery lags, and uncertainty over future supply conditions may account for such a delayed response. Failure to recognize lagged responses could potentially bias the income elasticity estimates with implications for the design of policy responses to the debt crisis. From an empirical standpoint, the key issues are the length of time that it takes for imports to adjust fully and the nature of the adjustment process. To maintain the analysis at a manageable scale, it is assumed that the full response takes place in one year (Grossman 1982 and Goldstein and Khan 1985) and that the dynamic response follows either a Koyck adjustment lag or an Almon distributed lag.[8]

Testing for the validity of the restrictions imposed by these two dynamic specifications involves comparing the sum of squared residuals for both the original and an "unrestricted" dynamic specification. The latter is constructed by eliminating the parameter restrictions associated with the original dynamic specification and adding, as regressors, all predetermined variables lagged one period.[9] The associated test-statistic under the null hypothesis is

$$F=\left((SSR_0 - SSR_1)/n\right)/\left(SSR_1/(T-K)\right) \sim F(n,\ T-K), \qquad (5)$$

where SSR_0 = sum of squared residuals under the null hypothesis,
SSR_1 = sum of squared residuals under the alternative hypothesis,
n = number of additional parameters,
K = number of regressors.

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[8]For the Koyck distributed lag, $\alpha_{j\ell}$ is set to zero for $\ell>1$ and all j. For the Almon distributed lag, δ is set to zero. The Almon lag is assumed to follow a second degree polynomial as in Thursby and Thursby (1984). Endpoint restrictions in this polynomial were needed to avoid the multicollinearity problems, which are also indicated by Grossman (1982). As Klein et. al. (1985) point out, multicollinearity problems are more serious for two-stage least squares than for OLS.

[9]Note that the construction of the unrestricted specification will not include the lagged dependent variable if this variable already exists in the original specification.

Although this test is powerless to discriminate among various specifications for which the null hypothesis is not rejected, it indicates whether a given dynamic specification is not valid.

Constancy in structural parameter estimates is needed to forecast accurately the consequences of either policy decisions or changes in the exogenous variables. However, structural parameters may be changing because of changes in trade patterns during the process of economic development or in government policies. Furthermore, one may question the hypothesis of parameter constancy in light of the pronounced changes in oil prices and exchange rates of the seventies. To test for this hypothesis, (2) is first estimated with data through 1979 and then used to forecast non-oil imports through 1981. Under the null hypothesis of parameter constancy the expected forecast error is zero, and the associated test-statistic is (Chow 1960, p. 560)

$$(6) \quad \Big(\sum_{t=1}^{T} \hat{u}(t)^2 - \sum_{t=1}^{T_1} \hat{u}(t)^2 \Big) / T_2 \; / \Big(\sum_{t=1}^{T_1} \hat{u}(t)^2 / (T_1 - K) \Big) \sim F(T_2, T_1 - K).$$

where T_1 = number of observations in the estimation period,
T_2 = number of observations in the forecast period.

Price homogeneity may not hold in empirical analysis with macrodata such as ours. Aggregation across commodities or use of unit value indexes as a proxy for transaction prices may account for an empirical rejection of price homogeneity. Therefore, it might be of interest to examine whether price homogeneity holds. Given the log-linear specification, testing for price homogeneity amounts to expressing (2) in terms of price levels and then testing whether the sum of price coefficients is zero. The test-statistic for this hypothesis is distributed as F(1, T-K).[10]

4. Data construction

Central to this analysis is the availability of quarterly time series of non-oil imports for Canada, Germany, Japan, the United Kingdom, and the United States from non-OPEC developing countries. Since, as far as we are aware, data of this nature are not publicly available, a detailed explanation of the methodology for its construction and the associated sources appears in the data appendix.[11]

Non-oil imports from developing countries are derived as the difference between total and oil imports, both from developing countries. Data for each country's total imports from developing countries, measured in dollars, are obtained from the Direction of Trade compiled by the International Monetary Fund.[12] Data for each country's oil imports from non-OPEC developing countries, in value terms, are not readily available. However, data on bilateral oil imports (crude plus products) for each of the five countries from non-OPEC developing

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[10]The validity of price homogeneity is tested at each point in time and not just in the long-run. For the Koyck lag, the null hypothesis is $\varepsilon_{px} + \varepsilon_{p} + \varepsilon_{qx}=0$ where ε_i is the compensated price elasticity for the ith price; for the Almon lag, the null hypothesis is $\psi_{px,2} + \psi_{p,2} + \psi_{qx,2}=0$, where $\psi_{i,2}$ is the quadratic term in the Almon polynomial for the ith price. If there are no cross-price effects, then $\psi_{qx,2}=\varepsilon_{qx}=0$.

[11]The Yearbook of International Trade Statistics, published by the United Nations, presents bilateral trade flows with commodity disaggregation, but on an annual basis.

[12]The Direction of Trade does not include bilateral trade flows disaggregated by commodity. In addition, data for Ecuador and Gabon need to be excluded from the group of non-oil developing countries and included in the group of oil-exporting countries, which is the basis for our calculations.

countries, measured in barrels per day, can be obtained from the Quarterly Oil Statistics compiled by the Organization for Economic Cooperation and Development.[13]

With data on oil import prices, one can estimate the value of oil imports from developing countries. Note, however, that neither OPEC's official price nor the spot price are ideally suited to value oil imports from non-OPEC developing countries. Differences in the sulphur content of oil imports from alternative suppliers, in the crude-product composition of imports, and in transportation costs limit considerably the usefulness of the above prices in our study. To bypass this problem, the paper computes first a price of oil for each country as the ratio between the value of total oil imports and the total volume of oil imports. This average price, which is influenced by oil purchases from OPEC, is then adjusted to take into account the existing country-differences in the crude-product composition of oil imports, the different regional sources for imports, and the different gravities of crude oil.

With data on the value of oil imports from developing countries, non-oil imports are computed as the difference between total and oil imports, both from developing countries. As a percentage in 1981, non-oil imports from developing countries account for 5.2 percent of total imports for Canada, 12.3 percent for Germany, 13.9 percent for Japan, 13.6 percent for the United Kingdom, and 18.9 percent for the

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[13]The earliest date covered by this source, on a quarterly basis, is 1973, which determines the starting period of our analysis. This data source measures oil in metric tons; the data in this study are converted to barrels using standard conversion factors.

United States. The aggregate of these imports account for 56.6 percent of total exports of developing countries to industrial countries.

The price for non-oil exports of developing countries, P_X, is a weighted geometric average of the prices of non-oil raw materials and of manufactures. The weights vary over time and are equal to the (normalized) shares of these two classes of goods in merchandise exports of non-OPEC developing countries. Note that this export price is based on multilateral trade weights, which is a limitation of our analysis. However, we found no better alternative. Each country's real non-oil imports from non-OPEC, M, are obtained by deflating their nominal non-oil imports by the non-oil dollar export price of developing countries.

The export price of developed countries, Q_X, is a weighted geometric average of their dollar export prices, with weights changing over time and equal to bilateral trade shares. Finally, the exchange rate, the GDP deflator and real GNP for each country are conventionally defined. The data appendix contains the official data sources, the details regarding the constructions of our data set, and time-series plots of the more relevant relations.

5. Empirical Results

5.1 Elasticity Estimates

The parameters associated with (2) are estimated using two-stage least squares with quarterly data for the period 1974I to 1981IV. In addition to considering two lag adjustments, we test for the importance of cross-price effects, which results in a total of four estimating equations per country. Table 3 displays the long-run estimates of income and price elasticities and the significance levels associated with each of the six hypotheses described in section 3.[14]

For Canada, the long-run income elasticity ranges between 1.0 and 1.5. The own-price elasticity ranges between -0.3 and -0.9 whereas the cross-price elasticity varies between -0.4 and -0.9. Based on the test-results, the best specification for Canada allows cross-price effects with a Koyck distributed lag. For this specification, it is not possible to reject the hypotheses of normality, serial independence, and homoskedasticity. Furthermore, the data support the hypotheses of price homogeneity and parameter constancy.

For Germany, the income elasticity ranges between 1.9 and 2.0, which is a narrow range of variation. The own-price elasticity ranges from -1.0 to -1.3, whereas the cross-price elasticity varies from -0.1 to -0.5. The only specification fully supported by the data has a Koyck distributed lag with no cross-price effects. For this specification, all three hypotheses about the residual are accepted; similarly, the hypotheses of price homogeneity, and parameter constancy cannot be rejected by the data.

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[14]Predicted values for the export price are generated according to (t-statistics in parentheses):

$$P_{xt} = \underset{(0.9)}{0.82} + \underset{(1.8)}{0.000757Y_{t-1}} - \underset{(-4.6)}{0.0173EX_{t-1}} + \underset{(3.0)}{0.0174PDOM_{t-1}}, \quad R^2=0.95, \quad 1971I-1981IV$$

where Y is our five-country GDP aggregate, in 1972 dollars and exchange rates; EX is the weighted average value of the dollar, and PDOM is the weighted average value of consumer price indexes for the five countries with 1972 exchange rates. The sample means of these variables are 1.885 for P_x, 2313 for Y, 100.841 for EX, and 60.69 for PDOM.

For Japan, the own-price elasticity ranges from -1.3 to -1.4 whereas the cross-price elasticity turns out to be not statistically significant. The results also point to a negative income elasticity that ranges from -0.2 to -0.4, being rather significant for the Almon specification. A negative income elasticity for imports is not necessarily in contradiction with economic theory if domestic goods are perfect substitutes for imports. Under this assumption, Magee (1975) establishes that imports will have a negative income elasticity when the income response of the domestic demand for importables is sufficiently small.[15] In this case, an increase in income is associated with greater production of domestic importables, which reduces the import gap. Because the composition of developing countries' exports has been shifting towards the kind of goods that Japan produces, an increase in real income in Japan means greater availability of domestic importables, which reduces Japan's imports from developing countries.[16] Note that this negative income elasticity is not due to a violation of the maintained hypotheses for the error term. Furthermore, the data support the hypotheses of price homogeneity, lag structure, and parameter constancy.

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[15]This condition can be stated as $(SI/DI)\eta_{s,y}>\eta_{d,y}$, where $\eta_{s,y}$ and $\eta_{d,y}$ are the domestic income elasticity of supply and demand respectively, and SI and DI are the domestic supply and demand for importables.

[16]Japan's negative income elasticity for these imports might be the result of a sustained shift away from developing countries and towards developed countries as a source of inputs. Lower quality and unreliable supply of the former countries may account for such a shift. Khan and Ross (1975) find a negative elasticity for potential income in total, multilateral imports of Japan. Appendix 1 allows for cyclical and secular income effects, but the results still point to a negative income elasticity.

For the United Kingdom, the income elasticity estimate varies from 1.5 to 2.1. The own-price elasticity ranges from -0.1 to -0.2, whereas the cross-price elasticity is not significantly different from zero. The data support the hypotheses of normality, homoskedasticity, price homogeneity, parameter constancy, and dynamic specification. However, the residuals have serial correlation of order greater than one, a problem not detected by the Durbin-Watson statistic. In view of this serial correlation, it is difficult to give full credit to the test results for the United Kingdom, which suggests that the associated estimates should be seen as tentative.[17]

For the United States, the income elasticity ranges from 1.8 to 2.2. The estimate of the own-price elasticity ranges from -0.5 to -2.9, whereas the cross-price elasticity varies from -0.4 to -2.9. The test results reveal that, of the three hypotheses for the error term, only homoskedasticity is rejected by the data with any consistency. The Almon distributed lag with cross-price effects produces the more reasonable estimates, even though this lag structure is not fully supported by the data. The alternative specifications, while consistent with the statistical criteria, do not have significant price elasticities which is in direct contradiction to the available evidence (Grossman 1982, Warner and Kreinin 1983).

The evidence of table 3 suggests several general propositions. First, income elasticities estimated at the country level do not display any tendency towards the estimates of either Cline (1984) or Dornbusch

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[17]When the serial correlation problem is corrected, the estimates for income, own- and cross price elasticities remain virtually unchanged. The reason to present the specification with the serially correlated errors is to maintain uniformity of specification across countries.

(1985). Rather, they reveal a tendency towards a value of 1.5, which is consistent with the evidence of Thursby and Thursby (1984) and Goldstein and Khan (1985). To emphasize these differences, table 4 uses the results of table 3 to compute income and price elasticities for an OECD-aggregate. The results indicate that the aggregate income elasticity varies between 1.3 and 1.6, which is not only a narrow range of variation, but one that is far below the elasticity estimates of Cline and Dornbusch.[18]

Second, with the exception of Canada and the United Kingdom, the estimates of the own-price elasticity are smaller than both -1 and the cross-price elasticity. This evidence suggests that non-oil imports from developing countries face greater competition from domestic goods than from exports of developed countries, which is consistent with the findings of Grossman (1982). From a commercial policy standpoint, large own-price elasticities suggest that protectionist actions might be effective in eliminating competition from developing countries. But by the same token, this effectiveness might exacerbate debt-servicing difficulties of the latter countries with a potentially adverse feedback effect on OECD countries. Third, the Koyck lag adjustment seems to receive greater support from the data than the Almon specification, a finding already noted by Thursby and Thursby (1984).

Overall, the elasticity estimates shown in table 3 are consistent with both economic theory and estimates from independent

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[18]Note that Riedel estimates an income elasticity close to ours, despite his assumption of no price effects. However, his analysis is valid until 1978 and refers to manufactured goods only, which because of their relatively high price elasticity, tend to display relatively small price variations that might lead to statistically insignificant price effects.

studies, possess a narrow range of variation, and satisfy a number of statistical criteria. All of these considerations give some credence to our estimates.

5.2 Implications of Our Findings for Debt Servicing

One of the most important questions currently faced by policy makers is whether exports of debtor countries can grow faster than their interest payments--that is, whether their debt-servicing requirements are sustainable. Because these exports are tied to growth in industrial countries, it might be of interest to estimate the OECD growth rate consistent with sustainable debt servicing. To this end, total export revenues are modeled as

$$X = P_x(Y)\, M\big(P_x(Y)/(E\, P_y),\ Y\big)/\beta, \tag{7}$$

where β represents the share of exports of developing countries to industrial countries. Under the assumption of constant β, differentiation of (7) with respect to Y yields

$$\hat{X} = [(\hat{P}_x/\hat{Y})(1 + \varepsilon) + \eta]\hat{Y}, \tag{8}$$

where
$\hat{X}$ = growth rate of total exports in nominal terms,
$\hat{P}_x$ = growth rate of the dollar price of exports,
$\hat{Y}$ = growth rate of industrial countries,
ε = own-price elasticity <0,
η = income elasticity >0.

According to (8), higher growth in industrial countries translates into higher export revenues of developing countries through two channels: an income effect, represented by η, and a price effect which is decomposed into a terms-of-trade effect, $\hat{P}_x/\hat{Y}$, and a direct price effect, ε. Both equation (8) and the sustainability condition (growth in nominal exports$\geq$nominal interest rate) might be used to derive a relation between OECD growth and interest rates consistent with sustainable debt servicing:

$$(9) \qquad \hat{Y}^*/r \geq 1/\left((\hat{P}_X/\hat{Y})(1 + \varepsilon) + \eta\right) ,$$

where $\hat{Y}^*$ is the threshold OECD growth rate and r is the nominal interest rate. According to (9), $\hat{Y}^*$ is inversely related to both the terms-of-trade effect and the income elasticity, but directly related to both the own-price elasticity ($\varepsilon<0$) and nominal interest rates.

Substituting $\eta=1.6$, $\varepsilon=-0.7$, and $\hat{P}_X/\hat{Y}=0.97$ into equation (9), we find that an increase in interest rates of 1 percent must be accompanied by a 1/2 percent increase in OECD growth for debtor countries to service their debts on a sustainable basis.[19] Thus if interest rates are equal to 8 percent (as in Cline 1984, p.60), then servicing sustainability requires an OECD growth rate of at least 4.3 percent, which is above Cline's (1984, p.67) estimate of 3 percent.[20] The difference between these two growth estimates can be traced to Cline's assumption of a zero price elasticity and to his relatively high income elasticity estimate, since both of these considerations tend to lower the critical growth rate associated with a given interest

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[19]These parameter estimates are found in table 4, and they provide the lowest threshold growth rate. According to the regression results of footnote 14, a one percent increase in Y raises Px by 0.97 percent. Chu and Morrison (1984) estimate an income-price elasticity of 2, but their analysis excludes manufactured goods, which tend to have large price elasticities for demand and supply, and thus relatively small price changes in response to demand-supply shifts.

[20]The critical growth rate is derived as 4.3= 8/(0.97(1-0.7)+1.6). With simulations of the LINK model, Klein (1984) finds a critical growth rate of 4.66 percent per year.

rate.[21] To the extent that OECD countries, as a whole, will not sustain a 4.3 growth rate, these findings suggest that OECD growth, important as it may be, will not be the decisive factor in enabling borrowing countries to service their debt on a sustainable basis.

6. Conclusions

The objective of this paper has been to estimate income and price elasticities of non-oil imports of major industrial countries from non-OPEC developing countries. These elasticities have been the subject of increased attention recently in view of their importance for designing policy responses to the debt crisis. Despite their importance, a review of the literature reveals sharply divided views regarding their magnitudes. This lack of consensus stems from three sources: use of multilateral trade flows aggregated across countries, omission of price effects, and reliance on ordinary least squares for parameter estimation. The elasticity estimates derived in this study eliminate each of these limitations.

The empirical results at the country level yield an aggregate income elasticity that varies from 1.3 to 1.6, a relatively narrow range

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[21] Cline has pointed out to us that his average elasticity is approximately 2, below his marginal elasticity estimate of 3. The lower average elasticity is due to both a subjective interpretation of what the average OECD growth rate is and a negative intercept in his estimating equations (see Cline 1985). A negative intercept implies a declining trend in imports of industrial countries from developing countries, a trend not borne out by the data. More likely, a negative intercept is the result of omitted variables and measurement errors that impart an upward bias to the marginal income elasticity. More importantly, Cline's (1984) long-term projection model relies on the marginal and not the average elasticity. In any event, substitution of his average elasticity and zero price elasticity into (9) yields a critical growth rate of 2.7 percent, well below our growth estimate.

of variation, and one which suggests an upward bias for estimates of previous studies. With respect to the question of debt-servicing sustainability, our elasticity estimate suggests that reliance on growth of industrial countries to pull out the developing countries from the present debt crisis is not warranted.

This conclusion is subject to a number of qualifications. First, the analysis has dealt with the bloc of non-OPEC developing countries that is a larger aggregate than just debtor countries. It is conceivable that bilateral trade between the United States and major debtors is characterized by higher income elasticities than those obtained here. We are not aware of any available evidence on the magnitude of these elasticities, and it seems that their estimation is a natural avenue for future research. Second, interest rates and OECD growth are not independent of each other, as the analysis of this paper has assumed; a more general equilibrium analysis is needed. Finally, some of the elasticity estimates need further refinement and further testing. Though this analysis has not exactly pinned down the elasticities, it has narrowed down considerably the range of disagreement. Given these limitations, and the importance of this subject, it seems that further research will yield positive returns.

Table 1

Non-oil Exports of Developing Countries

Comparison of Selected Studies

Author	Country Aggregation Exporter	Importer	Data	Commodity	Elasticity Income	Price
Bond (1985)[a]	Non-Oil LDC	Industrial	Annual 1967-81	All Goods	2.4	-0.1, -0.8
Goldstein Khan (1982)[b]	Non-Oil LDC	Industrial	Annual 1963-80	Non-Oil	1.3	0.0
Cline (1984)[c]	World	Industrial	Annual 1961-81	Non-Oil	3.1	0.0
Dornbusch[c] (1985)	Non-Oil LDC	World	Annual 1960-83	Non-Oil	2.4, 4.7	-1.2
Grossman[d] (1982)	Non-Oil LDC	U.S.	Quarterly 1968-78	7-digit SITC	0.2, 7.5	-4.5, -0.5
Riedel[c] (1984)	Non-Oil LDC	Industrial	Annual 1960-78	Non-Oil	0.9, 1.3	0

a. The estimation method is indirect least squares.

b. The estimation method uses the average of the percentage changes of the ratio between LDC exports to OECD countries and the OECD real GDP.

c. The estimation method is ordinary least squares.

d. The estimation method is two-stages least squares.

Table 2
Non-oil Imports from Non-OPEC Developing Countries
Income Elasticities and Country Aggregation Biases
1974-1981

Level of Aggregation	Income Elasticity η	$\bar{R}^2$	$H_0: \eta_i = \eta_{us}$ F(2,145) (sig.level)	$H_0: \eta_i = \eta$ F(5,145) (sig.level)
Canada	1.265*	-0.03	6.162 (0.003)	
Germany	1.013*	-0.01	6.036 (0.003)	
Japan	-1.209*	-0.03	6.112 (0.003)	
United Kingdom	0.239*	-0.03	6.108 (0.003)	
United States	5.931	0.27		
Pooled data: fixed effects	1.595*	0.01		2.546 (0.03)
Aggregate of 5 Countries	2.858	0.16		

* Coefficient not significant at the 5 percent significance level.

The dependent variable is the growth rate of non-oil imports from non-OPEC developing countries, and the explanatory variable is the income growth rate for the associated country bloc.

Column 3 presents test-results for the hypothesis that the income elasticity of the ith country equals the U.S. income elasticity.

Column 4 presents the test-result for the hypothesis of a common income elasticity across countries.

Table 3
Non-Oil Imports from Non-OPEC Developing Countries
Long-run Elasticity Estimates
1974-1981

Canada

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Income	1.46	0.97	1.52	0.95*
Own-price	-0.85	-0.50*	-0.36	-0.25
Cross-Price	0.0	0.0	-0.94	-0.38
$\bar{R}^2$	0.42	0.08	0.41	0.05
SER	0.10	0.13	0.10	0.13
D.W.	1.73	0.96	1.66	0.97
Hypotheses Tested				
Normality J.B.[a]	0.98	0.77	0.92	0.77
Autocorrelation[b]	0.94	0.98	0.93	0.98
Homoskedastic ARCH[c]	-0.52	0.90	-0.47	0.84
Homogeneity[d]	0.48	0.84	0.14	0.91
Lag Structure[e]	0.73	0.93	0.74	0.94
Chow[f]	0.02	0.16	0.01	0.14

Germany

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Income	2.01	1.93	2.02	1.99
Own-Price	-0.95	-1.14	-0.98	-1.30
Cross-Price	0.0	0.0	-0.06*	-0.46
$\bar{R}^2$	0.92	0.85	0.92	0.86
SER	0.05	0.07	0.05	0.06
D.W.	2.23	0.83	2.25	1.00
Hypotheses Tested				
Normality JB[a]	0.28	0.69	0.27	0.78
Autocorrelation[b]	0.78	0.85	0.79	0.90
Homoskedastic ARCH[c]	0.86	0.54	0.96	0.08
Price Homogeneity[d]	0.50	0.98	0.50	0.83
Lag Structure[e]	0.93	0.99	0.96	0.99
Chow[f]	0.90	0.88	0.89	0.99

See notes at the end of the table.

Table 3
(continued)

Japan

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Income	-0.16*	-0.36*	-0.13*	-0.38
Own-Price	-1.26	-1.26	-1.39	-1.25
Cross-Price	0.0	0.0	-0.35*	-0.12*
$\bar{R}^2$	0.59	0.64	0.57	0.62
SER	0.09	0.08	0.09	0.08
D.W.	1.79	1.60	1.83	1.57
Hypotheses Tested				
Normality J.B.[a]	0.35	0.67	0.41	0.66
Autocorrelation[b]	0.23	0.37	0.22	0.37
Homoskedastic ARCH[c]	0.01	0.33	-0.15	0.19
Price Homogeneity[d]	0.00	0.00	0.33	0.08
Lag Structure[e]	0.02	0.84	0.09	0.45
Chow[f]	0.67	0.69	0.62	0.93

United Kingdom

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Income	1.45	1.75	1.35	2.06
Own-Price	-0.22	-0.11*	-0.21	-0.12*
Cross-Price	0.0	0.0	-0.05*	-0.15*
$\bar{R}^2$	0.75	0.75	0.74	0.74
SER	0.05	0.05	0.05	0.05
D.W.	1.91	1.70	1.89	1.75
Hypotheses Tested				
Normality J.B.[a]	0.01	0.36	0.03	0.46
Autocorrelation[b]	0.99	0.99	0.99	0.99
Homoskedastic ARCH[c]	-0.22	-0.09	-0.22	0.15
Price Homogeneity[d]	0.62	0.64	0.60	0.51
Lag Structure[e]	0.39	0.44	0.51	0.68
Chow[f]	0.61	0.79	0.62	0.74

See notes at the end of table.

Table 3
(continued)

United States

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Income	1.96	2.20	1.81	1.87
Own-Price	-0.50*	-0.63*	-0.91*	-2.90
Cross-Price	0.0	0.0	0.42*	1.89
$\bar{R}^2$	0.94	0.89	0.93	0.91
SER	0.06	0.07	0.06	0.06
D.W.	2.19	1.59	2.27	2.14
Hypotheses Tested				
Normality J.B.[a]	0.05	0.46	0.02	0.95
Autocorrelation[b]	0.45	0.91	0.45	0.92
Homoskedastic ARCH[c]	2.80	4.60	3.05	3.50
Price Homogeneity[d]	0.44	0.79	0.45	0.50
Lag Structure[e]	0.37	0.99	0.58	0.98
Chow[f]	0.54	0.24	0.48	0.10

* Coefficient not significant at the 5 percent significance level.

a. Significance level associated with the normality hypothesis.

b. Significance level associated with the no autocorrelation hypothesis.

c. t-statistic associated with the homoskedasticity hypothesis.

d. Significance level associated with the price homogeneity hypothesis.

e. Significance level associated with the unrestricted dynamic specification.

f. Significance level associated with the parameter stability hypothesis.

With the exception of the ARCH test, if the reported significance level exceeds 0.95, then the associated hypothesis is rejected. For the ARCH test, a t-value of 1.96 is required to reject the null hypothesis.

The dummy varaible D takes a value of 1 in 1975I for the United States and in 1975IV and 1980I for the United Kingdom.

Table 4
Income and Own-Price Elasticities
Country Level and Aggregate Level

	OECD[a] Shares	Income elasticity		Own-Price elasticities	
		smallest	largest	smallest	largest
Canada	4.7	0.95	1.52	-0.85	-0.25
Germany	16.0	1.93	2.02	-1.30	-0.95
Japan	21.0	-0.38	-0.13	-1.39	-1.25
U.K.	8.6	1.35	2.06	-0.22	-0.11
U.S.	49.7	1.81	2.20	-2.90	-0.50
Aggregate	100	1.29	1.64	-2.00	-0.68

a. Normalized shares in OECD GDP. For the actual shares in the OECD aggregate, multiply by 0.70; these shares are obtained from the OECD Economic Outlook, 1981, p. 16.

Appendix 1

Estimates for Alternative Specifications

This appendix presents elasticity estimates which allow for both business cycle and quantum effects. In addition, it examines the extent to which the functional form of (2) is supported by the data.

A1.1 Cyclical and Secular Responses to Output

A number of empirical studies have shown that the income elasticity might vary over the business cycle. From an empirical standpoint, the key question is to decompose a given income path into its secular and its cyclical components. Khan and Ross (1975) and Marston (1971) estimate secular (or potential) income as a trend of actual income, which permits computing income fluctuations as the difference between potential and actual income. This approach has been criticized by Haynes and Stone (1983), who argue that a spectral decomposition of output provides a more reliable estimation procedure.

Given that the Multi-Country Model operates in time domain only, and given that Haynes and Stone acknowledge that their approach has certain limitations, this paper estimates potential output as a trend of actual output. Under this assumption, equation (2) becomes

$$\text{(A1)} \qquad \ln M_t = \alpha_0 + \alpha_1 \ln YPOT_t + \alpha_2 \ln (GDP/YPOT)_t + \\ + \alpha_3 (L) \ln P_t + \alpha_4 (L) \ln Q_t + \delta \ln M_{t-1},$$

where $YPOT = EXP(\beta_0 + \beta_1 \, TIME)$ with the β's estimated by OLS. Note that (A1) implicitly assumes that a decomposition of output into its cyclical and secular components eliminates lagged effects of income on imports (Marston 1971). This observation suggests that the value of δ should be zero in estimation. But, for the sake of sensitivity, the results presented here include the case where δ is non-zero.

Table A1 presents long-run elasticity estimates following the format of Table 3. On the whole, a comparison of the results between these two tables reveals that the use of potential output (as constructed here) produces no major changes in the elasticity estimates or in the various test-statistics. The two exceptions are the United Kingdom (where there the income elasticy increases and the own-price elasticity declines) and Canada (where there is an increase in the significance levels of the various hypotheses). It must be emphasized that this robustness of parameter estimates rests on the assumption that potential output can be estimated as trend of actual output. A more complete sensitivty analysis should address the issues raised by Haynes and Stone (1983).

A1.2 Quantum Effects

A second limitation of equation (2) is the assumption of no quantum effects -- that is, the response of imports to changes in either prices or income is the same regardless of the magnitude of the changes in these variables. The hypothesis of quantum effects is examined here by postulating the following parameter behavior:

$$\alpha_1(L) = \alpha_1 = \alpha_{10} + \alpha_{11}\ \Delta \ln Y_t$$

$$\alpha_2(L) = \alpha_2 = \alpha_{20} + \alpha_{21}\ \Delta \ln P_t$$

$$\alpha_3(L) = \alpha_2 = \alpha_{30} + \alpha_{31}\ \Delta \ln Q_t.$$

With the above formulation, testing for the hypothesis of no-quantum effects amounts to testing whether α_{11}, α_{21} and α_{31} are zero. Once again, it is assumed that the lagged response of imports is due to the omission of quantum effects, and that once these effects are recognized, there is no need for additional lagged variables.

Elasticity estimates presented in table A2 reveal a relatively robust income elasticity but a good deal of sensitivity in the own- and cross-price elasticities. Several reasons may account for this sensitivity. First, dynamic adjustments are not solely due to quantum effects, as it is implicitly assumed in the results of table A2. Second, already high levels of collinearity might be exacerbated, which prevents isolation of coefficient estimates.

A1.3 Choice of Functional Form

The general functional form of equation (2) is

$$\text{(A2)} \quad (M_t^{\lambda} - 1)/\lambda = \alpha_0 + \left(\alpha_1(L)/\delta(L)\right)\left((Y_t^{\lambda} - 1)/\lambda\right) + $$

$$+ \left(\alpha_2(L)/\delta(L)\right)\left((P_t^{\lambda} - 1)/\lambda\right)$$

$$+ \left(\alpha_3(L)/\delta(L)\right)\left((Q_t^{\lambda} - 1)/\lambda\right) + u_t$$

where λ is the Box-Cox parameter, $\delta(L) = 1 - \delta L$, $\alpha_j(L) = \sum \alpha_{j\ell} L^{\ell}$, (for j=1,2,3), $u_t \sim NID(0, \sigma^2)$, and L is the lag operator. The value of λ is determined by maximizing $\pounds_1 + (\lambda-1)\sum \ln Y_t$, where $\pounds_1$ is the concentrated log-likelihood function for $\lambda=1$. The maximizing value of λ is found through a grid-search on which λ is allowed to vary from 0 to 1 with a 0.1 step size. This procedure is applied to a total of eight specifications for each country: with and without cross-price effects, with and without potential output, and two distributed lags (Koyck and Almon).

Figure A1 displays the log-likelihood function for each value of λ for all specifications for all countries. The results reveal a log-likelihood function almost invariant to the choice of Box-Cox parameter. One possible reason for this invariance is the constancy of the import-GDP ratio (see Appendix 2), which would give the same income elasticity estimate for either $\lambda=0$ or $\lambda=1$.

However, to find that elasticity estimates might be invariant to the choice of λ is not equivalent to saying that the properties of the error term are invariant to the choice of λ, a point stressed by Seaks and Layson (1983). They argue that the optimal λ is influenced by the presence of heteroskedasticity. To recognize this influence, they derive the log-likelihood function with (proportional) heteroskedasticity, under the assumption of normality. The approach followed here is to test the assumptions behind the error term before altering the likelihood function. After all, if the residuals do not behave according to the normal distribution, then there is no point in deriving its log-likelihood function with or without heteroskedastic errors.

Table A3 indicates whether a given specification passes (P) or fails (F) the assumptions of normality, serial independence, and homoskedasticity for each value of λ. Out of 440 cases (11x8x5), the hypothesis of normality is rejected in 14 instances (Canada 9, Japan 1, United States 4), the hypothesis of serial independence is rejected in 81 instances (Canada 1, United Kingdom 80), and the hypothesis of homoskedasticity is rejected in 57 instances, all of them for the United States. The results for the United Kingdom indicate serial correlation of order four, which does not necessarily invalidate the choice of λ, since there is no evidence of first-order serial correlation. The results for the United States indicate a fairly well grounded heteroskedasticity problem for the Almon distributed lag. In contrast, the data supports the three hypotheses for the Koyck distributed lag for $\lambda>0.4$, for which the hypothesis of $\lambda=0$ cannot be rejected. These results, when combined with the ease of interpretation of a logarithmic formulation, provides some basis for the choice of functional form of (2).

Table A1
Non-Oil Imports from Non-OPEC Developing Countries
Long-run Elasticity Estimates
Secular-Cyclical Effects
1974-1981

Canada

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Potential Income	1.44	0.95*	1.80	0.96*
Own-price	-1.00	-0.56*	-0.27	-0.38*
Cross-Price	0.0	0.0	-1.83*	-0.24
$\bar{R}^2$	0.40	0.06	0.39	0.02
SER	0.11	0.13	0.11	0.13
D.W.	1.73	0.98	1.62	0.97
Hypotheses Tested				
Normality J.B.[a]	0.97	0.83	0.97	0.86
Autocorrelation[b]	0.94	0.98	0.90	0.98
Homoskedastic ARCH[c]	-0.52	0.83	-0.43	0.85
Price Homogeneity[d]	0.99	0.93	0.99	0.99
Lag Structure[e]	0.71	0.99	0.73	0.98
Chow[f]	0.02	0.33	0.02	0.38

See notes at the end of table.

Germany

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Potential Income	2.22	2.07	2.33	1.96
Own-Price	-1.09	-1.10	-1.07	-1.13
Cross-Price	0.0	0.0	-0.07*	-0.64
$\bar{R}^2$	0.92	0.90	0.92	0.93
SER	0.05	0.05	0.05	0.09
D.W.	2.27	1.15	1.52	1.95
Hypotheses Tested				
Normality JB[a]	0.31	0.32	0.33	0.08
Autocorrelation[b]	0.66	0.51	0.65	0.31
Homoskedastic ARCH[c]	0.90	-0.95	0.74	-1.04
Price Homogeneity[d]	0.83	0.95	0.22	0.67
Lag Structure[e]	0.99	0.99	0.95	0.99
Chow[f]	0.95	0.99	0.95	0.98

Table A1
(continued)

Japan

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Potential Income	-0.26*	-0.34	-0.29*	-0.29*
Own-Price	-1.33	-1.27	-1.44	-1.24
Cross-Price	0.0	0.0	-0.21	-0.05
$\bar{R}^2$	0.59	0.62	0.58	0.61
SER	0.09	0.08	0.09	0.08
D.W.	1.92	1.56	1.95	1.54
Hypotheses Tested				
Normality J.B.[a]	0.28	0.69	0.33	0.68
Autocorrelation[b]	0.18	0.40	0.16	0.40
Homoskedastic ARCH[c]	-0.22	0.20	-0.33	-0.03
Price Homogeneity[d]	0.47	0.00	0.43	0.08
Lag Structure[e]	0.03	0.83	0.41	0.67
Chow[f]	0.60	0.69	0.56	0.68

See notes at the end of table.

United Kingdom

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Potential Income	1.78	2.34	1.69	2.28
Own-Price	-0.12*	-0.08*	-0.11*	-0.09*
Cross-Price	0.0	0.0	-0.05*	-0.04*
$\bar{R}^2$	0.75	0.73	0.74	0.72
SER	0.05	0.05	0.05	0.06
D.W.	1.93	1.61	1.92	1.60
Hypotheses Tested				
Normality J.B.[a]	0.02	0.45	0.01	0.45
Autocorrelation[b]	0.99	0.98	0.99	0.98
Homoskedastic ARCH[c]	0.07	1.03	0.03	0.85
Price Homogeneity[d]	0.43	0.00	0.42	0.16
Lag Structure[e]	0.72	0.64	0.94	0.52
Chow[f]	0.83	0.89	0.80	0.86

Table A1
(continued)

United States

	No Cross-Price		Cross-Price	
	Koyck	Almon	Koyck	Almon
Potential Income	1.94	2.06	1.82	1.82
Own-Price	-0.65*	-0.43*	-1.00*	-2.60
Cross-Price	0.0	0.0	0.35*	1.79
$\bar{R}^2$	0.94	0.90	0.93	0.92
SER	0.06	0.07	0.06	0.06
D.W.	2.13	1.40	2.20	2.02
Hypotheses Tested				
Normality J.B.[a]	0.01	0.15	0.00	0.68
Autocorrelation[b]	0.69	0.82	0.70	0.80
Homoskedastic ARCH[c]	2.82	3.97	3.14	3.20
Price Homogeneity[d]	0.95	0.93	0.94	0.99
Lag Structure[e]	0.65	0.99	0.63	0.91
Chow[f]	0.71	0.95	0.67	0.68

* Coefficient not significant at the 5 percent significance level.

a. Significance level associated with the normality hypothesis.

b. Significance level associated with the no autocorrelation hypothesis.

c. t-statistic associated with the homoskedasticity hypothesis.

d. Significance level associated with the price homogeneity hypothesis.

e. Significance level associated with the unrestricted dynamic specification.

f. Significance level associated with the parameter stability hypothesis.

With the exception of the ARCH test, if the reported significance level exceeds 0.95, then the associated hypothesis is rejected. For the ARCH test, a t-value of 1.96 is required to reject the null hypothesis.

The dummy varaible D takes a value of 1 in 1975I for the United States and in 1975IV and 1980I for the United Kingdom.

Table A2
Non-oil imports from Non-OPEC Developing Countries
Income and Price Elasticities
Quantum Effects

Long Run Elasticities	Canada	U.K.	Germany	Japan	U.S.
Income					
α_{10}	1.17	0.89*	2.28	-0.17*	2.07
α_{11}	-0.04*	-0.04*	0.54	0.06*	-0.09*
Own-Price					
α_{20}	-0.77*	-0.16*	-1.16	-0.70	-0.71*
α_{21}	-1.68*	0.38*	-4.39	-2.78*	0.25*
Cross-Price					
α_{30}	-0.06*	0.25*	-0.49	-0.63*	0.25*
α_{31}	-4.35*	-0.95*	8.30	-0.89*	-2.00*
R^2 (adj.)	0.39	0.47	0.94	0.22	0.90
Normality: JB[a]	0.68	0.59	0.10	0.21	0.99
Homoskedasticity ARCH[a]	-0.54	-0.70	0.69	1.36	4.75
Serial Indep.[a]	0.23	0.99	0.80	0.98	0.99

* Coefficient estimate is not significant at the 5 percent significance level.

a. See notes in Table 3.

Table A3
Non-Oil Imports from Non-OPEC Developing Countries
Box-Cox Tests and Testing of Error Properties
(Notes at the End of Table)

	λ	Koyck			Almon		
		Normality	Serial Indep.	Homosked.	Normality	Serial Indep.	Homosked.
Canada 1	0.0	F	P	P	P	P	P
	0.1	F	P	P	P	P	P
	0.2	F	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	F	P
Canada 2	0.0	P	P	P	P	F	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P
Canada 3	0.0	F	P	P	P	P	P
	0.1	F	P	P	P	P	P
	0.2	F	P	P	P	P	P
	0.3	F	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P
Canada 4	0.0	F	P	P	P	P	P
	0.1	F	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P

	λ	Koyck			Almon		
		Normality	Serial Indep.	Homosked.	Normality	Serial Indep.	Homosked.
Germany 1	0.0	P	P	P	P	P	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P
Germany 2	0.0	P	P	P	P	P	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P
Germany 3	0.0	P	P	P	P	P	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P
Germany 4	0.0	P	P	P	P	P	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P

Table A3
(continued)

	λ	Koyck Normality	Koyck Serial Indep.	Koyck Homosked.	Almon Normality	Almon Serial Indep.	Almon Homosked.
Japan 1	0.0	P	P	P	P	P	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P
Japan 2	0.0	P	P	P	P	P	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P
Japan 3	0.0	P	P	P	P	P	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P
Japan 4	0.0	P	P	P	F	P	P
	0.1	P	P	P	P	P	P
	0.2	P	P	P	P	P	P
	0.3	P	P	P	P	P	P
	0.4	P	P	P	P	P	P
	0.5	P	P	P	P	P	P
	0.6	P	P	P	P	P	P
	0.7	P	P	P	P	P	P
	0.8	P	P	P	P	P	P
	0.9	P	P	P	P	P	P
	1.0	P	P	P	P	P	P

	λ	Koyck Normality	Koyck Serial Indep.	Koyck Homosked.	Almon Normality	Almon Serial Indep.	Almon Homosked.
U.K. 1	0.0	P	F	P	P	F	P
	0.1	P	F	P	P	F	P
	0.2	P	F	P	P	F	P
	0.3	P	F	P	P	F	P
	0.4	P	F	P	P	F	P
	0.5	P	F	P	P	F	P
	0.6	P	F	P	P	F	P
	0.7	P	F	P	P	F	P
	0.8	P	F	P	P	F	P
	0.9	P	F	P	P	F	P
	1.0	P	F	P	P	F	P
U.K. 2	0.0	P	F	P	P	F	P
	0.1	P	F	P	P	F	P
	0.2	P	F	P	P	F	P
	0.3	P	F	P	P	F	P
	0.4	P	F	P	P	F	P
	0.5	P	F	P	P	F	P
	0.6	P	F	P	P	F	P
	0.7	P	F	P	P	F	P
	0.8	P	F	P	P	F	P
	0.9	P	F	P	P	F	P
	1.0	P	F	P	P	F	P
U.K. 3	0.0	P	F	P	P	P	P
	0.1	P	F	P	P	P	P
	0.2	P	F	P	P	P	P
	0.3	P	F	P	P	P	P
	0.4	P	F	P	P	P	P
	0.5	P	F	P	P	F	P
	0.6	P	F	P	P	F	P
	0.7	P	F	P	P	F	P
	0.8	P	F	P	P	F	P
	0.9	P	F	P	P	F	P
	1.0	P	F	P	P	F	P
U.K. 4	0.0	P	F	P	P	P	P
	0.1	P	F	P	P	P	P
	0.2	P	F	P	P	P	P
	0.3	P	F	P	P	F	P
	0.4	P	F	P	P	F	P
	0.5	P	F	P	P	F	P
	0.6	P	F	P	P	F	F
	0.7	P	F	P	P	F	P
	0.8	P	F	P	P	F	P
	0.9	P	F	P	P	F	P
	1.0	P	F	P	P	F	P

Table A3
(continued)

	λ	Koyck Normality	Koyck Serial Indep.	Koyck Homosked.	Almon Normality	Almon Serial Indep.	Almon Homosked.
U.S. 1	0.0	P	P	F	P	P	F
	0.1	P	P	F	P	P	F
	0.2	P	P	F	P	P	F
	0.3	P	P	P	P	P	F
	0.4	P	P	P	P	P	F
	0.5	P	P	P	P	P	F
	0.6	P	P	P	P	P	F
	0.7	P	P	P	P	P	F
	0.8	P	P	P	P	P	F
	0.9	P	P	P	P	P	F
	1.0	P	P	P	P	P	F
U.S. 2	0.0	P	P	F	F	P	F
	0.1	P	P	F	F	P	F
	0.2	P	P	F	F	P	F
	0.3	P	P	F	F	P	F
	0.4	P	P	P	P	P	F
	0.5	P	P	P	P	P	F
	0.6	P	P	P	P	P	F
	0.7	P	P	P	P	P	F
	0.8	P	P	P	P	P	F
	0.9	P	P	P	P	P	F
	1.0	P	P	P	P	P	P
U.S. 3	0.0	P	P	F	P	P	F
	0.1	P	P	F	P	P	F
	0.2	P	P	F	P	P	F
	0.3	P	P	P	P	P	F
	0.4	P	P	P	P	P	F
	0.5	P	P	P	P	P	F
	0.6	P	P	P	P	P	F
	0.7	P	P	P	P	P	F
	0.8	P	P	P	P	P	F
	0.9	P	P	P	P	P	F
	1.0	P	P	P	P	P	F
U.S. 4	0.0	P	P	F	P	P	F
	0.1	P	P	F	P	P	F
	0.2	P	P	F	P	P	F
	0.3	P	P	F	P	P	F
	0.4	P	P	P	P	P	F
	0.5	P	P	P	P	P	F
	0.6	P	P	P	P	P	F
	0.7	P	P	P	P	P	F
	0.8	P	P	P	P	P	F
	0.9	P	P	P	P	P	F
	1.0	P	P	P	P	P	F

Case 1: no cross-price effects
Case 2: cross-price effects
Case 3: potential output and no cross-price effects
Case 4: potential output and cross-price effects

Figure A1
Non-Oil Imports from Non-OPEC Developing Countries
Box-Cox Tests
(x-axis: Box-Cox parameter; y-axis: log Likelihood)

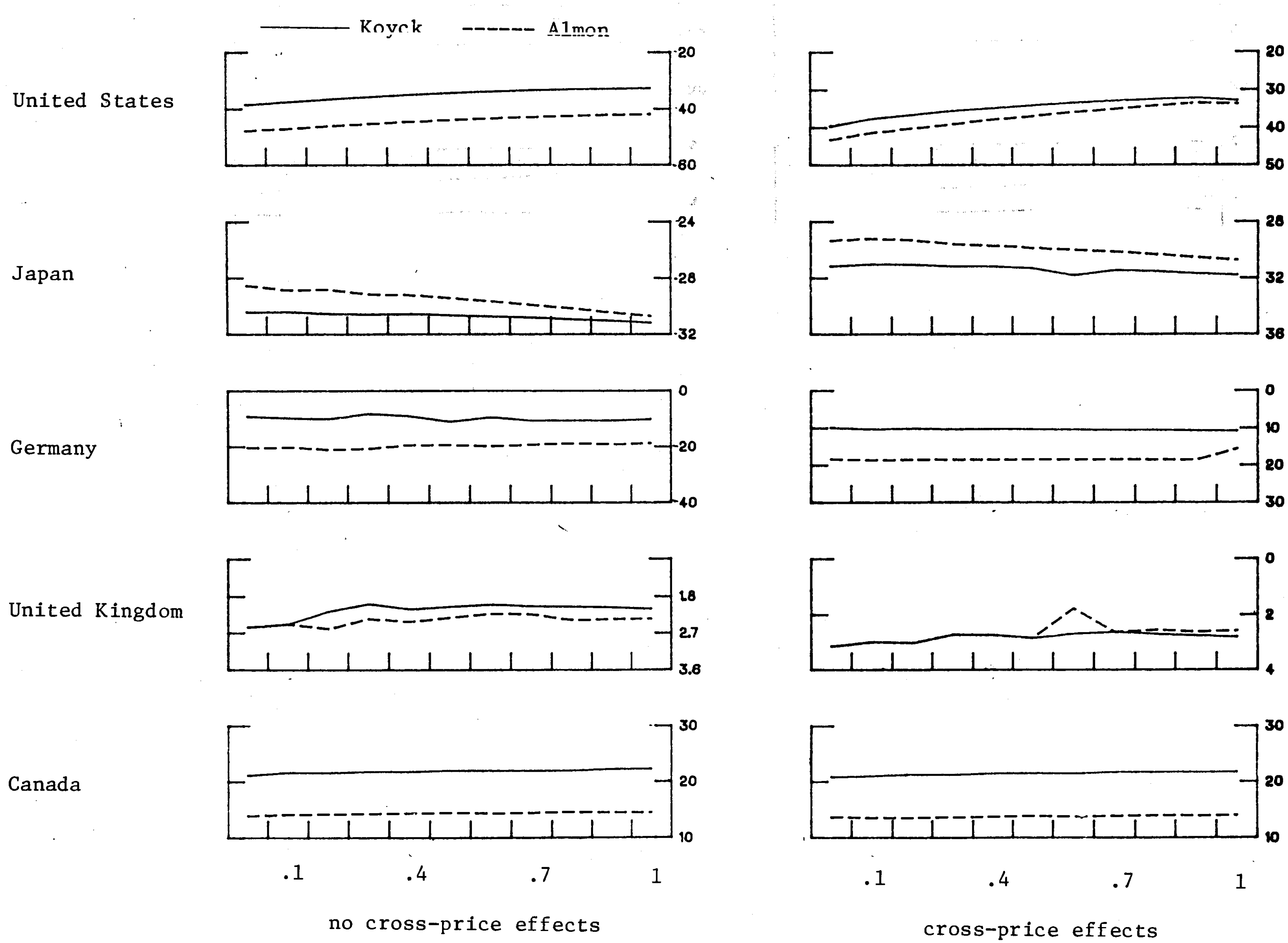
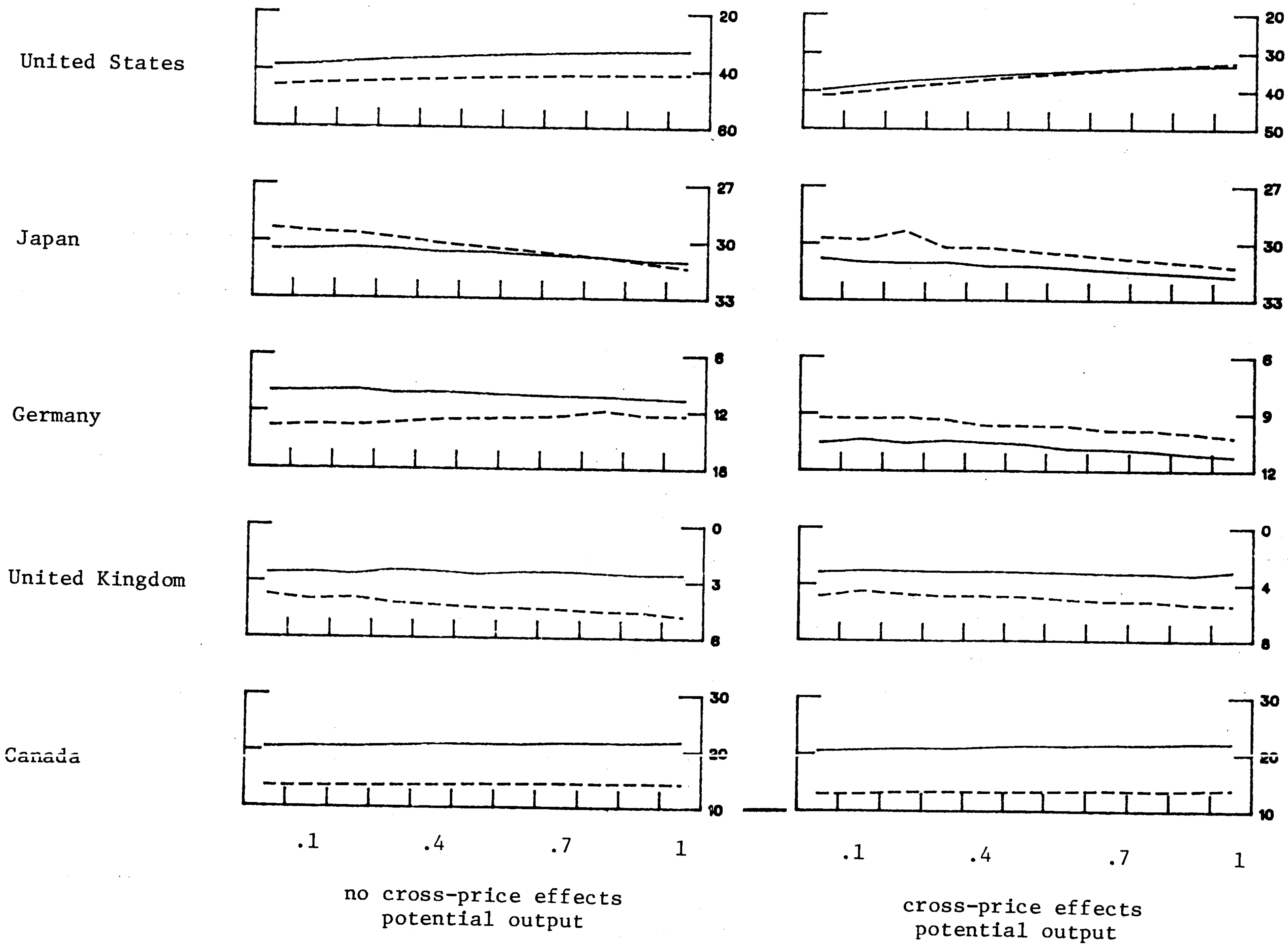


Figure A1
(continued)



Appendix 2

Definitions of Variables and Data Used

All data are in billions of U.S. dollars, quarterly at annual rates, unless otherwise noted. Where source data differs, it has been scaled to conform to this convention. A complete explanation of all source abbreviations follows the data definitions.

M_i = real non-oil imports of the i^{th} developed country from non-OPEC developing countries.

= [MiLV - (MiLO * (MiPETV * iER/MiTO))]/LPXNO.

MiLV = goods imports of country i from non-OPEC developing countries (millions of $US, FOB), DOT line 71.

MiLO = oil (crude and refined) imports of country i from non-OPEC developing countries (thousand metric tons), OECD, divided by 0.136 (metric tons/barrel).

MiPETV = Petroleum imports of country i (local currency), IFS line 71a [for Germany, Japan, U.K., U.S.]; BOC Cansim series B43154 (crude) and B43157 (refined) [for Canada].

iER = U.S. dollar exchange rate ($U.S./local currency), MDL: quarterly average of series SXMBCD (Canada), SXMBDM (Germany), SCDBJY (Japan), and SXDBUKP (U.K.).

MiTO = Total oil imports of country i (thousand metric tons), OECD divided by 0.136 (metric tons/barrels).

LPXNO = Non-OPEC developing countries non-oil export price index: Weighted average of external trade deflators for manufacturers and non-oil primary products (WB), rebased to 1972 = 1, converted from annual to quarterly data according to seasonal pattern of non-OPEC LDC export unit value index, IFS line 74D.

Y_i = Real income of i^{th} developed country.

= iGNP (1972 prices).

Canada: nominal GNP, Cansim series D40551 (millions of Canadian $), divided by constructed absorption deflator, CSR Table 1.2.

Germany: constructed from components (billions of DM), DIW.

Japan : constructed from components (billions of Yen), BOJ.

U.K. : nominal GDP (billions of pounds sterling), ET, Table 2, multiplied by 0.62113 (implicit GDP deflator), ET, Table 4.

U.S. : NIA Table 1.2, line 1.

P_i = Relative price (foreign prices/domestic prices).

= (LPXNO/iEI)/iPGNP.

LPXNO = Non-OPEC developing country non-oil export price index (WB, defined above), divided by 1972 average value.

iEI = Spot Exchange Rate Index --$US/local currency exchange rate (MDL, defined above), divided by 1972 average value.

iPGNP = GNP Deflator.

Canada: Nominal GNP (millions of Canadian $), CSR Table 1.2, series D40551, Germany: Nominal GNP (billions of DM), DIW, defined above).

Japan: Nominal GNP constructed from components (billions of Yen), BOJ, divided by Real GNP (BOJ, defined above).

U.K.: Nominal GNP (billion of pounds sterling), ET Table 2, divided by real GNP (ET, defined above).

U.S.: NIA Table 7.1, line 1.

Sources

BOC Bank of Canada .

BOJ Bank of Japan.

CSR Canadian Statistical Review, published quarterly by Statistics Canada.

DIW "Lange Reihen der vierteljahrlichen volkswirtschaftlichen Gesamtrechnung fur die Bundesrepublik Deutschland", published quarterly by Deutsches Institut fur Wirtschaftsforshung, Berlin.

DOT Direction of Trade Statistics, published monthly by the International Monetary Fund.

ET Economic Trends, published monthly by U.K. Central Statistical Office.

IFS International Financial Statistics, published by the International Monetary Fund.

MDL Macro Data Library of the Federal Reserve Board of Governors.

NCA National Income Accounts in Survey of Current Business, published monthly by U.S. Department of Commerce, Bureau of Economic Analysis.

OECD Quarterly Oil Statistics, Tables B1 (Crude + Natural Gas Liquids + Refinery Feed Stocks) and B2 (Total Products), published quarterly by OECD International Energy Agency.

WB World Bank, Economic Analysis and Projections Department, Division of Global Analysis & Projections.

Figure A2
Non-Oil Imports from Non-OPEC Developing Countries
Relative Prices

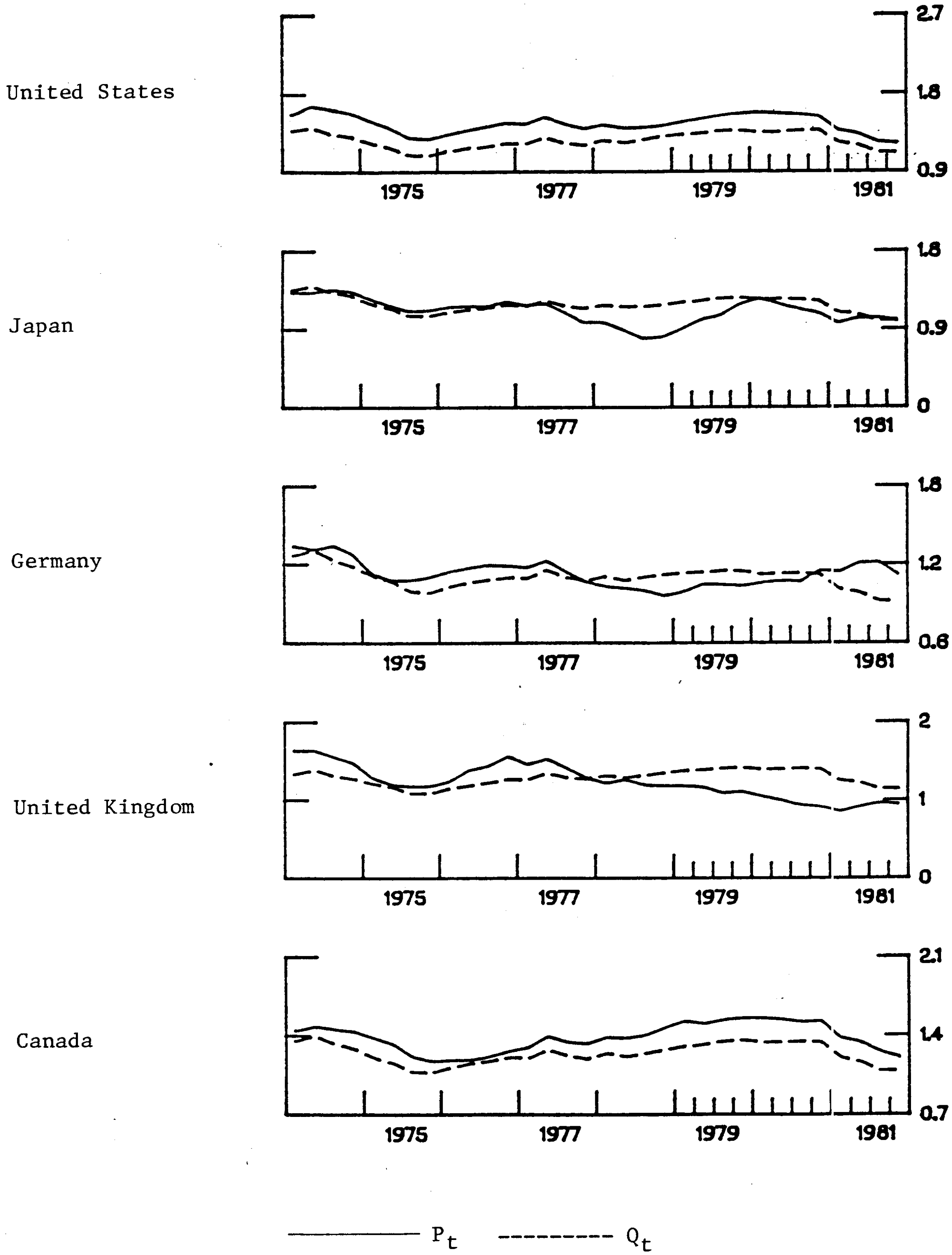
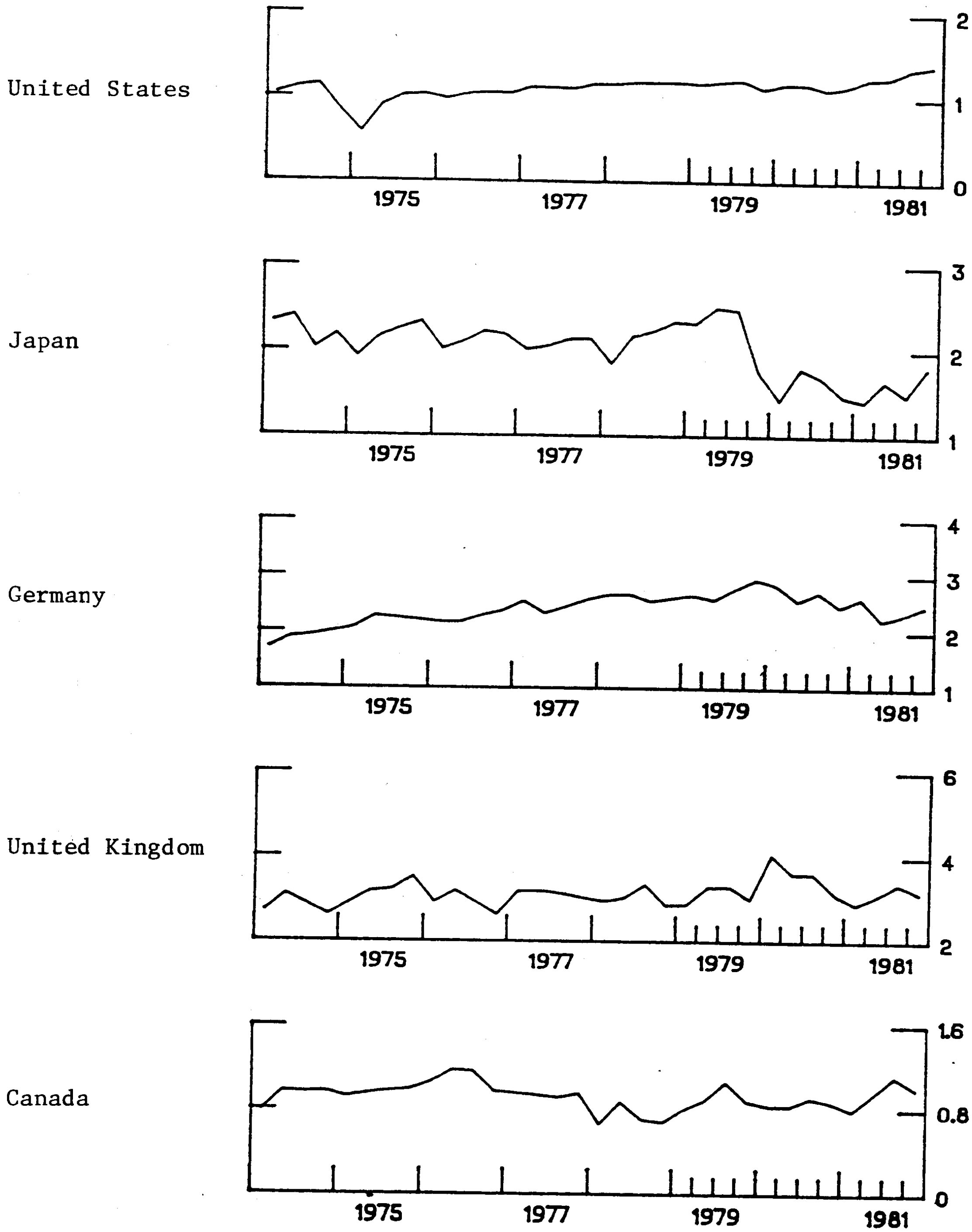


Figure A3
Non-Oil Imports from Non-OPEC Developing Countries
Import-GDP Ratio



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