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Time-Series Estimation of Structural Import Demand Equations: A Cross-Country Analysis

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Abstract

This paper derives a structural import demand equation and estimates it for a large number of countries, using recent time series techniques that address the problem of nonstationarity. Because the statistical properties of the different estimators have been derived only asymptotically, econometric theory does not offer any guidance when it comes to comparing different estimators in small samples. Consequently, the paper derives the small-sample properties of both the ordinary-least-squares (OLS) and the fully-modified (FM) estimators using Monte Carlo methods. It is shown that FM dominates OLS for both the short- and long-run elasticities.

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SUMMARY

The traditional import demand function is specified as a log-linear function of the relative price of imports and real income. Because of data constraints and the empirical success of this specification, it has dominated the empirical literature for more than a quarter century, but questions about its microeconomic foundation arise because it has not been derived from utility maximization. Another issue that has been largely ignored in the literature is the problem of nonstationarity, which is found in most macroeconomic variables and invalidates classical statistical inference: if the variables that enter the import demand equation contain a unit root, ignoring nonstationarity in these variables may cause serious inference problems.

The paper seeks to address these problems, first, by deriving an empirically tractable import demand equation that can be estimated for a large number of countries, using recent time-series techniques that address the nonstationarity present in the data. Second, because the statistical properties of the different estimators have been derived only asymptotically, the paper derives the small-sample properties of both the ordinary least squares (OLS) and the fully modified (FM) estimators of the short- and long-run elasticities, using Monte Carlo methods. It is shown that the FM estimators dominate the OLS estimators, even in small samples. Both price and income elasticities generally have the expected sign and are precisely estimated. The average price elasticity is close to zero in the short run but is slightly higher than unity in the long run. A similar pattern holds for income elasticities: the short-run income elasticities are on average less then 0.5, while the long-run income elasticities are close to 1.5.

I. INTRODUCTION

The empirical investigation of the import demand function has been one of the most active research areas in international economics. This is evidenced by the many surveys on this topic, although most focus on industrial countries.[2] Perhaps one of the main reasons for its popularity is its application to a wide range of important macroeconomic policy issues such as the international transmission of domestic disturbances, where these elasticities are a crucial link between economies; the impact of expenditure-switching through exchange rate management and commercial policy on a country's trade balance; and the degree to which the external balance affects a country's growth.

The traditional import demand function is specified as a log-linear function of the relative price of imports and real income. Because of data constraints and the empirical success of this specification, it has dominated the empirical literature for more than a quarter century. But, questions about its microeconomic foundation arise since it has not been derived from utility maximization. Another issue that has been largely ignored in the literature is the problem of nonstationarity, which is found present in most macroeconomic variables and which invalidates classical statistical inference. Thus, if the variables that enter the import demand equation contain a unit root, ignoring nonstationarity in these variables may cause serious inference problems.

The objective of this paper is twofold. First, the paper seeks to address the two problems discussed above by deriving an empirically tractable import demand equation that can be estimated for a large number of countries, using recent time series techniques that address the issue of nonstationarity present in the data. Second, because the statistical properties of the different estimators have been derived only asymptotically, econometric theory does not offer any guidance when it comes to comparing the performance of different estimators in small samples. Consequently, the paper derives the small sample properties of both the Ordinary Least Squares (OLS) and the Fully-Modified (FM) estimators of the short- and long-run elasticities, using Monte Carlo methods. It is shown that the FM estimators dominates the OLS estimators, even in small samples.

The derived aggregate import demand equation is log-linear in the relative price of imports and an activity variable defined as GDP minus exports.[3] An important insight from the explicit derivation of the aggregate import demand equation is that the definition of the activity variable depends on the aggregation level.[4] The model predicts a unique cointegrating vector among imports, the relative price of imports and the activity variable. This prediction is not rejected by the data, and the cointegrating vector is estimated efficiently by the Phillips-Hansen FM estimator.

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[2]See Houthakker and Magee (1969) for an early significant contribution, Goldstein and Khan (1985) for a recent survey, and Faini, Pritchett, and Clavijo (1992) for an analysis of developing countries' imports.

[3]As will be shown in the next section, the correct activity variable is GDP minus exports, not GDP as in the standard import demand equation.

[4]Because disaggregated import prices are not available for most developing countries, only aggregate import demand equations can be estimated. For highly disaggregated import demand equations for the U.S., see Marston (1990) and Swagel (1995).

Two recent papers follow a similar methodology. Clarida (1994) derives a similar import demand function for U.S. nondurable consumption goods from explicit intertemporal optimization, carefully taking into account data nonstationarity. Similarly, Reinhart (1995) estimates both structural import and export demand functions for twelve developing countries using Johansen's cointegration approach.

The results underscore the presence of nonstationarity in the data and the adverse consequences of neglecting it. Both price and income elasticities generally have the expected sign and are precisely estimated. The average price elasticity is close to zero in the short run but is slightly higher than one in the long run. It takes five years for the average price elasticity to achieve 90 percent of its long-run level. A similar pattern holds for income elasticities in the sense that imports react relatively slowly to changes in domestic income. The short-run income elasticities are on average less then 0.5, while the long-run income elasticities are close to 1.5. Industrial countries have both higher income and lower price elasticities than do developing countries. On average, these estimates are relatively close to Reinhart's.[5]

Empirical researchers are generally interested in two statistical properties of their estimates of import elasticities. First, they are interested in the magnitude of these elasticities. A relevant question, then, is how close the estimates are to their true value. The systematic deviation of estimates from their true value is measured by the bias of the estimates. Second, they are interested in inference, that is, hypotheses testing, about these estimates. For example, are the price and income elasticities significantly different from one? Testing such hypotheses requires knowing the distribution of the t-statistic (defined as the coefficient estimate divided by its standard deviation). The asymptotic distribution of this statistic is unknown for the long-run elasticities because these elasticities are nonlinear transformations of the import demand coefficients. In addition, the definition of the long-run elasticities includes the lagged dependent variable whose t-statistic follows a nonstandard distribution in the nonstationary case. In light of this, using the critical values of the t-distribution for hypothesis testing may be misleading. Consequently, the small sample distribution of the t-statistic for both the short- and long-run elasticities are computed using Monte Carlo methods.

The analysis shows that the OLS bias is significantly higher than the FM bias for both the short- and long-run elasticity estimates. The FM bias reaches its minimum when the relative price of imports and the activity variable are exogenous. Strong endogeneity of the explanatory variables (that is, high correlation between the import demand innovations and the explanatory variables innovations) may induce substantial bias. But for most countries—being "small"relative to the rest of the world—the relative price of imports and the activity variable are only weakly endogenous, leading to a relatively small bias. The bias of long-run elasticities is generally much lower than the bias of short-run elasticities. For the benchmark case in which both explanatory variables are assumed to be exogenous, the t-statistics of the short-run elasticities are symmetric around zero but are flatter than the asymptotic t-distribution. This implies that an inference based on the usual t- or F-statistic may be misleading. For example, the exact confidence intervals are wider than those

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[5]Her average long-run price and income elasticities are -0.66 and 1.31, respectively. The corresponding estimates in this paper are -1.08 and 1.45. The small discrepancy may simply reflect different samples (these averages are over 12 countries in Reinhart and over 66 countries in this paper) as well as different estimation methods.

based on the t-statistic. The t-statistic distribution of the short-run elasticities become skewed and flatter when the relative price of imports and/or the activity variable is allowed to be endogenous. The stronger the endogeneity, the larger is this departure from the asymptotic t-distribution.

II. THE MODEL

Assume that the import decision in each country is made by an infinitely lived representative agent who decides how much to consume from the domestic endowment (d_t) and from the imported good (m_t).[6] The home good is the numeraire. The intertemporal decision can be formalized by the following problem:

$$\underset{\{d_t, m_t\}_{t=0}^{\infty}}{Max} \quad E_0 \sum_{t=0}^{\infty} (1+\delta)^{-1} u(d_t, m_t) \tag{1}$$

subject to:

$$b_{t+1} = (1+r) b_t + (e_t - d_t) - p_t m_t \tag{2}$$

$$e_t = (1-\rho)\bar{e} + \rho e_{t-1} + \xi_t, \qquad \xi_t \sim (0, \sigma^2) \tag{3}$$

$$\lim_{T \to \infty} \frac{b_{T+1}}{\prod_{t=0}^{T} (1+r)^{-1}} = 0 \,, \tag{4}$$

where δ is the consumer's subjective discount rate; r is the world interest rate; b_{t+1} is the next period stock of foreign bonds if positive, and the next period's debt level if negative; e_t is the stochastic endowment which follows an AR(1) process with unconditional mean $\bar{e}$ and an unconditional variance $\sigma^2/(1-\rho^2)$, where σ^2 is the variance of the iid innovation ξ_t and ρ determines the degree of persistence of the endowment shocks; and p_t is the relative price of the foreign good, that is, the inverse of the usual definition of terms of trade. In this two-good economy, p_t also represents the relative price of imports. Equation (2) is the current account equation, equation (3) is the stochastic process driving the endowment shock, and equation (4) is the transversality condition that rules out Ponzi games. The first order conditions of this problem are:

[6] The strong assumptions are necessary in order to derive an aggregate import demand equation which does not require more data than what is available. Some of the pitfalls induced by these simplifying assumptions are discussed in Marquez (1994).

$$u_t^d = \lambda_t \tag{5}$$

$$u_t^m = \lambda_t p_t \tag{6}$$

$$\lambda_t = (1+\delta)^{-1}(1+r)\,E_t \lambda_{t+1} , \tag{7}$$

where λ_t is the Lagrange multiplier on the current account equation. From equation (5), λ_t is the marginal utility of the domestic good. Following Clarida (1994, 1996) and Ogaki (1992), it is assumed that the instantaneous utility function u is addilog:[7]

$$u(d_t,m_t) = A_t d_t^{1-\alpha}(1-\alpha)^{-1} + B_t m_t^{1-\beta}(1-\beta)^{-1} \qquad \alpha>0, \beta>0 \tag{8}$$

$$A_t = e^{a_0 + \epsilon_{A,t}} \tag{9}$$

$$B_t = e^{b_0 + \epsilon_{B,t}} \tag{10}$$

where A_t and B_t are exponential stationary random shocks to preferences, $\epsilon_{A,\,t}$ and $\epsilon_{B,\,t}$ are stationary shocks and α and β are curvature parameters. Substituting equation (8) into equations (5) and (6) yields:

$$d_t = \lambda_t^{-\frac{1}{l}\alpha} A_t^{\frac{1}{\alpha}} \tag{11}$$

$$m_t = \lambda_t^{-\frac{1}{\beta}} B_t^{\frac{1}{\beta}} p_t^{-\frac{1}{\beta}} . \tag{12}$$

Substituting equations (9)-(11) into equation (12) and taking logs yields:

$$\tilde{m}_t = c - \frac{1}{\beta}\tilde{p}_t + \frac{\alpha}{\beta}\tilde{d}_t + \epsilon_t , \tag{13}$$

where $c_0 = (1/\beta)(b_0 - a_0)$, and $\epsilon_t = (1/\beta)(\epsilon_{B,t} - \epsilon_{A,t})$. A tilde indicates the log of the corresponding variable. In this model, $x_t = e_t - d_t = GDP_t - d_t$, where x_t is exports. Consequently, $d_t = p_t - x_t$. Thus, the model yields an equation for import demand that is close to the standard import demand function except that the correct activity variable is $GDP_t - x_t$ rather than GDP_t. Equation (13) can be rewritten as:

$$\tilde{m}_t = c - \frac{1}{\beta}\tilde{p}_t + \frac{\alpha}{\beta}(\widetilde{GDP_t - x_t}) + \epsilon_t . \tag{14}$$

Taking logs of equation (11) yields:

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[7]For the properties of the addilog utility function, see Houthakker (1960).

$$\tilde{d}_t = \frac{1}{\alpha}\tilde{A}_t - \frac{1}{\alpha}\tilde{\lambda}_t \ . \tag{15}$$

Because each of the three variables in the import demand equation (13) can either be trend-stationary (TS) or difference-stationary (DS), four cases need to be considered (Table 1). In the next section, results from unit root tests show that the first case is the most common, with some countries falling into the second category. The prime interest is the estimates of the standard price and income elasticities for import demand, defined (respectively) as the coefficients of the log of the relative price of imports (-1/β) and the log of the activity variable (α/β). Note that $\tilde{m}_t$ and $\tilde{p}_t$ are, in general, endogenously determined by import demand and import supply (not modeled here). Therefore, $\tilde{p}_t$ is likely to be correlated with the error term ϵ_t in equation (14). Thus OLS would yield biased estimates of the price and income elasticities. The Phillips-Hansen FM estimator corrects for this potential simultaneity bias, as well as for autocorrelation, in the cointegration framework.

Equation (14) will be estimated in a dynamic form (that is, with the lagged dependent variable included as an explanatory variable) which proved to be more successful in the estimation stage.[8] It is obtained by postulating a partial adjustment process of *actual* imports toward import demand:[9]

$$\Delta \tilde{m}_t^a = \phi\,[\tilde{m}_t - \tilde{m}_{t-1}^a] \ , \qquad |\phi| < 1 \ , \tag{16}$$

where $\tilde{m}_t^a$ and $\tilde{p}_t$and $\tilde{m}_t^a$denote actual and demanded imports, respectively. If ϕ is close to one, it implies that actual imports adjust quickly to import demand. Substituting equation (14) into (16) yields the final import demand equation:

$$\tilde{m}_t^a = \theta_0 + \theta_1\tilde{m}_{t-1}^a + \theta_2\tilde{p}_t + \theta_3(\widetilde{gdp_t - x_t}) + \epsilon_t \ , \tag{17}$$

where $\theta_0=\phi\, c$, $\theta_1=1-\phi$, $\theta_2=-\phi\,(1/\beta)$, and $\theta_2=\phi\,(\alpha/\beta)$. Note that all the coefficients of the import demand equation can be recovered from equation (17). The discussion above and Table 1 remain

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[8]A specification analysis by Thursby and Thursby (1984) shows that this type of dynamic specification outperforms the static ones.

[9]This is equivalent to assuming that $\tilde{m}_t^a = \phi\sum_{j=0}^{\infty}(1-\phi)^j\tilde{m}_{t-j]}$. This adjustment process has been widely used in the literature on empirical trade equations: see Goldstein and Khan (1985). Supply factors and foreign exchange availability may be the source of this noninstantaneous adjustment. An alternative way of bringing in the lagged dependent variable is to assume that the error term ϵ_t is autocorrelated and to use the Cochrane-Orcutt transformation to yield a white noise error. This method did not work very well in this study because it introduces not only the lagged dependent variable but also the lag of the explanatory variables. Severe multicollinearity problems resulted due to the high autocorrelation of the explanatory variables.

valid for equation (17) as long as $|\phi| < 1$, which is the case for most countries in our sample (see Table 2).[10]

[10] A $|\phi| < 1$ does not preclude $\tilde{m}_t^a = \phi \sum^{\infty} (1-\phi)^j \tilde{m}_{t-1}$ from having a unit root since equation (17) shows that $\tilde{m}_t^a = \phi \sum_{j=0} (1-\phi)^j \tilde{m}_{t-1}$ can inherit a unit root if either or both $\tilde{p}_t$ and $\tilde{d}_t$ have a unit root.

Table 1: The four possible model specifications

Model Specification	Model predictions and testing strategy
1. All three variables are difference-stationary (DS) In the model, the following three assumptions are necessary to achieve DS for all three variables: (a) For $\tilde{d}_t$ to be DS, we must assume $r = \delta$. Then the Euler equation (7) becomes: $$\lambda_t = E_t\lambda_{t+1} \quad (18)$$ Thus, λ_t can be written as: $\lambda_t = \lambda_{t+1} + e_t$, where e_t is such that $E_t e_t = 0$. In other words, λ_t has a unit root and, therefore, $\tilde{d}_t$ will also inherit a unit root since $\tilde{A}_t$ is stationary. If $\tilde{d}_t$ has a unit root, then, from equation (13), $\tilde{m}_t$ will also have a unit root. (b) The log of the relative price of imports will be assumed to be difference-stationary (we will see that this assumption cannot be rejected statistically for most countries).1/ (c) $\tilde{p}_t$ and $\tilde{d}_t$ are not cointegrated with cointegrating vector $(1\ {-\alpha})$.	Under assumptions (a) – (c), equation (13) implies that $\tilde{m}_t, \tilde{d}_t$, and $\tilde{p}_t$ are cointegrated with cointegrating vector $(1\ 1/\beta\ {-\alpha/\beta})$. Furthermore, this cointegrating vector is unique (up to a scale factor), since the import demand equation (13) has three I(1) variables and two common stochastic trends.2/ If a cointegration relation between these three variables does not exist, estimation of the import demand equation (13) will result in a spurious regression. Hence, to detect this potential spuriousness, a residual-based cointegration test will be performed on equation (13).

1/ $\tilde{p}_t$ is either exogenous under a perfectly elastic import supply or is endogenously determined by the interaction of the demand and supply of imports. The supply of imports is not modeled explicitly here.

2/ See Stock and Watson (1988).

2. *One of the three variables is trend-stationary (TS)* We have three cases depending on which variable is TS: (a) $\tilde{m}_t$ is TS. The model would yield this case under these three assumptions: $\tilde{p}_t$ is DS; assumption (a) in case 1; and $\tilde{p}_t$ and $\tilde{d}_t$ are cointegrated with cointegrating vector (1 - α). (b) $\tilde{p}_t$ is TS. (c) $\tilde{d}_t$ is TS. From equations (7) and (15), $\tilde{d}_t$ will be TS if $\delta > r$.	(a) $\tilde{p}_t$ and $\tilde{d}_t$ are cointegrated with cointegrating vector (1 -α). (b) $\tilde{m}_t$ and $\tilde{d}_t$ are cointegrated with cointegrating vector (1 -1/β). (c) $\tilde{m}_t$ and $\tilde{p}_t$ are cointegrated with contegrating vector (1 -α/β). In all three cases, if a cointegration relation between these pairs of variables does not exist, attempts to estimate the import demand equation will result in a spurious regression. Hence, to detect this potential spuriousness, a residual-based cointegration tests will be performed on equation (13).
3. *Two of the three variables are TS*	This case can be viewed as a rejection of the model, since there is no linear combination of the three variables that yields a stationary process.
4. *All three variables are TS* This is the only case in which classical inference is valid.	The import demand equation (13) becomes a classical regression equation with population coefficients (1 1/β -α/β).

III. ESTIMATION RESULTS

The import demand equation (17) will be estimated by both the OLS and the FM estimator. The FM estimator is an optimal single-equation method based on the use of OLS with semiparametric corrections for serial correlation and potential endogeneity of the right-hand variables. The method was developed in Phillips and Hansen (1990) and generalized to include deterministic trends by Hansen (1992a). The FM estimator has the same asymptotic behavior as the full systems maximum likelihood estimators.[11]

The data comes from the World Bank database BESD. The sample includes 77 countries for which the required data are available for a reasonable time span (the list of countries is given in Table 2). In general, the data are available from 1960 to 1993.[12] The usual problem is of course the choice of the corresponding proxies for the variables in the model, since the model is usually a crude simplification of reality—which is the case here. Data constraints highly restrict this choice. Total imports and exports of goods and services will be used for m_t and x_t in equation (17). The relative price of imports p_t will be computed as the ratio of the import deflator to the GDP deflator.[13] The activity variable will be computed as the difference between GDP and exports.[14]

A. Unit root test

The Fully-Modified procedure assumes that some of the variables entering the cointegrating equation (17) have a unit root and that there exists a stationary linear combination of these variables. This section tests for the existence of a unit root in all three variables in the import demand equation (17), namely real imports of goods and services (*m*), the relative price of imports (*p*) and the activity variable GDP minus exports (*gdpx*). The unit root hypothesis is tested using the augmented-Dickey-Fuller (ADF) test. The lag length (*k*) in the ADF regression is selected using the Schwarz criterion (Table 2). For m_t, only 4 out of the 77 countries reject the unit root at 5 percent or less (Australia at 1 percent, Nicaragua, Peru and Philippines at 5 percent). Similarly, the null of a unit root in p_t is rejected only for 3 countries (China at 1 percent, Papua New Guinea and Uruguay at 5 percent). Finally, as far as $gdpx_t$ is concerned, the unit root is rejected for 10 countries (Burundi, Central African Republic, Iceland, Switzerland, Trinidad and Tobago at 1 percent; Korea, Rwanda, Togo, Tunisia and Zaire at 5 percent). Thus for most of the countries, the unit root hypothesis cannot be rejected at conventional significance levels. This finding, of course, may reflect to a certain extent the low power of the ADF.

B. Import demand equations

The results underscore the presence of nonstationarity in the data and the adverse consequences of neglecting it. Table 2 shows that most countries—60 of the 77—fall into the first case of Table 1 (the unit root hypothesis cannot be rejected for all three variables in the import demand equation) and the remaining

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[11]For more details see Phillips and Hansen (1990), Phillips and Loretan (1991) and Hansen (1992a).

[12]The following countries have a shorter data range: Cameroon 1965–93, Ecuador 1965–93, Sudan 1960–91, Tunisia 1961–93 and Yugoslavia 1960–90.

[13]Feenstra (1994) points out the problem that these aggregate prices do not account properly for quality upgrade over time.

[14]Even though the behavior of imports of consumption and intermediate goods may differ, data availability precludes us from analyzing disaggregated import demand equations.

countries —17 of the 77—into the second case (the unit root hypothesis can be rejected for only one of the three variables). In the first case, the model predicts a cointegrating relationship between the three I(1) variables, and in the second case between the two I(1) variables. No country belongs to either the third or fourth cases.

Table 3 shows both the OLS and FM estimates of the import demand equation. Only countries with the right sign for the price and income elasticities are reported (66 of the 77 countries). The columns of Table 3 labeled x_{-1}, *p* and *gdpx* give, respectively, the coefficient estimates of the lagged dependent variable (log of imports of goods and nonfactor services), the short-term price elasticity (that is, the coefficient of the log of relative price of imports) and the short-term income elasticity (the coefficient of the log of *gdpx*). The long-run price and income elasticities are defined as the short-run price and income elasticities divided by one minus the coefficient estimate of the lagged dependent variable. They are given by E_p and E_y for the FM estimates.[15] The column labeled *ser* reports the standard error of the regression. Finally, the column labeled *AC* gives Durbin's autocorrelation test. It amounts to estimating an AR(1) process on the estimated residuals of the import equation. Durbin's test is simply a significance test of the AR(1) coefficient using the usual t-test. For the OLS regressions, AR(1) autocorrelation is detected (at 10 percent or less) for 17 of the 66 countries.

Even though Table 3 reports both the OLS and FM estimates of the import demand equation, the discussion will focus only on the latter since both estimation methods yield relatively close results. The short-run price elasticities vary from −0.01 (Algeria) to −0.86 (Malawi) with a sample average (over the 66 countries) of −0.26, a median of −0.22, and a standard deviation of 0.19. Therefore, imports appear to be quite inelastic in the short term. The long-run price elasticities vary from −0.02 (Chile) to −6.74 (Benin). The sample average is −1.08, the median is −0.80, and the standard deviation is 1.08. As expected, imports are much more responsive to relative prices in the long run than in the short run. The short-run income elasticities vary from 0.0 (Zaire) to 1.36 (Haiti). The sample average is 0.45, the median is 0.32, and the standard deviation is 0.34. Thus, the average short-run income elasticity is significantly less than 1. The long-run income elasticities vary from 0.03 (Zaire) to 5.48 (Uruguay). The sample average is 1.45, the median is 1.32, and the standard deviation is 0.93. Thus imports respond much more to both relative prices and income in the long-run than in the short-run. E_p^c and E_y^c give the long-run price and income elasticities corrected for bias. The correction is generally small. As will be discussed in the next section, the bias is negligible when the relative price of imports and the activity variable are either exogenous or weakly endogenous, as is the case for most countries. Since unit-price and unit-income elasticities are widely used as benchmark values, a formal test for long-run unit-price and unit-income elasticities is provided in the columns labeled $E_p = -1$ and $E_y = 1$, respectively. This test uses exact critical values of the t-statistic (given in Table 8 and will be discussed in the next section). Fifteen of the 66 countries reject a long-run unit-price elasticity and 27 countries reject a long-run unit-income elasticity at 10 percent or less. The fit as measured by $\bar{R}^2$ is good.

Table 1 showed that in the first two cases, estimates of the price and income elasticities will be meaningful only if the I(1) variables are cointegrated. A cointegration test is therefore required. The results of the Phillips-Ouliaris residual test of cointegration is given in Table 3 under the heading P-O. Even with a relatively small sample size (and therefore low power), the null of noncointegration is rejected for 49 of the 66 countries (at 1 percent in most cases).

An interesting question is whether the long-run income and price elasticities differ significantly between industrial and developing countries. The answer is given by the following two regressions:

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[15]The OLS estimates of E_p and E_y are close to the FM estimates and were therefore omitted from Table 3.

$$E_y = \underset{(17.49)}{0.96} + \underset{(10.59)}{1.010}\,dumdc \qquad R^2 = 0.66 \tag{19}$$

$$|E_p| = \underset{(12.03)}{0.73} - \underset{(-3.25)}{0.316}\,dumdc \qquad R^2 = 0.63 \tag{20}$$

where E_p and E_y are, respectively, the long-run price and income elasticities and *dumdc* is a dummy variable that takes the value of one for an industrial and zero for a developing country. The two equations are generalized-least-squares (GLS) regressions of the long-run income and price elasticities on *dumdc*.[16] Industrial countries have significantly higher (by 1.01) long-run income elasticities than developing countries (equation 19) and face much more inelastic import demand than do developing countries (equation 20).

IV. SMALL-SAMPLE PROPERTIES OF THE OLS AND FM ESTIMATORS

A. Small-sample bias of the short- and long-run elasticities

The bias for the OLS and the FM estimates of the short- and long run price and income elasticities varies significantly with the degree of endogeneity of the explanatory variables, i.e. with the correlation between the innovations in the import demand equation and in the relative price of imports (R_{12}), and the correlation between the innovations in the import demand equation and in the activity variable (R_{13}). The FM bias reaches its minimum when $R_{12}=R_{13}=0$ and equals -0.37 percent, 0.99 percent and -1.14 percent for the dependent variable, and the short-run price and income elasticities, respectively. This implies that both the short-run price and income elasticities are underestimated, the former by 0.99 percent and the latter by 1.14 percent.[17] The corresponding OLS figures are -3.79 percent and 3.69 percent. The OLS bias is generally much higher than the corresponding FM one. Note that for this benchmark case (where $R_{12}=R_{13}=0$), OLS differs from FM both in magnitude and in the direction. Negative values of R_{12} tend to bias both the price and the income elasticities downward while positive ones induce an upward bias. Negative values of R_{13} tend to bias both the price and the income elasticities upward while positive values induce a downward bias. The bias becomes substantial for high values of R_{12} and R_{13}.

Because long-run elasticities depend not only on the short-run elasticities (α_1 and α_2) but also on the adjustment speed as measured by the coefficient on the lagged dependent variable (α_1), the bias in the short-run elasticities does not translate one-for-one to the long-run elasticities. The OLS bias is generally much higher than the corresponding FM one. When $R_{12}=R_{13}=0$, the FM bias is still the minimum for the price elasticity (0.27 percent) but is slightly higher than the minimum for the income elasticity (-0.41 percent). The corresponding OLS figures are 1.81 percent and -1.86 percent. These values imply that both the long-run price and income elasticities are underestimated. Negative values of R_{12} tend to bias both long-run elasticities upward, while positive values have the opposite effect. Negative values of R_{13} induce an upward bias in the long-run price elasticity and a downward bias in the long-run income elasticity. The reverse holds

[16]The variance-covariance matrix in the GLS estimation is constructed using the Fully-Modified estimates of the variances of the income and price elasticities for each country. The R^2 is computed using Buse's method which yields a properly normalized statistic for GLS residuals.

[17]Because the price elasticity is negative while the income elasticity is positive, these elasticities are underestimated if the price elasticity bias is positive and the income elasticity bias is negative.

for positive values of R_{13}. Interestingly, the bias on the long-run elasticities is generally lower than the bias on the short-run elasticities.

B. Small-sample distribution of the t-statistic

For the benchmark case in which both explanatory variables are assumed to be exogenous ($R_{12}=R_{13}=0$), the small-sample t-distribution for the imports relative price (p) and the activity variable (y) are symmetric but are wider than the asymptotic t-distribution (Table 5). For reference, the asymptotic critical values of the t-distribution at 1 percent, 5 percent, and 10 percent are -2.33, -1.65, and -1.28, respectively. The corresponding small-sample critical values are -2.55, -1.78, and -1.36 for p, and -2.71, -1.86, and -1.44 for y. The t-distribution of the lagged dependent variable (m_{-1}) is skewed to the left, as expected, since m_t has a unit root. When p is allowed to be endogenous (that is, $R_{12}\neq 0$), the distribution of its t-statistic becomes skewed, while the t-statistic distribution of y becomes flatter. Similarly, when y is allowed to be endogenous (that is, $R_{13}\neq 0$), the distribution of its t-statistic becomes skewed, while the t-statistic distribution of p becomes flatter. The stronger the endogeneity of p or y, that is, the larger (in absolute value) R_{12} or R_{13}, the larger is this departure from the asymptotic t-distribution. The only significant difference between the OLS and the FM t-distributions is that the FM is flatter than the OLS (Table 6).

For the benchmark case $R_{12}=R_{13}=0$, the t-distribution of E_p (the long-run price elasticity) and E_y (the long-run income elasticity) are symmetric but flatter than the asymptotic t-distribution.[18] The 1 percent, 5 percent, and 10 percent critical values are -2.76, -1.82, and -1.38 for E_p, and -3.09, -1.93, and -1.48 for E_y. Similar to the short-run elasticity case, when p is allowed to be endogenous, the t-statistic distribution of E_p becomes skewed, while the t-statistic distribution of E_y becomes flatter. Similarly, when y is allowed to be endogenous, the t-statistic distribution of E_y becomes skewed, while the t-statistic distribution of E_p becomes flatter. The stronger the endogeneity, the larger is the deviation from the asymptotic t-distribution. The only significant difference between the OLS and the FM t-distributions is that the FM t-distributions are flatter than the former, as was the case for the short-run elasticities (Table 8).

V. CONCLUSIONS

Despite the stringent constraints imposed by data availability, which dictated both the level of aggregation as well as the simplicity of the model, this analysis provides the applied researcher with some interesting insights:

- First, the paper offers a wide range of income and price elasticities for both industrial and developing countries, estimated within a consistent framework using recent time series techniques that address nonstationarity in the data.

- Second, the long-run price and income elasticities for a large majorigy of countries have the right sign expected from theory and, in most cases, are statistically significant.

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[18]The t-statistics for E_p and E_y are derived using the Taylor approximation of var(E_p) and var(E_y):

$$var(E_p)=(\frac{1}{1-\alpha_1})^2 var(\alpha_2)+[\frac{\alpha_2}{(1-\alpha_1)^2}]^2 var(\alpha_1)+2(\frac{1}{1-\alpha_1})[\frac{\alpha_2}{(1-\alpha_1)^2}]cov(\alpha_1,\alpha_2),$$

where α_1 is the coefficient of the lagged dependent variable and α_2 is the short-run price elasticity; var(E_y) is obtained by substituting α_2 by α_3 in var(E_p), where α_3 is the short-run income elasticity.

- Third, the analysis shows that industrial countries tend to have significantly higher income elasticities and lower price elasticities than developing countries.

- Finally, econometric theory is uninformative about the properties of the import demand elasticity estimates for two reasons: the sample size for developing countries is generally small while most econometric results are asymptotic, and inference about the import demand elasticities requires knowledge of the distribution of their t-statistics which is not known for the long-run elasticities (even asymptotically) because they are nonlinear transformations of the import demand coefficients. In addition the definition of the long-run elasticities includes the lagged dependent variable, whose t-statistic follows a nonstandard distribution in the nonstationary case. Consequently, Monte Carlo methods were used to compute the exact bias as well as the exact distribution of the t-statistic for the short- and long-run elasticities, allowing more reliable inference. The bias and the distribution of the t-statistic are shown to depend critically on the degree of endogeneity of the explanatory variables.

Table 2: Augmented-Dickey-Fuller test for variables entering the import demand equation

Country	*m*	*k*	*p*	*k*	*gdpx*	*k*	*nobs*
1 ALGERIA	-0.33	1	1.08	2	-1.25	2	34
2 ARGENTINA	-3.29	2	-2.04	1	-2.44	1	34
3 AUSTRALIA	-4.45 **	1	-1.71	1	-2.15	1	34
4 AUSTRIA	-1.77	1	-1.67	1	-1.50	1	34
5 BELGIUM-LUXEMBOURG	-1.79	1	-0.09	2	-2.08	1	34
6 BENIN	-0.56	2	-1.12	2	-0.89	1	34
7 BRAZIL	-1.11	1	0.21	1	-2.64	1	34
8 BURUNDI	-3.09	1	-2.85	3	-4.46 **	1	34
9 CAMEROON	-1.28	1	0.40	1	-1.16	1	29
10 CANADA	-2.54	1	0.69	1	-1.45	1	34
11 CENTRAL AFRICAN REPUBLIC	-0.07	2	-3.17	1	-4.86 **	1	34
12 CHAD	-2.08	1	-1.85	1	-3.34	1	34
13 CHILE	-1.99	1	-2.15	1	-2.07	2	34
14 CHINA	-1.89	1	-4.33 **	1	-2.40	2	34
15 COLOMBIA	-2.17	1	-0.28	1	-1.98	1	34
16 CONGO	-2.10	2	-2.25	1	-2.55	2	34
17 COSTA RICA	-1.78	1	-1.04	2	-3.43	1	34
18 COTE D'IVOIRE	-0.25	1	-2.69	1	-2.74	1	34
19 DENMARK	-2.11	1	-1.60	1	-1.88	1	34
20 DOMINICAN REPUBLIC	-3.51	1	-1.10	1	-2.94	1	34
21 EGYPT	-1.21	1	-0.83	1	-2.50	2	34
22 EL SALVADOR	-2.20	2	-1.80	1	-1.40	2	34
23 FINLAND	-1.82	1	-1.71	1	-1.40	2	34
24 FRANCE	-2.03	1	-1.49	1	-1.62	1	34
25 GABON	-1.03	1	-1.31	1	-2.36	1	34
26 GAMBIA	-1.60	1	-3.06	1	-1.28	1	34
27 GERMANY	-1.87	2	-1.90	1	-1.52	1	34
28 GREECE	-2.66	1	-1.19	1	0.20	1	34
29 GUATEMALA	-1.98	1	-0.81	1	-2.25	1	34
30 HAITI	-2.83	1	0.88	1	-1.73	1	34
31 HONDURAS	-2.91	1	-2.62	2	-3.08	2	34
32 ICELAND	-1.82	1	-0.94	2	-4.38 **	3	34
33 INDIA	-2.20	1	-2.16	1	-2.71	1	34
34 INDONESIA	-1.88	1	-2.31	1	-1.64	1	27
35 IRELAND	-2.54	1	0.04	1	-2.20	1	34
36 ISRAEL	-1.69	1	-1.97	1	-1.71	1	34
37 ITALY	-2.15	1	-0.39	1	-1.10	1	34
38 JAPAN	-2.04	1	-2.09	1	-1.54	1	34
39 KENYA	-2.02	1	-0.41	1	-1.25	1	34
40 KOREA	-1.48	1	-2.30	2	-3.76 *	1	34
41 MADAGASCAR	-2.92	1	-1.77	1	-2.45	1	34
42 MALAWI	-2.46	1	-1.97	1	-2.77	1	34
43 MALAYSIA	-2.01	1	0.27	1	-2.38	1	34
44 MAURITANIA	-1.53	1	-2.50	2	-2.55	1	34
45 MAURITIUS	-2.44	2	-2.22	1	-1.99	1	34
46 MEXICO	-3.47	2	-1.17	1	-1.63	1	34
47 MOROCCO	-1.67	1	-1.41	1	-1.50	1	34
48 MYANMAR	-1.69	1	-1.37	2	2.39	1	34
49 NETHERLANDS	-2.22	1	-1.98	1	-2.23	1	34
50 NEW ZEALAND	-3.28	1	-2.37	2	-2.00	1	34

Country	*m*	*k*	*p*	*k*	*gdpx*	*k*	*nobs*	*Country*	*m*	*k*	*p*	*k*	*gdpx*	*k*	*nobs*
51 NICARAGUA	-3.81 *	1	-1.96	1	-2.52	1	34	65 SWEDEN	-2.06	1	-0.73	1	-1.52	1	34
52 NIGERIA	-1.23	2	-2.57	1	-0.58	1	34	66 SWITZERLAND	-1.41	1	-2.74	1	-4.27 **	2	34
53 NORWAY	-1.74	1	1.29	1	-2.47	1	34	67 THAILAND	-1.39	1	-1.88	1	-2.00	1	34
54 PAKISTAN	-2.79	1	-2.34	2	-2.50	1	34	68 TOGO	-0.39	1	-3.31	1	-3.62 *	1	34
55 PANAMA	-2.26	1	-1.69	1	-1.45	1	34	69 TRINIDAD AND TOBAGO	-2.59	1	0.95	1	-4.35 **	1	34
56 PAPUA NEW GUINEA	-2.83	1	-3.63 *	3	-1.88	2	33	70 TUNISIA	-1.32	1	-1.55	1	-3.75 *	1	33
57 PARAGUAY	-2.45	1	-1.28	1	-1.97	1	34	71 TURKEY	-1.81	1	-1.87	1	-1.40	1	34
58 PERU	-3.78 *	2	-1.34	1	-1.65	1	34	72 UNITED KINGDOM	-2.17	1	-3.48	1	-1.59	2	34
59 PHILIPPINES	-3.68 *	2	-0.41	1	-1.67	1	34	73 UNITED STATES	-2.34	1	-2.69	1	-0.59	1	34
60 PORTUGAL	-2.31	1	-0.64	1	-0.60	1	34	74 URUGUAY	-1.89	1	-3.72 *	1	-2.22	2	34
61 RWANDA	-2.31	1	-1.65	3	-3.55 *	1	34	75 YUGOSLAVIA	-1.76	1	0.25	1	-2.62	1	31
62 SOUTH AFRICA	-3.18	1	0.07	1	-0.37	1	34	76 ZAIRE	-2.56	1	-1.72	1	-4.02 *	1	30
63 SPAIN	-2.68	1	-1.47	1	-1.51	2	34	77 ZAMBIA	-2.09	1	-2.73	1	-2.27	1	34
64 SUDAN	-1.79	1	-1.97	1	-1.39	1	32								

Note: Variables are real imports of goods and non-factor services (*m*), the real exchange rate (*p*), computed as the ratio of imports deflator to GDP deflator, and GDP minus exports (*gdpx*). These three variables are tested for the existence of a unit root using the Augmented-Dickey-Fuller (ADF) test. The optimal lag selected by the Schwarz criterion in the ADF regression is given by *k*. Critical values are a linear interpolation between the critical values for T=25 and T=50 given in Hamilton (1993, Table B.6, case 4), where T is the sample size. Significance levels at 1% and 5% are indicated by ** and *, respectively.

Table 3: Import demand equations

	OLS estimates						Fully-Modified estimates												
	m_{-1}	p	gdpx	AC	ser	R^2	m_{-1}	p	gdpx	E_p	E_y	E_p^c	E_y^c	ser	R^2	P-O	E_p=-1	E_y=1	nobs
1 ALGERIA	0.81	-0.06	0.16	0.45	0.15	0.92	0.87	-0.01	0.11	-0.08	0.83	-0.07	0.84	0.07	0.91	-3.66	1.73	-0.74	34
	7.71	-0.41	1.73	2.65			16.14	-0.14	2.23	-0.14	3.66 a								
2 ARGENTINA	0.42	-0.64	0.80	0.19	0.16	0.80	0.42	-0.68	0.70	-1.17	1.21	-1.07	1.27	0.12	0.80	-5.24 a	-0.85	1.12	34
	3.50	-5.00	4.57	1.01			4.71	-6.96	5.25	-5.99 a	6.38 a								
3 AUSTRALIA	0.49	-0.34	0.70	0.25	0.07	0.98	0.82	-0.12	0.21	-0.66	1.19	-0.64	1.22	0.08	0.97	-10.82 a	0.28	0.52	34
	3.93	-1.78	3.81	1.34			5.57	-0.55	0.95	-0.54	3.22 b								
4 AUSTRIA	0.76	-0.33	0.48	-0.07	0.04	1.00	0.82	-0.27	0.32	-1.50	1.76	-1.56	1.77	0.03	1.00	-5.55 a	-1.19	2.25	34
	10.02	-2.20	2.64	-0.36			14.11	-2.39	2.23	-3.55 a	5.23 a								
5 BELGIUM-LUXEMBOURG	0.95	-0.17	-0.04	-0.09	0.05	0.99	0.96	-0.11	0.00	-2.57	0.10	-2.68	0.10	0.03	0.99	-5.45 a	-1.14	-0.76	34
	57.15	-1.96	-0.59	-0.44			76.91	-1.86	0.09	-1.86 b	0.08								
6 BENIN	0.90	-0.54	0.37	0.07	0.14	0.93	0.93	-0.47	0.34	-6.74	4.91	-6.66	4.83	0.08	0.94	-4.77 a	-1.68	1.38	34
	16.68	-1.58	1.04	0.43			29.26	-2.29	1.61	-1.97 b	1.74 b								
7 BRAZIL	0.83	-0.30	0.19	0.31	0.12	0.96	0.84	-0.29	0.20	-1.73	1.24	-1.80	1.25	0.07	0.96	-4.35 b	-0.95	1.41	34
	8.17	-2.78	1.64	1.71			12.97	-4.16	2.72	-2.24 c	7.26 a								
8 BURUNDI	0.63	-0.27	0.55	-0.10	0.11	0.96	0.81	-0.19	0.31	-0.99	1.63	-0.98	1.60	0.07	0.96	-6.10 a	0.01	1.58 c	34
	5.16	-1.29	3.46	-0.52			10.20	-1.44	2.83	-1.23	4.09 a								
9 CAMEROON	-0.01	-0.76	1.02	0.28	0.08	0.96	0.10	-0.69	0.91	-0.77	1.01	-0.80	1.00	0.07	0.96	-3.88 c	1.95	0.24	29
	-0.05	-3.91	5.71	1.40			0.72	-4.23	6.07	-6.53 a	25.24 a								
10 CANADA	0.53	-0.57	0.72	0.19	0.05	0.99	0.58	-0.54	0.63	-1.28	1.48	-1.33	1.49	0.03	0.99	-4.11 a	-1.77	5.35 a	34
	4.36	-3.14	3.76	0.90			7.27	-4.78	4.78	-8.00 a	16.56 a								
11 CHILE	0.26	-0.09	1.41	0.42	0.11	0.93	0.37	-0.01	1.18	-0.02	1.87	-0.01	1.94	0.12	0.93	-3.79	8.66 a	4.89 a	34
	2.14	-1.29	6.63	2.74			2.95	-0.14	5.21	-0.14	10.47 a								
12 CHINA	0.76	-0.19	0.53	0.41	0.19	0.98	0.89	-0.04	0.24	-0.39	2.16	-0.39	2.12	0.17	0.97	-3.78	0.39	1.34	34
	9.73	-1.00	3.15	2.54			10.99	-0.24	1.39	-0.26	2.50 a								
13 COLOMBIA	0.32	-0.63	0.76	0.25	0.13	0.93	0.46	-0.44	0.59	-0.80	1.09	-0.78	1.09	0.10	0.92	-3.02	0.59	1.13	34
	1.37	-2.35	3.06	1.03			2.54	-2.09	3.04	-2.38 b	13.38 a								
14 CONGO	0.60	-0.42	0.36	0.41	0.15	0.81	0.71	-0.29	0.25	-1.02	0.87	-1.02	0.88	0.11	0.81	-3.43	-0.03	-0.56	34
	4.01	-2.21	2.31	2.33			6.21	-2.02	2.16	-2.27 b	3.82 a								
15 COSTA RICA	0.74	-0.55	0.38	0.15	0.08	0.98	0.86	-0.57	0.16	-4.18	1.21	-3.99	1.22	0.07	0.98	-5.08 a	-1.27	0.53	34
	8.01	-5.90	2.48	0.82			10.35	-6.81	1.16	-1.67	3.09 a								
16 COTE D'IVOIRE	0.67	-0.46	0.32	0.24	0.10	0.95	0.67	-0.34	0.32	-1.04	0.96	-0.96	0.96	0.09	0.96	-3.91 c	-0.08	-0.26	34
	7.58	-2.93	3.55	1.85			8.43	-2.40	3.78	-2.24 b	6.86 a								
17 DENMARK	0.48	-0.14	0.89	0.05	0.04	0.99	0.58	-0.14	0.69	-0.34	1.63	-0.33	1.67	0.04	0.99	-5.45 a	3.98 a	4.64 a	34
	5.26	-1.72	4.78	0.29			6.84	-1.93	4.04	-2.05 c	11.98 a								

	m_{-1}	p	gdpx	AC	ser	R^2	m_{-1}	p	gdpx	E_p	E_y	E_p^c	E_y^c	ser	R^2	P-O	E_p=-1	E_y=1	nobs
18 DOMINICAN REPUBLIC	0.30	-0.32	0.69	0.16	0.16	0.90	0.51	-0.15	0.43	-0.30	0.86	-0.30	0.85	0.15	0.90	-5.72 a	2.36 c	-0.96	34
	1.89	-1.95	3.90	0.93			3.51	-0.98	2.63	-1.02	5.95 a								
19 EL SALVADOR	0.54	-0.49	0.71	0.39	0.10	0.91	0.66	-0.42	0.50	-1.23	1.47	-1.19	1.50	0.10	0.90	-3.75	-0.38	1.79	34
	4.46	-3.39	3.86	2.28			5.66	-3.05	2.74	-2.01 c	5.65 a								
20 FRANCE	0.41	-0.22	1.21	-0.18	0.04	1.00	0.50	-0.20	1.02	-0.40	2.02	-0.42	2.03	0.02	1.00	-6.78 a	6.85 a	23.05 a	34
	4.11	-3.61	5.41	-1.04			7.67	-5.50	6.95	-4.65 a	45.69 a								
21 GABON	0.55	-0.27	0.66	0.28	0.15	0.97	0.64	-0.22	0.52	-0.62	1.45	-0.60	1.46	0.12	0.97	-5.23 a	1.60	2.01 c	34
	6.24	-2.16	4.16	1.59			8.69	-2.17	3.98	-2.56 b	6.44 a								
22 GAMBIA	0.88	-0.18	0.11	-0.04	0.22	0.71	0.92	-0.13	0.12	-1.57	1.51	-1.49	1.48	0.10	0.70	-5.88 a	-0.48	0.53	34
	8.02	-1.31	1.00	-0.21			18.06	-2.04	2.43	-1.32 c	1.58 b								
23 GERMANY	0.49	-0.06	1.43	0.41	0.03	1.00	0.54	-0.10	1.26	-0.21	2.73	-0.20	2.76	0.03	1.00	-3.55	5.11 a	14.10 a	34
	6.12	-0.85	5.77	2.44			7.07	-1.41	5.19	-1.34	22.26 a								
24 GREECE	0.79	-0.40	0.33	-0.03	0.07	0.99	0.84	-0.26	0.21	-1.66	1.32	-1.62	1.32	0.05	0.99	-6.59 a	-1.60	1.04	34
	10.57	-3.30	2.29	-0.17			14.13	-2.65	1.73	-4.00 a	4.30 a								
25 HAITI	0.37	-0.56	1.72	-0.21	0.15	0.93	0.51	-0.51	1.36	-1.05	2.79	-1.03	2.74	0.11	0.94	-6.40 a	-0.28	4.91 a	34
	2.31	-3.77	3.22	-1.07			4.06	-4.33	3.15	-6.38 a	7.66 a								
26 HONDURAS	0.80	-0.14	0.17	0.22	0.09	0.95	0.86	-0.05	0.10	-0.39	0.74	-0.39	0.76	0.06	0.94	-4.24 b	0.74	-0.73	34
	9.62	-0.84	1.58	1.22			14.31	-0.47	1.42	-0.47	2.11								
27 ICELAND	0.16	-0.44	0.59	0.34	0.08	0.97	0.20	-0.38	0.57	-0.48	0.71	-0.50	0.70	0.08	0.98	-3.39	2.79 c	-8.85 a	34
	1.11	-3.19	5.48	2.05			1.27	-2.56	4.71	-2.53 b	21.62 a								
28 INDIA	0.66	-0.14	0.49	0.14	0.10	0.96	0.79	-0.03	0.28	-0.12	1.33	-0.11	1.33	0.07	0.96	-5.64 a	1.85	1.22	34
	5.04	-1.09	2.94	0.83			8.02	-0.25	2.14	-0.25	4.90 a								
29 INDONESIA	0.60	-0.62	0.36	0.44	0.10	0.99	0.67	-0.51	0.32	-1.56	0.98	-1.51	0.98	0.10	0.98	-2.86	-1.66	-0.16	27
	4.22	-2.56	2.21	2.38			4.62	-2.01	1.92	-4.64 a	7.98 a								
30 ISRAEL	0.62	-0.10	0.49	0.04	0.08	0.99	0.76	-0.08	0.32	-0.32	1.34	-0.32	1.35	0.07	0.98	-5.27 a	1.28	2.29 c	34
	4.53	-0.86	2.34	0.19			6.42	-0.71	1.81	-0.61	9.02 a								
31 ITALY	0.44	-0.21	0.99	0.04	0.05	0.99	0.48	-0.19	0.92	-0.35	1.75	-0.37	1.75	0.04	0.99	-4.86 a	8.15 a	14.29 a	34
	4.35	-3.69	5.04	0.22			6.16	-4.25	6.20	-4.46 a	33.33 a								
32 JAPAN	0.65	-0.14	0.38	-0.02	0.06	0.99	0.73	-0.14	0.29	-0.52	1.04	-0.53	1.07	0.05	0.99	-4.93 a	2.01	0.35	34
	6.00	-2.27	2.44	-0.08			9.55	-3.31	2.65	-2.15 c	8.49 a								
33 KENYA	0.47	-0.77	0.55	-0.33	0.12	0.75	0.57	-0.71	0.49	-1.66	1.14	-1.82	1.11	0.07	0.74	-6.25 a	-2.41 b	0.84	34
	3.38	-3.61	3.69	-1.54			7.03	-5.68	5.61	-6.09 a	6.90 a								
34 KOREA	0.74	-0.17	0.42	0.17	0.13	0.99	0.88	-0.10	0.16	-0.84	1.32	-0.75	1.33	0.11	0.99	-6.60 a	0.10	0.42	34
	6.14	-0.82	1.62	1.04			9.03	-0.59	0.78	-0.50	1.72 b								
35 MADAGASCAR	0.60	-0.26	-0.04	0.12	0.14	0.78	0.79	-0.15	0.11	-0.71	0.52	-0.69	0.52	0.11	0.77	-5.08 a	0.70	-0.50	34
	3.88	-1.46	-0.13	0.62			6.60	-1.13	0.50	-1.73 c	0.53								

	m_{-1}	p	gdpx	AC	ser	R^2	m_{-1}	p	gdpx	E_p	E_y	E_p^c	E_y^c	ser	R^2	P-O	E_p=-1	E_y=1	nobs
36 MALAWI	0.35	-0.94	0.68	0.26	0.13	0.78	0.48	-0.86	0.60	-1.65	1.14	-1.63	1.12	0.12	0.77	-4.79 a	-1.59	0.72	34
	2.57	-3.86	4.36	1.46			3.85	-3.85	4.07	-4.06 a	5.86 a								
37 MAURITANIA	0.81	-0.45	0.23	-0.13	0.21	0.87	0.91	-0.33	0.26	-3.61	2.83	-3.50	2.83	0.16	0.87	-6.82 a	-0.88	0.81	34
	8.37	-1.03	0.86	-0.77			12.52	-0.99	1.30	-1.22	1.25 c								
38 MAURITIUS	1.00	-0.26	0.10	0.51	0.10	0.96	0.96	-0.11	0.09	-2.78	2.25	-2.70	2.25	0.08	0.96	-3.11	-0.34	0.57	34
	15.32	-1.20	0.94	3.35			19.63	-0.65	1.07	-0.53	1.03								
39 MEXICO	0.69	-0.37	0.44	0.55	0.16	0.94	0.72	-0.22	0.37	-0.77	1.31	-0.64	1.35	0.10	0.94	-3.19	0.66	2.05 a	34
	5.22	-2.18	2.37	4.50			8.30	-1.98	2.95	-2.15 c	8.57 a								
40 MOROCCO	0.73	-0.21	0.33	0.21	0.10	0.96	0.81	-0.15	0.24	-0.78	1.23	-0.78	1.23	0.07	0.96	-4.46 b	0.38	1.11	34
	5.63	-1.41	2.16	1.15			8.38	-1.39	2.05	-1.34	6.02 a								
41 MYANMAR	0.81	-0.04	0.08	0.16	0.21	0.63	0.90	-0.06	0.01	-0.57	0.09	-0.60	0.09	0.12	0.61	-4.67 a	0.61	-1.49	34
	7.48	-0.37	0.74	0.80			14.28	-0.97	0.15	-0.83	0.15								
42 NEW ZEALAND	0.42	-0.38	1.12	0.14	0.07	0.96	0.60	-0.32	0.84	-0.80	2.11	-0.83	2.08	0.07	0.96	-5.21 a	0.94	5.54 a	34
	3.45	-4.11	4.54	0.72			4.81	-3.54	3.21	-3.72 a	10.55 a								
43 NICARAGUA	0.40	-0.15	0.36	0.12	0.18	0.43	0.52	-0.12	0.27	-0.26	0.57	-0.26	0.58	0.10	0.44	-9.37 a	6.28 a	-2.36 c	34
	2.68	-1.47	2.00	0.69			6.26	-2.27	2.77	-2.20 b	3.19 b								
44 NIGERIA	0.63	-0.34	0.59	0.55	0.17	0.95	0.67	-0.30	0.60	-0.90	1.81	-0.88	1.81	0.13	0.94	-3.05	0.74	3.39 a	34
	5.27	-2.75	2.50	3.49			7.21	-3.10	3.25	-6.96 a	7.59 a								
45 NORWAY	0.76	-0.41	0.16	0.05	0.05	0.98	0.82	-0.39	0.09	-2.22	0.53	-2.31	0.52	0.03	0.98	-5.01 a	-1.47	-1.58	34
	7.09	-1.90	1.28	0.27			11.44	-2.52	1.08	-2.68 b	1.79 c								
46 PAKISTAN	0.04	-0.52	0.83	0.27	0.11	0.85	0.15	-0.42	0.70	-0.49	0.82	-0.47	0.83	0.08	0.84	-4.18 b	6.67 a	-2.40	34
	0.26	-4.40	5.27	1.58			1.17	-4.71	5.95	-6.35 a	11.22 a								
47 PANAMA	0.49	-0.01	0.46	0.40	0.11	0.93	0.62	-0.06	0.38	-0.16	0.99	-0.16	1.00	0.08	0.91	-3.57	2.06	-0.06	34
	2.60	-0.03	2.34	2.31			4.28	-0.43	2.54	-0.40	9.73 a								
48 PAPUA NEW GUINEA	0.65	-0.27	0.79	0.25	0.08	0.96	0.75	-0.27	0.47	-1.08	1.86	-1.10	1.90	0.07	0.96	-9.44 a	-0.16	1.74	33
	8.93	-1.99	3.29	1.28			11.63	-2.25	2.17	-2.11 c	3.77 b								
49 PARAGUAY	0.53	-0.16	0.72	0.10	0.20	0.93	0.56	-0.14	0.69	-0.33	1.58	-0.30	1.57	0.11	0.94	-4.56 b	3.76 a	5.78 a	34
	2.98	-1.13	2.60	0.56			5.46	-1.73	4.15	-1.82 b	15.81 a								
50 PERU	0.53	-0.32	0.19	0.39	0.11	0.65	0.67	-0.21	0.17	-0.63	0.50	-0.61	0.52	0.11	0.62	-3.99 c	1.02	-2.09	34
	4.63	-3.04	2.15	2.29			5.80	-2.05	1.93	-1.75	2.13 c								
51 PHILIPPINES	0.79	-0.36	0.44	0.43	0.09	0.97	0.89	-0.29	0.24	-2.73	2.25	-2.73	2.26	0.09	0.97	-3.14	-0.88	1.79	34
	7.56	-2.22	2.27	2.38			9.02	-1.79	1.31	-1.39	3.22 b								
52 PORTUGAL	0.73	-0.38	0.40	0.18	0.10	0.97	0.75	-0.29	0.35	-1.18	1.42	-1.14	1.42	0.07	0.97	-4.24 b	-0.53	2.67 b	34
	6.47	-2.73	2.20	0.96			9.07	-2.86	2.65	-3.51 a	9.00 a								
53 RWANDA	0.38	-0.12	0.98	-0.04	0.14	0.96	0.49	-0.04	0.83	-0.07	1.63	-0.08	1.61	0.09	0.96	-6.51 a	4.31 a	7.21 a	34
	2.34	-0.67	3.63	-0.24			4.61	-0.33	4.85	-0.34	18.72 a								
54 SOUTH AFRICA	0.50	-0.53	0.33	0.19	0.10	0.87	0.56	-0.44	0.30	-1.00	0.67	-1.04	0.68	0.05	0.87	-5.23 a	-0.02	-5.62 a	34
	3.96	-3.43	3.39	1.10			8.65	-5.63	5.98	-5.58 a	11.45 a								

	m_{-1}	p	gdpx	AC	ser	R^2	m_{-1}	p	gdpx	E_p	E_y	E_p^c	E_y^c	ser	R^2	P-O	E_p=-1	E_y=1	nobs
55 SPAIN	0.56	-0.35	0.75	0.46	0.07	0.99	0.64	-0.26	0.61	-0.74	1.70	-0.74	1.71	0.08	0.99	-3.50	0.84	2.47 c	34
	4.94	-3.52	2.80	2.69			4.79	-2.31	1.95	-2.43 b	6.01 a								
56 SWEDEN	0.57	-0.06	0.94	-0.00	0.04	0.99	0.67	-0.05	0.71	-0.16	2.13	-0.16	2.18	0.03	0.99	-5.28 a	5.33 a	7.46 a	34
	5.26	-0.77	3.57	-0.02			7.45	-0.95	3.15	-1.00	14.04 a								
57 SWITZERLAND	0.87	-0.22	-0.05	0.23	0.06	0.98	0.92	-0.13	0.02	-1.64	0.23	-1.73	0.23	0.05	0.98	-3.97 c	-0.58	-0.32	34
	8.71	-1.22	-0.24	1.32			9.98	-0.76	0.09	-1.50	0.09								
58 THAILAND	0.69	-0.51	0.55	0.46	0.11	0.98	0.74	-0.38	0.44	-1.43	1.67	-1.37	1.69	0.08	0.98	-3.62	-0.82	4.13 a	34
	5.30	-2.66	2.69	2.87			7.65	-2.52	2.86	-2.74 b	10.29 a								
59 TRINIDAD AND TOBAGO	0.50	-0.49	0.25	0.16	0.12	0.98	0.57	-0.44	0.22	-1.02	0.50	-1.07	0.50	0.10	0.98	-4.88 a	-0.35	-3.12 b	34
	5.00	-5.15	2.52	0.85			6.91	-5.43	2.51	-15.51 a	3.16 b								
60 TURKEY	0.86	0.03	0.21	0.18	0.14	0.96	0.93	-0.03	0.13	-0.35	1.78	-0.34	1.80	0.10	0.95	-4.29 b	0.65	1.01	34
	5.68	0.27	0.89	0.93			8.58	-0.32	0.73	-0.35	2.30 b								
61 UNITED KINGDOM	0.49	-0.01	1.23	0.09	0.03	1.00	0.56	-0.03	1.08	-0.07	2.43	-0.07	2.45	0.02	0.99	-5.26 a	9.77 a	17.87 a	34
	6.61	-0.16	6.72	0.50			9.08	-0.71	7.01	-0.70	30.34 a								
62 UNITED STATES	0.44	-0.25	1.35	0.19	0.04	1.00	0.56	-0.23	1.09	-0.52	2.45	-0.50	2.51	0.04	1.00	-5.06 a	3.45 a	19.88 a	34
	4.92	-4.80	6.57	1.05			5.99	-4.53	4.94	-3.67 b	33.56 a								
63 URUGUAY	0.68	-0.20	1.38	0.22	0.12	0.92	0.77	-0.22	1.24	-0.99	5.48	-0.94	5.54	0.11	0.91	-3.78	0.02	3.23 b	34
	6.93	-1.93	3.94	1.30			8.24	-2.27	3.63	-1.66	3.95 a								
64 YUGOSLAVIA	0.69	-0.41	0.35	0.25	0.09	0.94	0.80	-0.33	0.25	-1.67	1.24	-1.65	1.22	0.09	0.94	-3.85 c	-1.11	0.81	31
	6.91	-3.74	2.58	1.24			8.34	-3.16	1.93	-2.76 a	4.21 a								
65 ZAIRE	0.92	-0.02	0.11	-0.14	0.18	0.90	0.93	-0.02	0.00	-0.34	0.03	-0.35	0.03	0.10	0.90	-5.60 a	0.94	-0.29	30
	9.48	-0.26	0.33	-0.66			18.10	-0.43	0.01	-0.49	0.01								
66 ZAMBIA	0.56	-0.51	0.16	0.06	0.11	0.93	0.62	-0.44	0.13	-1.17	0.34	-1.22	0.34	0.09	0.93	-8.82 a	-1.25	-4.86 a	34
	5.72	-4.56	2.28	0.32			8.35	-5.17	2.31	-8.55 a	2.45 c								
Mean	0.59	-0.32	0.56				0.68	-0.26	0.45	-1.08	1.45	-1.07	1.46						
Median	0.60	-0.31	0.48				0.69	-0.22	0.32	-0.80	1.32	-0.79	1.33						
Stdev	0.21	0.20	0.39				0.19	0.19	0.34	1.08	0.93	1.06	0.93						
Min	-0.01	-0.94	-0.05				0.10	-0.86	0.00	-6.74	0.03	-6.66	0.03						
Max	1.00	0.03	1.72				0.96	-0.01	1.36	-0.02	5.48	-0.01	5.54						

Note: The dependent variable is real imports of goods and non-factor services (m). The explanatory variables are the lagged dependent variable (m_{-1}), the real exchange rate (p) computed as the ratio of imports deflator to gdp deflator, and gdp minus exports (gdpx). The import demand equation is estimated using both OLS and the Phillips-Hansen Fully Modified estimator. The long-run price and income elasticities are given by E_p and E_y, respectively. E_p^c and E_y^c give the long-run price and income elasticities corrected for bias (see Table 4). For each country, the estimated coefficients and their t-stat (below the coefficient estimates) are provided. The following statistics are also provided: Durbin's test for autocorrelation (AC), R^2, standard error of the regression (ser), and the number of observations for each country (nobs). Cointegration between the three variables in the import demand equation is tested using the Phillips-Ouliaris residual test given in column P-O. Finally, the columns labeled E_p=-1 and E_y=1 report the two-tailed t-test for unit-price and unit-income elasticities, respectively. The asymptotic critical values for the Phillips-Ouliaris test at 10%, 5% and 1% are, respectively, -3.84, -4.16 and -4.64. The letters a, b and c indicate significance at 1%, 5% and 10%. Exact critical values (from Table 8) are used to compute the significance level of E_p, E_y, E_p=-1 and E_y=1

Table 4: Bias for short- and long-run elasticities for OLS and Fully-Modified estimators (percent)

Short-run price and income elasticities

		OLS					FM				
		R_{13}=-.7	R_{13}=-.3	R_{13}=0	R_{13}=.3	R_{13}=.7	R_{13}=-.7	R_{13}=-.3	R_{13}=0	R_{13}=.3	R_{13}=.7
R_{12}=-.7	α_1	6.25	-2.41	-12.45	-23.32	-33.24	5.32	-0.84	-9.10	-19.31	-29.56
	α_2	-19.98	-35.47	-47.91	-67.94	-79.06	-1.46	-15.11	-30.47	-52.68	-70.07
	α_3	-20.70	-4.56	14.65	37.19	59.93	-15.80	-3.09	13.89	35.89	58.90
R_{12}=-.3	α_1	9.48	2.13	-6.75	-13.64	-25.07	8.59	3.50	-3.54	-9.76	-20.70
	α_2	2.44	-3.85	-21.65	-24.48	-40.87	12.75	5.05	-10.80	-19.25	-38.61
	α_3	-23.88	-9.44	8.02	24.44	48.76	-21.60	-10.57	4.27	18.80	43.07
R_{12}=0	α_1	11.32	3.48	-3.07	-10.25	-21.78	10.13	4.68	-0.37	-6.40	-17.37
	α_2	12.43	3.45	-3.79	-11.97	-26.02	18.96	9.49	0.99	-8.89	-27.40
	α_3	-25.68	-10.08	3.69	18.99	43.80	-24.29	-12.57	-1.14	12.52	36.91
R_{12}=.3	α_1	13.77	6.71	0.16	-8.69	-19.84	11.86	7.04	2.10	-5.40	-15.73
	α_2	22.67	14.15	12.65	-3.53	-12.78	24.64	16.53	10.65	-4.65	-19.15
	α_3	-28.04	-14.22	-0.10	18.04	41.55	-26.99	-16.25	-5.26	11.12	34.12
R_{12}=.7	α_1	17.80	12.34	3.85	-7.63	-18.80	14.21	10.57	4.33	-5.15	-15.54
	α_2	43.20	41.79	32.29	25.67	11.98	34.99	30.78	20.44	8.66	-7.34
	α_3	-31.59	-20.05	-4.34	16.94	39.61	-30.64	-21.97	-8.70	11.41	34.04

Long-run price and income elasticities

		OLS					FM				
R_{12}=-.7	E_p	-43.29	-30.50	-15.83	-9.54	-1.22	-16.11	-13.53	-8.26	-5.81	-0.86
	E_y	-3.60	-6.93	-9.76	-10.39	-9.57	-2.63	-3.42	-4.88	-5.60	-5.70
R_{12}=-.3	E_p	-27.18	-10.70	-6.21	4.71	10.52	-9.95	-4.60	-3.43	1.84	5.82
	E_y	0.10	-3.01	-5.36	-4.70	-5.55	-0.69	-1.05	-2.26	-2.13	-2.87
R_{12}=0	E_p	-20.58	-6.37	1.81	8.58	15.70	-7.08	-2.91	0.27	3.91	8.47
	E_y	3.24	-0.48	-1.86	-2.88	-3.93	0.48	-0.15	-0.41	-0.80	-1.87
R_{12}=.3	E_p	-15.83	-3.14	10.65	12.69	21.80	-5.23	-1.26	4.27	5.70	11.68
	E_y	7.98	3.15	1.78	-0.62	-2.25	2.03	1.63	1.12	-0.07	-1.06
R_{12}=.7	E_p	-0.13	15.55	23.05	34.38	36.98	2.01	6.76	9.64	16.52	19.82
	E_y	14.35	14.63	7.32	1.44	-1.33	4.27	4.58	2.85	0.64	-0.84

Note: The bias is generated by simulating the import demand model: $m_t = \alpha_1 m_{t-1} + \alpha_2 p_t + \alpha_3 y_t + \varepsilon_{1t}$, $p_t = p_{t-1} + \varepsilon_{2t}$ and $y_t = y_{t-1} + \varepsilon_{3t}$; $(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}) \sim N(0,\Sigma)$ and $corr(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}) = R_{ij}$, i,j=1,2,3; m_t denotes imports, p_t is the real exchange rate and y_t is the activity variable, that is gdp-exports. All variables are in logs. The coefficients α_1, α_2 and α_3 are set to .70, -1.00 and 1.00, respectively. The long-run elasticities are defined as $E_p = \alpha_2/(1-\alpha_1)$ and $E_y = \alpha_3/(1-\alpha_1)$. The empirical distribution of the elasticties is generated from 5000 drawings of 34 observations each (the sample size in the data) from the import demand model. For each drawing, the import demand model is estimated. This yields 5000 estimates of the short- and long-run elasticities. For each drawing, the bias is simply the difference between the elasticity estimate and its true value. The Table reports the mean of these biases expressed in % of the true elasticities. The bias is computed for 5 different values of R_{12} (the correlation between ε_{1t} and ε_{2t}) and 5 different values of R_{13} (the correlation between ε_{1t} and ε_{3t}). This yields 25 bias estimates for each elasticity.

Table 5: OLS t-statistic critical values for the import demand equation parameters

		$R_{13}=-.7$			$R_{13}=-3$			$R_{13}=0$			$R_{13}=.3$			$R_{13}=.7$		
		m_{-1}	p	y	m_{-1}	p	y	m_{-1}	p	y	m_{-1}	p	y	m_{-1}	p	y
$R_{12}=-.7$	1%	-1.29	-3.24	-8.77	-2.71	-3.52	-5.93	-4.65	-4.12	-3.67	-6.80	-4.90	-2.31	-10.10	-6.14	-0.80
	5%	-0.49	-2.46	-6.90	-1.90	-2.74	-4.60	-3.61	-3.16	-2.61	-5.90	-3.88	-1.10	-8.84	-4.89	0.48
	10%	-0.12	-2.09	-5.98	-1.50	-2.34	-3.86	-3.19	-2.73	-2.05	-5.40	-3.35	-0.50	-8.33	-4.29	1.04
	90%	2.63	0.17	-1.01	1.14	-0.00	0.52	-0.52	0.01	1.99	-2.48	-0.09	3.80	-5.37	-0.24	5.91
	95%	3.07	0.54	-0.42	1.50	0.34	1.06	-0.13	0.39	2.55	-2.13	0.36	4.47	-5.02	0.39	6.86
	99%	3.94	1.23	0.65	2.24	1.04	2.20	0.52	1.02	3.73	-1.44	1.22	6.03	-4.31	1.50	8.78
$R_{12}=-3$	1%	-0.44	-2.59	-5.39	-1.84	-2.63	-3.88	-3.54	-3.15	-2.95	-4.69	-3.47	-2.03	-7.06	-4.08	-1.16
	5%	0.23	-1.82	-4.05	-1.19	-1.88	-2.80	-2.63	-2.35	-2.12	-3.97	-2.44	-1.11	-6.17	-3.07	-0.38
	10%	0.59	-1.50	-3.47	-0.81	-1.53	-2.34	-2.23	-1.95	-1.64	-3.50	-2.00	-0.71	-5.70	-2.52	0.07
	90%	3.35	0.82	-0.06	1.88	0.95	0.75	0.35	0.78	1.65	-0.84	1.07	2.30	-2.83	1.19	3.45
	95%	3.73	1.15	0.40	2.25	1.29	1.17	0.72	1.22	2.07	-0.49	1.50	2.78	-2.46	1.74	4.07
	99%	4.62	1.86	1.17	2.95	1.91	1.97	1.37	1.88	3.03	0.19	2.41	3.79	-1.85	2.90	5.41
$R_{12}=0$	1%	0.02	-2.28	-4.81	-1.54	-2.42	-3.42	-2.86	-2.55	-2.71	-4.07	-2.87	-2.03	-6.26	-3.44	-1.05
	5%	0.70	-1.51	-3.55	-0.92	-1.63	-2.50	-2.03	-1.78	-1.86	-3.25	-1.97	-1.22	-5.32	-2.43	-0.43
	10%	1.08	-1.17	-3.04	-0.55	-1.26	-2.03	-1.64	-1.36	-1.44	-2.80	-1.53	-0.85	-4.86	-1.89	-0.06
	90%	3.80	1.14	0.01	2.04	1.19	0.83	0.91	1.34	1.46	-0.15	1.53	2.01	-1.99	1.81	2.98
	95%	4.21	1.46	0.39	2.39	1.58	1.20	1.29	1.74	1.90	0.23	1.94	2.46	-1.63	2.32	3.54
	99%	5.10	2.20	1.07	3.23	2.34	1.93	1.98	2.52	2.71	0.83	2.76	3.38	-0.96	3.28	4.70
$R_{12}=.3$	1%	0.74	-1.80	-4.29	-0.94	-1.90	-3.30	-2.19	-1.86	-2.40	-3.71	-2.40	-1.71	-5.84	-2.77	-1.04
	5%	1.53	-1.17	-3.26	-0.25	-1.22	-2.37	-1.49	-1.14	-1.67	-2.95	-1.61	-1.05	-4.86	-1.68	-0.46
	10%	1.86	-0.85	-2.69	0.12	-0.87	-1.95	-1.12	-0.80	-1.29	-2.59	-1.16	-0.69	-4.38	-1.17	-0.13
	90%	4.64	1.51	0.09	2.78	1.56	0.67	1.46	1.91	1.31	0.04	1.94	1.93	-1.59	2.55	2.77
	95%	5.11	1.84	0.45	3.21	1.94	1.02	1.83	2.33	1.72	0.39	2.38	2.39	-1.21	3.13	3.29
	99%	5.96	2.52	1.07	4.04	2.63	1.76	2.60	3.15	2.40	1.10	3.35	3.22	-0.61	4.25	4.39
$R_{12}=.7$	1%	2.51	-1.15	-4.17	0.32	-0.97	-3.04	-1.64	-1.09	-2.16	-3.50	-1.27	-1.57	-5.43	-1.56	-1.08
	5%	3.31	-0.52	-2.90	1.10	-0.35	-2.14	-0.82	-0.34	-1.45	-2.65	-0.40	-0.94	-4.47	-0.46	-0.45
	10%	3.72	-0.17	-2.38	1.46	-0.02	-1.71	-0.48	0.00	-1.11	-2.28	0.11	-0.63	-4.02	0.18	-0.14
	90%	6.54	2.09	0.14	4.21	2.35	0.61	2.16	2.69	1.12	0.39	3.36	1.68	-1.16	4.36	2.41
	95%	7.04	2.42	0.47	4.63	2.71	0.93	2.55	3.11	1.46	0.75	3.86	2.09	-0.85	4.96	2.90
	99%	7.99	3.15	1.05	5.49	3.57	1.67	3.40	4.19	2.21	1.44	4.87	2.84	-0.21	6.26	4.23

Note: This table provides exact critical values of the OLS t-statistic at 1%, 5%, 10%, 90%, 95% and 99% significance levels. These critical values are generated by simulating the import demand model: $m_t=\alpha_1 m_{t-1}+\alpha_2 p_t+\alpha_3 y_t+\varepsilon_{1t}$, $p_t=p_{t-1}+\varepsilon_{2t}$ and $y_t=y_{t-1}+\varepsilon_{3t}$, $(\varepsilon_{1t},\varepsilon_{2t},\varepsilon_{3t})\sim N(0,\Sigma)$ and $corr(\varepsilon_{1t},\varepsilon_{2t},\varepsilon_{3t})=R_{ij}$, $i,j=1,2,3$; m_t denotes imports, p_t is the real exchange rate and y_t is the activity variable, that is gdp-exports. All variables are in logs. The coefficients α_1, α_2 and α_3 are set to .70, -1.00 and 1.00, respectively. For each of the coefficients, the critical values are computed by (i) setting the coefficient for which the critical values are computed to zero (restricted model). (ii) drawing 5000 samples of 34 observations each (the sample size in the data) from the restricted model. (iii) computing the usual t-statistic for each drawing. (iv) Finally, using the resulting vector of 5000 t-statistic values to generate an empirical distribution from which the critical values can be computed. For each coefficient, the empirical t-distribution is computed for 5 different values of R_{12} (the correlation between ε_{1t} and ε_{2t}) and 5 different values of R_{13} (the correlation between ε_{1t}, and ε_{3t}). This yields 25 empirical t-distributions for each of the three coefficients α_1.

Table 6: Fully-Modified t-statistic critical values for the import demand equation parameters

		$R_{13}=-.7$			$R_{13}=-.3$			$R_{13}=0$			$R_{13}=.3$			$R_{13}=.7$		
		m_{-1}	p	y	m_{-1}	p	y	m_{-1}	p	y	m_{-1}	p	y	m_{-1}	p	y
$R_{12}=-.7$	1%	-1.85	-3.28	-8.74	-3.65	-3.68	-6.05	-5.94	-4.22	-4.11	-9.48	-5.15	-3.01	-18.27	-6.29	-1.41
	5%	-0.48	-2.29	-6.70	-2.45	-2.72	-4.40	-4.51	-3.08	-2.87	-7.92	-3.80	-1.75	-15.84	-4.79	-0.05
	10%	0.20	-1.83	-5.69	-1.82	-2.20	-3.52	-3.88	-2.49	-2.23	-7.17	-3.15	-1.17	-14.57	-4.06	0.53
	90%	6.18	0.51	-0.49	2.52	0.73	1.13	-0.04	0.82	2.09	-2.81	0.75	3.45	-8.76	0.13	5.59
	95%	7.01	0.82	0.11	3.14	1.10	1.72	0.49	1.28	2.71	-2.26	1.24	4.25	-8.18	0.85	6.58
	99%	8.77	1.47	1.10	4.42	1.87	2.88	1.41	2.09	4.05	-1.34	2.29	6.04	-7.06	2.24	8.71
$R_{12}=-.3$	1%	0.05	-2.97	-5.51	-1.86	-3.11	-4.03	-3.95	-3.69	-3.49	-5.54	-3.74	-2.79	-9.41	-4.41	-2.23
	5%	1.13	-2.07	-3.84	-0.86	-2.11	-2.84	-2.70	-2.40	-2.39	-4.37	-2.52	-1.82	-7.80	-2.96	-1.23
	10%	1.75	-1.58	-3.20	-0.32	-1.66	-2.22	-2.15	-1.94	-1.83	-3.72	-2.02	-1.31	-7.02	-2.38	-0.78
	90%	6.05	1.18	0.72	3.36	1.39	1.28	1.29	1.33	1.83	-0.18	1.48	2.17	-2.78	1.61	3.12
	95%	6.77	1.60	1.34	3.93	1.84	1.83	1.74	1.81	2.37	0.25	2.04	2.77	-2.31	2.19	3.88
	99%	8.09	2.41	2.36	4.78	2.64	2.75	2.58	2.81	3.40	1.12	3.09	4.02	-1.42	3.40	5.43
$R_{12}=0$	1%	0.88	-2.65	-4.62	-1.38	-2.99	-3.62	-2.95	-3.13	-3.20	-4.67	-3.27	-2.83	-8.27	-3.80	-2.15
	5%	1.95	-1.81	-3.39	-0.45	-1.98	-2.51	-1.83	-2.06	-2.15	-3.51	-2.28	-1.76	-6.57	-2.62	-1.28
	10%	2.52	-1.41	-2.77	0.10	-1.55	-2.00	-1.34	-1.61	-1.64	-2.83	-1.74	-1.32	-5.87	-1.98	-0.83
	90%	6.68	1.34	0.75	3.54	1.50	1.28	2.04	1.64	1.68	0.68	1.77	1.97	-1.83	1.96	2.71
	95%	7.30	1.75	1.17	4.11	1.96	1.69	2.51	2.14	2.13	1.15	2.30	2.55	-1.29	2.59	3.40
	99%	8.73	2.58	2.06	5.23	2.97	2.64	3.43	3.17	3.14	1.88	3.42	3.73	-0.46	3.75	4.86
$R_{12}=.3$	1%	2.20	-2.39	-4.44	-0.59	-2.66	-3.55	-2.20	-2.83	-3.02	-4.32	-3.05	-2.45	-7.80	-3.29	-2.07
	5%	3.37	-1.65	-3.09	0.47	-1.72	-2.39	-1.21	-1.75	-2.02	-3.20	-2.08	-1.64	-6.16	-2.15	-1.26
	10%	3.90	-1.20	-2.48	1.00	-1.26	-1.90	-0.71	-1.31	-1.48	-2.61	-1.59	-1.20	-5.51	-1.54	-0.85
	90%	8.17	1.58	0.82	4.68	1.73	1.17	2.75	1.96	1.47	0.87	1.96	1.89	-1.46	2.43	2.57
	95%	8.81	2.01	1.23	5.24	2.19	1.61	3.30	2.48	1.95	1.30	2.49	2.46	-0.96	3.12	3.17
	99%	10.43	2.82	2.03	6.46	3.17	2.56	4.30	3.44	2.94	2.27	3.61	3.42	-0.07	4.40	4.44
$R_{12}=.7$	1%	5.52	-1.52	-4.21	1.32	-1.81	-3.13	-1.65	-2.25	-2.56	-4.93	-2.24	-2.10	-9.59	-2.21	-1.50
	5%	7.44	-0.80	-2.74	2.58	-1.14	-2.17	-0.59	-1.27	-1.70	-3.60	-1.24	-1.40	-7.92	-0.93	-0.78
	10%	8.21	-0.48	-2.17	3.21	-0.77	-1.68	-0.05	-0.80	-1.30	-2.98	-0.71	-1.01	-7.13	-0.27	-0.47
	90%	13.66	1.83	0.51	7.80	2.18	1.03	4.06	2.50	1.29	1.20	3.06	1.66	-2.15	4.05	2.21
	95%	14.57	2.25	0.80	8.47	2.68	1.40	4.69	3.07	1.72	1.86	3.68	2.14	-1.40	4.73	2.80
	99%	16.39	3.25	1.46	9.89	3.82	2.18	5.92	4.30	2.55	3.03	5.13	3.11	-0.20	6.42	4.16

Note: The table provides exact critical values of the Fully-Modified t-statistic at 1%, 5%, 10%, 90%, 95% and 99% significance levels. These critical values are generated by simulating the import demand model: $m_t = \alpha_1 m_{t-1} + \alpha_2 p_t + \alpha_3 y_t + \varepsilon_{1t}$, $p_t = p_{t-1} + \varepsilon_{2t}$ and $y_t = y_{t-1} + \varepsilon_{3t}$; $(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}) \sim N(0,\Sigma)$ and $corr(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}) = R_{ij}$, $i,j=1,2,3$; m_t denotes imports, p_t is the real exchange rate and y_t is the activity variable, that is gdp-exports. All variables are in logs. The coefficients α_1, α_2 and α_3 are set to .70, -1.00 and 1.00, respectively. For each of the coefficients, the critical values are computed by (i) setting the coefficient for which the critical values are computed to zero (restricted model). (ii) drawing 5000 samples of 34 observations each (the sample size in the data) from the restricted model. (iii) computing the usual t-statistic for each drawing. (iv) using the resulting vector of 5000 t-statistic values to generate an empirical distribution from which the critical values can be computed. For each coefficient, the empirical t-distribution is computed for 5 different values of R_{12} (the correlation between ε_{1t} and ε_{2t}) and 5 different values of R_{13} (the correlation between ε_{1t} and ε_{3t}). This yields 25 empirical t-distributions for each of the three coefficients.

Table 7: OLS t-statistic critical values for long-run import price and income elasticities

		$R_{13}=-.7$		$R_{13}=-.3$		$R_{13}=0$		$R_{13}=.3$		$R_{13}=.7$	
		E_p	E_y	E_p	E_y	E_p	E_y	E_p	E_y	E_p	E_y
	1%	-3.43	-9.70	-4.12	-6.84	-4.96	-4.13	-5.87	-2.36	-7.24	-0.81
	5%	-2.38	-7.66	-2.84	-4.97	-3.46	-2.70	-4.40	-1.11	-5.56	0.48
	10%	-2.00	-6.65	-2.35	-4.10	-2.86	-2.09	-3.67	-0.50	-4.74	1.05
$R_{12}=-.7$	90%	0.17	-1.01	-0.00	0.52	0.01	2.04	-0.09	4.04	-0.23	6.60
	95%	0.51	-0.42	0.33	1.08	0.39	2.68	0.37	4.89	0.40	7.65
	99%	1.02	0.65	0.92	2.36	1.05	4.23	1.30	6.87	1.60	9.87
	1%	-2.51	-6.76	-2.78	-4.72	-3.65	-3.29	-3.86	-2.06	-4.78	-1.23
	5%	-1.69	-4.75	-1.87	-3.05	-2.48	-2.27	-2.60	-1.15	-3.32	-0.38
	10%	-1.38	-3.92	-1.49	-2.48	-2.00	-1.71	-2.08	-0.72	-2.66	0.07
$R_{12}=-.3$	90%	0.77	-0.06	0.91	0.76	0.78	1.69	1.08	2.45	1.22	3.88
	95%	1.05	0.42	1.25	1.20	1.25	2.27	1.58	3.09	1.83	4.83
	99%	1.60	1.21	1.90	2.19	1.96	3.53	2.61	4.56	3.23	6.78
	1%	-2.02	-6.21	-2.46	-4.25	-2.76	-3.09	-3.12	-2.16	-3.85	-1.06
	5%	-1.39	-4.32	-1.58	-2.77	-1.82	-1.93	-2.08	-1.22	-2.60	-0.43
	10%	-1.10	-3.44	-1.24	-2.15	-1.38	-1.48	-1.58	-0.86	-1.97	-0.06
$R_{12}=0$	90%	1.05	0.01	1.16	0.83	1.34	1.49	1.56	2.15	1.87	3.39
	95%	1.32	0.39	1.56	1.19	1.78	1.97	2.04	2.70	2.46	4.19
	99%	2.02	1.08	2.37	2.06	2.64	3.18	2.99	4.11	3.64	6.43
	1%	-1.51	-5.82	-1.90	-4.16	-1.92	-2.76	-2.59	-1.80	-3.10	-1.00
	5%	-1.04	-3.89	-1.19	-2.60	-1.18	-1.74	-1.65	-1.01	-1.75	-0.45
	10%	-0.79	-3.07	-0.85	-2.04	-0.80	-1.28	-1.19	-0.69	-1.20	-0.12
$R_{12}=.3$	90%	1.37	0.09	1.53	0.66	1.96	1.28	2.03	2.02	2.68	3.09
	95%	1.69	0.45	1.90	1.03	2.43	1.76	2.52	2.60	3.43	3.94
	99%	2.39	1.09	2.78	1.74	3.42	2.91	3.72	4.09	4.93	5.86
	1%	-0.95	-6.07	-0.89	-4.07	-1.07	-2.43	-1.33	-1.58	-1.69	-0.99
	5%	-0.48	-3.63	-0.33	-2.39	-0.34	-1.42	-0.41	-0.87	-0.46	-0.41
	10%	-0.17	-2.67	-0.02	-1.77	0.00	-1.05	0.11	-0.59	0.18	-0.14
$R_{12}=.7$	90%	1.96	0.14	2.37	0.56	2.85	1.06	3.68	1.72	4.85	2.71
	95%	2.37	0.44	2.90	0.85	3.42	1.44	4.41	2.29	5.68	3.62
	99%	3.55	0.95	4.25	1.83	4.99	2.66	5.91	3.79	7.32	5.97

Note: This table provides exact critical values of the OLS t-statistic at 1%, 5%, 10%, 90%, 95% and 99% significance levels for long-run import price and income elasticities (E_p and E_y, respectively). These critical values are generated by simulating the import demand model: $m_t = \alpha_1 m_{t-1} + \alpha_2 p_t + \alpha_3 y_t + \varepsilon_{1t}$, $p_t = p_{t-1} + \varepsilon_{2t}$ and $y_t = y_{t-1} + \varepsilon_{3t}$; $(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}) \sim N(0,\Sigma)$ and $corr(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}) = R_{ij}, i,j=1,2,3$; m_t denotes imports, p_t is the real exchange rate and y_t is the activity variable, that is gdp-exports. All variables are in logs. The coefficients α_1, α_2 and α_3 are set to .70, -1.00 and 1.00, respectively. The long-run elasticities are defined as $E_p = \alpha_2/(1-\alpha_1)$ and $E_y = \alpha_3/(1-\alpha_1)$. Their respective t-statistic critical values are computed by (i) setting α_2 and α_3 equal to zero (restricted model). (ii) drawing 5000 samples of 34 observations each (the sample size in the data) from the restricted model. (iii) computing the usual t-statistic for E_p and E_y using the Taylor approximation formula for each drawing. (iv) using the resulting vector of 5000 t-statistic values to generate an empirical distibution from which the critical values can be computed. For both E_p and E_y the empirical t-distribution is computed for 5 different values of R_{12} (the correlation between ε_{1t} and ε_{2t}) and 5 different values of R_{13} (the correlation between ε_{1t} and ε_{3t}). This yields 25 empirical t-distributions for both long-run elasticities.

Table 8: Fully-Modified t-statistic critical values for long-run import price and income elasticities

		$R_{13}=-.7$		$R_{13}=-.3$		$R_{13}=0$		$R_{13}=.3$		$R_{13}=.7$	
		E_p	E_y	E_p	E_y	E_p	E_y	E_p	E_y	E_p	E_y
$R_{12}=-.7$	1%	-3.39	-9.95	-4.02	-6.81	-4.83	-4.41	-5.81	-3.08	-7.01	-1.40
	5%	-2.24	-7.40	-2.77	-4.77	-3.26	-2.99	-4.08	-1.79	-5.14	-0.05
	10%	-1.81	-6.23	-2.21	-3.71	-2.57	-2.28	-3.32	-1.19	-4.32	0.53
	90%	0.50	-0.49	0.72	1.12	0.82	2.12	0.75	3.62	0.13	6.16
	95%	0.80	0.11	1.09	1.69	1.25	2.80	1.26	4.57	0.86	7.26
	99%	1.36	1.12	1.79	3.01	2.14	4.37	2.35	6.86	2.33	9.81
$R_{12}=-.3$	1%	-3.03	-6.78	-3.24	-4.94	-3.98	-3.80	-4.09	-2.82	-4.91	-2.25
	5%	-1.97	-4.44	-2.07	-3.01	-2.53	-2.44	-2.67	-1.77	-3.16	-1.22
	10%	-1.55	-3.53	-1.67	-2.36	-1.97	-1.85	-2.06	-1.29	-2.48	-0.77
	90%	1.15	0.70	1.34	1.29	1.31	1.84	1.50	2.31	1.63	3.41
	95%	1.52	1.28	1.81	1.83	1.80	2.49	2.05	3.00	2.25	4.41
	99%	2.27	2.34	2.70	2.94	2.85	3.94	3.24	4.54	3.76	6.92
$R_{12}=0$	1%	-2.57	-5.91	-3.07	-4.21	-3.38	-3.65	-3.54	-3.08	-4.23	-2.14
	5%	-1.75	-3.90	-1.97	-2.73	-2.14	-2.22	-2.36	-1.77	-2.72	-1.25
	10%	-1.34	-3.05	-1.52	-2.06	-1.60	-1.69	-1.76	-1.30	-2.02	-0.81
	90%	1.30	0.73	1.46	1.25	1.65	1.70	1.77	2.06	1.99	3.04
	95%	1.68	1.11	1.98	1.68	2.16	2.25	2.38	2.79	2.69	3.95
	99%	2.48	2.02	2.89	2.76	3.32	3.63	3.61	4.35	4.11	6.25
$R_{12}=.3$	1%	-2.22	-5.53	-2.56	-4.33	-2.78	-3.35	-3.28	-2.59	-3.53	-2.02
	5%	-1.51	-3.63	-1.72	-2.57	-1.76	-2.08	-2.13	-1.57	-2.21	-1.21
	10%	-1.14	-2.73	-1.24	-1.95	-1.27	-1.49	-1.58	-1.17	-1.58	-0.82
	90%	1.52	0.80	1.68	1.15	1.98	1.49	2.04	1.94	2.52	2.80
	95%	1.91	1.21	2.20	1.57	2.56	2.00	2.61	2.61	3.32	3.77
	99%	2.75	2.02	3.27	2.46	3.70	3.38	3.90	4.11	4.91	5.80
$R_{12}=.7$	1%	-1.38	-5.92	-1.72	-3.97	-2.23	-2.89	-2.34	-2.27	-2.36	-1.38
	5%	-0.77	-3.22	-1.10	-2.40	-1.25	-1.71	-1.25	-1.34	-0.95	-0.76
	10%	-0.47	-2.38	-0.76	-1.73	-0.80	-1.26	-0.72	-0.98	-0.27	-0.47
	90%	1.79	0.50	2.17	0.99	2.58	1.26	3.25	1.70	4.32	2.43
	95%	2.24	0.78	2.76	1.35	3.23	1.74	4.03	2.28	5.19	3.24
	99%	3.28	1.41	4.22	2.33	4.98	2.85	6.01	3.75	7.30	5.65

Note: This table provides exact critical values of the Fully-Modified t-statistic, at 1%, 5%, 10%, 90%, 95% and 99% significance levels for long-run import price and income elasticities (E_p and E_y, respectively). These critical values are generated by simulating the import demand model: $m_t = \alpha_1 m_{t-1} + \alpha_2 p_t + \alpha_3 y_t + \varepsilon_{1t}$, $p_t = p_{t-1} + \varepsilon_{2t}$ and $y_t = y_{t-1} + \varepsilon_{3t}$; $(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}) \sim N(0,\Sigma)$ and $corr(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}) = R_{ij}, i,j=1,2,3$; m_t denotes imports, p_t is the real exchange rate and y_t is the activity variable, that is gdp-exports. All variables are in logs. The coefficients α_1, α_2 and α_3 are set to .70, -1.00 and 1.00, respectively. The long-run elasticities are defined as $E_p = \alpha_2/(1-\alpha_1)$ and $E_y = \alpha_3/(1-\alpha_1)$. Their respective t-statistic critical values are computed by (i) setting α_2 and α_3 equal to zero (restricted model). (ii) drawing 5000 samples of 34 observations each (the sample size in the data) from the restricted model. (iii) computing the usual t-statistic for E_p and E_y using the Taylor approximation formula for each drawing. (iv) using the resulting vector of 5000 t-statistic values to generate an empirical distibution from which the critical values can be computed. For both E_p and E_y the empirical t-distribution is computed for 5 different values of R_{12} (the correlation between ε_{1t} and ε_{2t}) and 5 different values of R_{13} (the correlation between ε_{1t} and ε_{3t}). This yields 25 empirical t-distributions for both long-run elasticities.

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