Estimation of an Import Demand Function for Indonesia: 1971-93

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Abstract The purpose of this paper is to specify and estimate an aggregate import demand function for Indonesia, and to discuss the implications of the results. Estimation is based on annual data for real imports, real GDP and relative prices over the period 1971-1993. Income and price elasticities of demand are estimated using the log-linear functional form. Econometric tests indicate that the choice between alternative functional forms is important for purposes of statistical robustness. The empirical results show that relative prices and real income are important factors influencing import demand. In general, imports to Indonesia are found to be income elastic, which suggests that, as this economy grows, the demand for imports will grow at a faster rate. The demand for imports is found to be price inelastic.

1. INTRODUCTION

Since the seminal work of Learner and Stern [1970] concerning the estimation of income and price elasticities of aggregate import demand, many empirical studies have examined the determinants of the demand for imports and have estimated import demand functions (e.g., see Murray and Ginman [1976], Khan and Ross [1977], Boylan et al. [1980], Melo and Vogt [1984], Gafar [1988], Gafar [1995], and Abbott and Seddighi [1996]). A general problem faced by researchers in this area has been the choice of the appropriate functional form for estimating import demand models. The theory of international trade provides very little guidance as to the choice of appropriate functional form for specifying and estimating an import demand equation. Two of the most commonly used functional forms for import demand are the linear and the log-linear formulations. A primary purpose of this paper is to estimate empirically the aggregate import demand function for Indonesia and discuss the implications of the results.

Since the Indonesian economy has experienced strong economic growth during the period 1971-1993, it is interesting to examine whether there has been a commensurate rise in Indonesia's propensity to import over the same period. Income and price elasticities of demand are estimated using the log-linear functional form. These estimates are important to exporters (importers) when making strategic business decisions and to governments formulating economic policies. Business planning, economic development policies and the output from international trade models are very much dependent on the size of the income and price elasticities of imports.

Section 2 of the paper examines the import demand model and details some of the methodological issues associated with empirical estimation. Section 3 presents and evaluates the estimated results, and Section 4 draws conclusions from the empirical analysis and discusses some potential policy implications.

2. THE IMPORT DEMAND MODEL

From Learner and Stern [1970], a simple form of the import demand equation can be specified which relates the quantity of imports demanded to income, the price of imports and the price of domestic substitutes. The import demand equation at time t is written as:

$$M_t = f(Y^d_t, P^m_t, P^d_t) \qquad (1)$$

where M_t is the quantity of imports demanded at time t, Y^d_t is domestic income at time t, P^m_t is the price level for the imports at time t, and P^d_t is the domestic price level at time t.

It is suggested by the theory of demand that ordinary or 'Marshallian' demand functions are homogeneous of degree zero in prices and income, which implies the

absence of money illusion and allows the demand for imports to be expressed as a function of real income and relative prices. The restricted import demand function is written as:

$$M_t = g(Y_t, R_t) \quad (2)$$

where $Y_t = Y^d_t/P^d_t$ and represents real domestic income, and $R_t = P^m_t/P^d_t$, the ratio of the price of imports to the domestic price level. Such a demand function implicitly imposes the restriction that the effect of the two price variables on demand will be equal, but opposite in sign. The linear formulation of the aggregate import equation for time t is:

$$M_t = \delta + \alpha_0 Y_t + \beta_0 R_t + \varepsilon_t \quad (3)$$

where δ is the constant term in the regression, α_0 is the marginal propensity to import, β_0 is the import coefficient of relative prices, and ε_t is an independently and identically distributed random error term. From economic theory, it is expected that $\alpha_0 > 0$ and $\beta_0 < 0$. However, Goldstein and Khan [1976] have argued that if imports represent the difference between domestic consumption and domestic production of imported goods, production might rise faster (slower) than consumption in response to a rise in real income. Therefore, imports could fall (rise) as real income increases, resulting in a negative (positive) sign for the coefficient α_0.

In log-linear form, the import demand equation is written as:

$$ln\, M_t = \delta^* + \phi_0 ln Y_t + \theta_0 ln R_t + u_t \quad (4)$$

where ln is the natural logarithm and u_t is an independently and identically distributed random error term. It would be expected from economic theory that $\phi_0 > 0$ and $\theta_0 < 0$ but, as discussed previously, ϕ_0 could be negative.

The choice between a linear and log-linear import demand equation is important because the functional form affects the measurement of the explanatory variable's influence on demand. Kmenta [1986] explained that misspecification of the functional form can result in misspecification of the error term, and hence a violation of the classical assumptions. This results in the estimates being biased.

Previous research by Khan and Ross [1977], Boylan et al. [1980] and Doroodian et al. [1994] has argued that specification of a log-linear form is preferable when estimating import demand functions as the use of this form allows the researchers to interpret the coefficients of the dependent variables as the elasticities with respect to the independent variable. It is also useful for accommodating the heteroscedasticity problem. While the literature provides an intuitive guide to the selection of an appropriate functional form, researchers often seek empirical reasons for selecting or rejecting a particular functional form. Fortunately, there are a number of statistical tests available that can assist in the choice between linear and log-linear models (for example, see Box and Cox [1964], Sargan [1964], and Bera and McAleer [1989]). These tests permit the data to determine what functional form is more appropriate.

Equations (3) and (4), as formulated, exhibit *ex ante* relationships. Replacement of M_t by actual imports implies instantaneous adjustment to changes in real income and relative prices. This is a restrictive assumption, which can be relaxed by formulating and incorporating a partial- adjustment process for imports into the model. In this function, the change in imports in period t is related to the actual level of imports in the previous period. For the linear model, this function is:

$$\Delta M_t = M_t - M_{t-1} = \lambda(M_t^* - M_{t-1}),\ 0 \le \lambda \le 1 \quad (5)$$

where M_t^* is the desired quantity of imports demanded at time t, and λ is the adjustment coefficient. By substituting equation (3) into (5), the dynamic import demand equation becomes:

$$M_t = \lambda\delta + \lambda\alpha_0 Y_t + \lambda\beta_0 R_t + (1-\lambda)M_{t-1} + \lambda\varepsilon_t \quad (6)$$

with the long-run impacts of changes in real income and relative prices calculated by dividing the regression coefficients by λ. For further discussion on distributed lag models, see Judge et al. [1988].

A final empirical issue that must be examined is the validity of the restriction imposed on the relative price variable in equations (3) and (4). In these equations, the price variable was specified in relative terms to satisfy the homogeneity postulate and also to reduce problems with multicollinearity between the import and domestic price variables. Murray and Ginman [1976] argued that the restriction imposed on equation (2) may not be valid because: (a) the weight assigned to some commodities may differ between the import price index and the domestic price level; and (b) consumers may react differently to a change in import price from the way they would react to an equal but opposite change in the domestic price index. To ensure that equations (3) and (4) are correctly specified, it is important to test the restriction on the relative price variables.

For example, the log-linear import demand equation (4) can be re-written as:

$$lnM_t = \delta + \alpha_0 lnY_t + \gamma_0 lnP^m{}_t + \gamma_1 lnP^d{}_t + \varepsilon_t \quad (7)$$

where γ_0 represents the 'own price' effect on import demand and γ_1 is the 'domestic price' effect on import demand. It is expected that $\gamma_0<0$ and $\gamma_1>0$. Estimation of the unrestricted equation (7) allows testing of the condition $\gamma_0 + \gamma_1 = 0$.

3. THE DATA, MODEL AND EMPIRICAL RESULTS

This study uses annual data for the period 1971-93 to estimate empirically the aggregate import demand function for Indonesia. The data used are real imports (M_t), the value of imported goods and services deflated by the import price index (1990=100), real GDP (Y_t), nominal GDP adjusted by the GDP deflator (1990=100), and the relative price (R_t) is the ratio of the import price index divided by the domestic wholesale price index (1990=100).

Table 1. Testing linear versus log-linear import demand function

Dependent variable in model M1 is real import.
Dependent variable in model M2 is log of real import.
23 observations used from 1971 to 1993.
Number of replications 100.

Non-Nested Test Statistics and Choice Criteria

Test Statistics	M1 against M2	M2 against M1
S-Test 100 replications	NONE	0.494 [0.621]
PE-Test	2.515 [0.012]	-1.533 [0.125]
BM-Test	2.422 [0.015]	-2.065 [0.039]
DL-Test	2.627 [0.009]	0.751 [0.453]

Sargan's Likelihood Criterion for M1 versus M2 = -6.469 favours M2
Vuong's Likelihood Criterion for M1 versus M2 = -14.918 [0.000] favours M2

S-Test is the SC-c test proposed by Pesaran and Pesaran [1995] and is the simple version of the simulated Cox test statistic.
PE-Test is due to MacKinnon et al. [1983].
BM-Test is due to Bera and McAleer [1989].
DL-Test is the double-length regression test statistic due to Davidson and MacKinnon [1984].
Sargan's likelihood criterion is due to Sargan [1964].
Vuong's likelihood criterion is due to Vuong[1989].

Note: For details of these tests and likelihood criteria, See Pesaran and Pesaran [1996].

Initially, the PE test, the Bera-McAleer test, the DL test, and the Sargan and Vuong's likelihood criteria were performed on the import demand equation to test the linear form of the import demand equation against its log-linear counterpart. Results of all the tests (except the S-test) given in Table 1 indicate that the levels formulation is rejected but the logarithmic version is not. Thus, the log-linear form is the appropriate specification for aggregate imports of Indonesia. The two choice criteria also favour the log-linear over the linear specification. Consequently, the import demand equation was specified and estimated in log-linear form, according to equation (4). As can be seen in Table 1, there is no Cox S-Test statistic for testing the log-linear against the linear model. Pesaran and Pesaran (1996) observe that if the probability of drawing a negative value of the independent variable under the linear model is larger than 0.0001, the Cox statistic for testing the log-linear against the linear model cannot be computed. Consequently, the Microfit programme only computes the Cox S-statistic for testing the log-linear against the linear model.

The restricted import demand in equation (4) was estimated by ordinary least squares and the results are presented in Table 2, in which the F-statistic (F) and $\bar{R}^2$ indicate that the explanatory variables explain a significant proportion of the variation in the demand for imports. Diagnostic tests presented in Table 3 show no serious problems with heteroscedasticity, non-normality of the residuals or autoregressive conditional heteroscedastic (ARCH) effects in the residuals, and there is no significant model misspecification.

Table 2. OLS estimates of restricted demand equation (4) for aggregate imports of Indonesia: 1971-1993

Constant	Income	Price	$\bar{R}^2$	F	LM(1)
2.304 (1.171)	1.241 (0.101)	-0.874 (0.203)	0.905	106.1	7.586

Note: Since the LM statistic for residual serial correlation is significant, the equation was re-estimated by the method of maximum likelihood with AR(2) errors. Standard errors are in parentheses.

Table 3. Diagnostic tests

Reset	Bera-Jarque	LM(Het)	LM (ARCH)
0.767	1.083	0.688	0.149

Note: For details of these tests, see Pesaran and Pesaran [1996].

As the LM(1) test statistic is significant (7.586), indicating serial correlation in the residuals, the import demand equation was re-estimated using maximum likelihood with a second-order autoregressive error process. The results are presented in Table 4.

It appears from the above table that the maximum likelihood estimates of both ρ_1 and ρ_2 are highly

significant. Since there is significant serial correlation, and the sample size is small, no testing of unit roots is undertaken. However, the model is re-estimated in first differences to examine the sensitivity of the previous empirical results to changes in the assumptions. The results are presented in Tables 5 and 6. It is apparent from these results that there are no serious problems with this model. The estimated values of the parameters have the expected signs, and the income and price variables satisfactorily explain the variation in the demand for imports. The LM(1) statistic is not significant and there is no problem of serial correlation. Diagnostic testing shows no serious problems with heteroscedasticity or non-normality of the residuals, no autoregressive conditional heteroscedastic (ARCH) effects in the residuals, and no model misspecification.

Table 4. ML estimates of restricted demand equation (4) for aggregate imports of Indonesia: 1971-1993 with AR (2) process [a]

Constant	Income	Price	ρ_1	ρ_2	$\bar{R}^2$	F
1.698 (1.623)	1.214 (0.103)	-0.617 (0.247)	0.963 (5.681)	-0.583 (-3.44)	0.952	109.6

[a] Standard errors are in parentheses; ρ_1 and ρ_2 are the first- and second-order autoregressive parameters, respectively.

Table 5. OLS estimates of import demand equation (4) in first differences for aggregate imports of Indonesia: 1971-1993[a]

Income	Price	$\bar{R}^2$	F	LM(1)
1.342 (0.472)	-0.789 (0.348)	0.176	5.477	1.341

[a] Equation (4) was re-estimated without a constant. Standard errors are in parentheses.

Table 6. Diagnostic tests

Reset	Bera-Jarque	LM(Het)	LM (ARCH)
0.279	0.915	1.223	0.129

Note: For details of these tests, see Pesaran and Pesaran [1996].

The unrestricted form of the import demand equation (7) was also estimated. A Wald test was conducted to test the linear restriction that $\gamma_0 + \gamma_1 = 0$ (that is, the effects of the import price variable and the domestic price variable are equal, but opposite in sign). The value of the Wald statistic was 1.88, which is less than the critical value of $\chi^2_{0.05}(1) = 3.84$. Thus, the restriction is found to be valid and the relative price formulation in the import demand model is appropriate.

The estimated income and price elasticities (see Table 5) are of the expected signs, with the income elasticity being statistically significant at the 1% level. This evidence supports the hypothesis that an increase in real income in Indonesia over the period 1971 to 1993 has seen a commensurate rise in aggregate imports. In addition, the income elasiticty exceeds one (although not significantly so), which suggests that the demand for imports has increased by a greater proportion than real income. Therefore, if Indonesia's economy continues to show strong economic growth, there will be potential for exporting countries (such as Australia) to increase sales to Indonesia.

The relative price elasticity of imports is statistically significant at the 5% level and has the expected sign. It is less than one in absolute value (although not significantly so), suggesting that the demand for imports in Indonesia is price inelastic and that demand will be less responsive to changes in relative price. Overall, the results suggest that any exporting nation that improves its international price competitiveness has some scope to increase market share and net exports to Indonesia.

Results of the current study for Indonesia are comparable to those of several previous studies. For example, Khan and Ross [1977] used a log-linear model to estimate aggregate import demand equations for the United States, Canada and Japan. They found income and prices to be important determinants of demand, and estimated income elasticities to be between 0.75 and 1.39, and price elasticities to be between -0.74 and -1.88. Boylan et al. [1980] followed a similar approach to Khan and Ross [1977] and examined aggregate imports for three smaller countries in the European Economic Community - Ireland, Denmark and Belgium. They estimated income elasticities to be between 1.58 and 1.84, and price elasticities to be between -0.17 and -0.52. Siddique [1997] also used a log-linear model to estimate the import demand equation for manufactured goods, machinery and manufactured articles, and aggregate imports for Malaysia for the period 1979-92. He found income to be an important determinant of import demand in Malaysia and the estimated income elasticity to be 1.91. The relative price elasticity had the correct sign but was not significant.

Estimation of dynamic import demand model using equation (6) did not produce any satisfactory results and are not presented here. The coefficient of lagged imports was found to be statistically insignificant. As we are using annual data, it is possible that the adjustment to

equilibrium is adequately captured within a single period. Potential multicollinearity between the income variable and the lagged imports variable could also be a reason why the t-ratio for the coefficient for lagged imports appears to be statistically insignificant (Gafar [1988]). Akhtur [1980] also used a partial adjustment model to estimate long-run income and price elasticities of aggregate imports for Canada, France, Italy, Japan, the United States, the United Kingdom and Germany. Overall, the estimated income elasticities ranged from about 1.5 for Canada to around 2.5 for Germany, the United States and the United Kingdom. Price elasticity estimates, on the other hand, ranged from -0.2 to -0.8 and were significant for most countries.

Finally, the theory of cointegration of economic time series has developed enormously over the past decade and is used to treat issues of non-stationary time series and spurious regression. Cointegration techniques are particularly suited to estimating import demand functions. Recently, Asseery and Peel [1991] and Doroodian et al. [1994] estimated long-run and short-run elasticities of demand for imports using cointegration. Asseery and Peel analysed import demand for Canada, Japan, the United Kingdom, the United States and West Germany, and observed that the estimated long-run income and price elasticities were generally lower in magnitude than estimates from the traditional models. The effect was particularly pronounced for price elasticities.

Doroodian et al. [1994] estimated elasticities for aggregate imports to Saudi Arabia and found the long-run income and price elasticities to be significantly larger than those in the short-run. It was found that the real income elasticity was 0.22 in the short run and 0.47 in the long-run, which implies that imports are considered as necessary goods in Indonesia. The own price elasticity of imports was -0.68 in the short run and -1.45 in the long run, indicating that import demand tends to be elastic in the long run. On the other hand, the import elasticity with respect to the price of domestic goods was 1.3 in the short run and 2.9 in the long run, suggesting that consumers respond more to an equal change in domestic prices than to an equal change in import prices. Unfortunately, as mentioned earlier, the short span of data available from Indonesia precluded the use of these techniques in this study. As more data become available, it would be interesting to estimate import demand functions for Indonesia using the techniques of cointegration and to compare the results with those presented here.

4. CONCLUSIONS

A number of conclusions can be drawn from the analysis. First, tests of functional form show that the log-linear functional form was the appropriate specification for aggregate imports. If researchers are to obtain robust results, it is important that they test for the appropriate functional form.

Second, the empirical results provide further evidence that real income and relative prices are important determinants of the demand for imports. It was found that the income elasticity was greater than one (although not significantly so), which suggests that, generally speaking, imports into Indonesia are income elastic. As Indonesia's economy grows, imports will grow at a greater rate. This will provide some opportunity for existing and potential exporters to Indonesia.

The price elasticity was found to be less than one in absolute value (but not significantly so), suggesting that the demand for imports into Indonesia is price inelastic.

Given the signs and magnitude of the estimated income and price elasticities and the proximity of Australia to Indonesia, there is significant scope for Australia to increase exports to Indonesia. If Australia's government and industry can reduce business costs and become more internationally price competitive, Australia has a significant potential to increase market share and net exports to Indonesia.

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