

## The Functional Form of the Aggregate Import Demand Equation: Evidence from Developing Countries

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The specification of the appropriate functional form of the aggregate import demand equation is an important methodological problem, which affects the estimates of demand elasticities and the conclusions about the impact of policy changes. In the absence of any guidance from economic theory we determine the appropriate form empirically using a generalized functional form based on the Box-Cox method and find, that for a large number of developing countries the log-linear form is the preferred choice for the aggregate import demand equation.

### INTRODUCTION

In the estimation of the import demand equation economic theory has little to suggest about the choice of the appropriate functional form. Conventionally, the choice has been made from the class of linear and log-linear functional forms on grounds of convenience or by reference to standard goodness-of-fit criteria.<sup>1</sup> But this procedure is unsatisfactory as it involves a certain degree of arbitrariness which has important economic and statistical implications. It has been pointed out [see Khan and Ross (1977)] that apart from the statistical problems of biased and inconsistent estimates, an inappropriate functional form of the aggregate demand relationship can significantly affect policy conclusions about the influence of explanatory variables. Further, the use of the log-linear formulation constrains the price and income elasticity estimates to be constant over the estimation period; while the linear form of the import demand equation implies a decreasing price elasticity and an income elasticity tending towards one. Thus, the specification of the appropriate functional form is an important methodological problem.

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<sup>1</sup> See for example [Khan (1975); Melo and Vogt (1984); Sarmad and Mahmood (1987)].

An empirical solution to the problem of the appropriate choice of the functional form of the import demand equation is provided by Box and Cox (1964). The Box-Cox method enables to determine the appropriate form from a particular class of functions by specifying a generalized functional form.

Khan and Ross (1977) and Boylan *et al.* (1980) have used the Box-Cox procedure to determine the appropriate functional form of the import demand equation for three major industrial countries the United States, Canada and Japan – and for three small European economies – Ireland, Denmark and Belgium. They show that, in general, for developed countries, the log-linear formulation of the import demand equation is preferable to the linear formulation. It would be interesting to see if the conclusions of Khan and Ross (1977) can be further generalized for the case of developing countries.

In this paper, we present the results of estimating a general power function of the aggregate import demand equation for a large number of countries that include two from Latin America – Peru and Venezuela, two from Africa – Morocco and Kenya and two relatively less developed countries from Europe – Greece and Portugal.

The standard import demand equation relates the quantity of imports to the relative price of imports to domestic prices and to domestic real income. However, since the Box-Cox test is sensitive to the specification of the equation, we work with a modified version of the standard import demand equation, which takes into account factors specific to developing countries like government restrictions on imports and real foreign exchange reserves. Thus, the dependent variable – quantity of imports – is related to the domestic income level, foreign exchange availability and the ratio of import price to domestic price adjusted for tariffs.<sup>2</sup>

We use annual data for the period 1960 to 1981. Real imports, and the unit value indices have been taken from the United Nations *International Trade Statistics Yearbook* and from the *Monthly Bulletin of Statistics* of the United Nations. The series for real income and for the domestic price indices, have been computed from the *World Tables* of the World Bank. Custom duties have been obtained from various issues of the *Government Finance Statistics Yearbook* of the International Monetary Fund and real foreign exchange reserves have been computed from the *International Financial Statistics* of the International Monetary Fund.

<sup>2</sup>The fact that a proportion of imports may have no domestic substitutes will cause a bias in the estimation of the import equations. We use the wholesale price index as the best available measure of the price of domestically produced tradable goods, which includes both imported goods and non-tradable domestically produced goods. We have shown elsewhere [see Sarmad and Mahmood (1987)] that because of this error of measurement the extent of the bias in the true price elasticity of the demand for imports is given by  $(1-\omega)P_d^t/P_d^o$ , the weight of the true price of domestic goods in the observed price of goods.

## THE GENERAL FORM OF THE IMPORT DEMAND EQUATION

In notational form the aggregate import equation for developing countries can be written as

$$M^d = f_i(P^a, Y, Fx) \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

where

- $M^d$  = quantity of imports demanded;
- $f_i$  = the function whose mathematical form is to be specified;
- $P^a$  =  $(1+t)P^i/P^d$  = ratio of price of imports to domestic price level adjusted for tariffs;
- $Y$  = real gross national product; and
- $Fx$  = real foreign exchange reserves.

$\partial M^d/\partial P$  is expected to be  $< 0$  and  $\partial M^d/\partial Y$  can be  $\geq 0$ . For a given time  $t$  Equation (1) can be written in linear terms as

$$M_t^d = \alpha_0 + \alpha_1 P_t^a + \alpha_2 Y_t + \alpha_3 Fx_t + e_t \quad \dots \quad \dots \quad (2)$$

where  $e$  is a random error term, while the log-linear formulation is

$$\text{Log } M_t^d = \beta_0 + \beta_1 \text{Log } P_t^a + \beta_2 \text{Log } Y_t + \beta_3 \text{Log } Fx_t + e_t \quad \dots \quad (3)$$

Khan and Ross refer to a number of biases that can result in the estimation of Equations (2) and (3). These biases arise from simultaneity between quantity of imports and their price,<sup>3,4</sup> from errors of measurement<sup>5</sup> and from the assumption of instantaneous adjustment by importers to changes in one or both of the explanatory variables.

The assumption of instantaneous adjustment can be relaxed by using a partial adjustment mechanism for imports, which introduces a lag in to the determination of imports such that Equation (2) becomes

$$M_t = \gamma_0 + \gamma_1 P_t^a + \gamma_2 Y_t + \gamma_3 Fx_t + \gamma_4 M_{t-1} + \omega_t \quad \dots \quad (4)$$

<sup>3</sup>The analysis here follows that of Khan and Ross (1977).

<sup>4</sup>In the case of the countries we are dealing with the problem of simultaneity should not arise in any serious form because of the small share of these countries in world trade. It is therefore, safe to work with the assumption that these countries face an infinitely elastic supply curve.

<sup>5</sup>See footnote 2.

and Equation (3) becomes

$$\begin{aligned} \text{Log } M_t = & \theta_0 + \theta_1 \text{Log } P_t^a + \theta_2 \text{Log } Y_t + \theta_3 \text{Log } Fx_t + \\ & \theta_4 \text{Log } M_{t-1} + \epsilon_t \quad \dots \quad \dots \quad \dots \quad (5) \end{aligned}$$

In the case of the equilibrium import equation the generalized functional form is given by the following:

$$\begin{aligned} (M_t^\lambda - 1)/\lambda = & a_0 + a_1 (P_t^{a\lambda} - 1)/\lambda + a_2 (Y_t^\lambda - 1)/\lambda + \\ & a_3 (F_x^\lambda - 1)/\lambda + e_t \quad \dots \quad \dots \quad \dots \quad (6) \end{aligned}$$

which reduces to Equations (2) and (3) for values of  $\lambda=1$  and 0.

The parameters of Equation (6) are obtained by the maximum likelihood method, which for a given value of  $\lambda$  yields:

$$L_{max}(\lambda) = -T/2 \log \hat{\sigma}^2(\lambda) + (\lambda-1) \log M_t \quad \dots \quad \dots \quad (7)$$

where  $L_{max}(\lambda)$  = the log of the likelihood function of Equation (6) maximized with respect to  $\lambda$ , and

$\hat{\sigma}^2(\lambda)$  = the maximum likelihood value of  $\sigma^2$ .

The value of  $\lambda$  ( $\lambda_{max}$ ) which maximizes  $L_{max}(\lambda)$  enables to determine the functional form of the import demand equation using the following confidence interval for  $\lambda$  based on the chi-squared distribution:

$$L_{max}(\lambda_{max}) - L_{max}(\lambda) < \frac{1}{2} \chi^2(\kappa)$$

where  $\kappa$  is the degrees of freedom.<sup>6</sup>

The procedure described is easily generalized for the dynamic import equation.

## RESULTS

Functional form tests were conducted for values of  $\lambda$  ranging from -1.4 to 1.4 at intervals of 0.1. The results of estimating a partial adjustment mechanism for imports showed that in the case of Kenya and Peru adjustment to changes in demand take place within the year. For the other four countries - Morocco, Venezuela,

<sup>6</sup> A referee has correctly pointed out that an alternative approach could be to calculate  $L_{max}$  and then test against  $\lambda=0$  and  $\lambda=1$ . The difference between the likelihood functions at  $\lambda$  and  $\lambda=0$  and  $\lambda=1$  is distributed as  $\frac{1}{2}\chi^2$ .

Portugal and Greece, the results do not warrant the rejection of the hypothesis of no instantaneous adjustment. For these countries the functional form tests were conducted for the disequilibrium model. In cases where the hypothesis of no serial correlation could not be rejected on the basis of the *D.W.* statistic the functional form tests were conducted with adjustment for serial correlation.

The values of  $\lambda$  which maximize  $L_{max}(\lambda)$  and confidence intervals for  $\lambda$  are reported in Table 1.

Table 1  
Value of  $\lambda$  which Maximizes  $L_{max}(\lambda)$  and Confidence Interval for  $\lambda$

Country	$\lambda$	95 Percent Confidence Interval for $\lambda$	
Morocco	-0.7	-1.61,	0.02 <sup>b</sup>
Kenya	0.0	-0.96,	0.72
Venezuela	-0.1	-0.72,	0.45
Peru	0.0	-0.10,	0.15
Portugal	-0.2	-0.41,	0.08
Greece	0.5	-0.04,	0.99 <sup>a</sup>

Note: a and b refer to 97.5 percent and 90 percent confidence intervals.

For Kenya and Peru  $L_{max}(\lambda)$  is maximized for  $\lambda=0$  and the 95 percent confidence interval for  $\lambda$  excludes the value of 1. For Venezuela and Portugal also there is convincing evidence that the log-linear form of the aggregate import demand equation is the appropriate form

For Morocco,  $L_{max}(\lambda)$  is maximized for  $\lambda = -0.7$  and the 95 percent confidence level excludes the values of  $\lambda=0$  and  $\lambda=1$ . However, the value of  $\lambda=0$  is included in the 97.5 percent confidence interval. On the other hand, the 95 percent confidence interval for Greece includes the values of the both  $\lambda=0$  and  $\lambda=1$ . It is only in the 90 percent confidence interval that the value of  $\lambda=0$  is included and that of  $\lambda=1$  excluded.

The evidence presented above allows one to conclude that the log-linear form of the aggregate import demand equation is a more appropriate functional form as compared with the linear formulation.

Table 2 reports the parameter estimates corresponding to the log-linear formulation of the aggregate import demand equations for the six countries, their respective *t*-values, the coefficient of determination  $\bar{R}^2$ , the standard error and the Durbin-Watson statistic.

Table 2  
Log-linear Form of the Aggregate Import Demand Equations

Dependent Variable	Constant	Log $P_t^a$	Log $Y_t$	Log $Fx_t$	Log $M_{t-1}$	$\bar{R}^2$	S.W.	D.W.
Morocco	-5.000 (-1.596)	-0.072 (-0.148)	1.737 (1.635)	-0.188 (-1.207)	0.457 (1.284)	0.926	0.139	1.84
Kenya	-0.725 (-1.502)	-0.848 (-4.960)	0.885 (6.095)	0.008 (0.868)		0.913	0.088	2.08
Venezuela	-0.103 (-0.129)	-1.019 (-2.990)	0.078 (0.254)	0.302 (3.039)	0.753 (4.748)	0.960	0.093	2.25
Peru	1.393 (1.263)	-0.679 (-7.505)	0.472 (1.597)	-0.102 (-0.867)		0.911	0.114	1.72
Portugal	-2.184 (-3.149)	-0.927 (-7.714)	0.970 (5.098)	0.065 (1.270)	0.230 (2.230)	0.989	0.080	1.95
Greece	-1.295 (-1.828)	-0.711 (-3.148)	0.646 (2.899)	0.041 (0.876)	0.399 (2.697)	0.990	0.047	1.59

Note: Values in parenthesis are t-values.

The results show that the parameter estimates for the adjusted relative price and income variables have the expected signs and are in almost all cases statistically significant at the 90 percent level. However, in at least two cases the parameter estimate for the foreign exchange availability variable is statistically significant only at the 80 percent level.

## CONCLUSIONS

Functional form tests were conducted on the basis of the Box-Cox method for the dynamic import demand model for a number of countries. In those cases where the coefficient of the lagged dependent variable was insignificant the functional form tests were conducted for the equilibrium model. Wherever there was evidence of serial correlation the tests were conducted with adjustment for serial correlation.

The results show that the log-linear form of the import demand equation is preferable to the linear formulation.

Khan and Ross (1977) and Boylan *et al.* (1980) demonstrated that for three major industrial countries and three small European countries the log-linear functional form of the import demand equation was the preferred choice. We have shown that these results can be generalized for a large number of relatively less developed countries, which have significantly different economic structures and are at varying levels of development.

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