IMPORT DEMAND FOR BARBADOS: A PRODUCTION THEORY APPROACH

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INTRODUCTION

International trade flows between developing countries and the rest of the world are generally considered as vital transmission mechanisms for self-sustained economic growth and development. For example, these trade flows may include factor inputs that may embody advanced technologies, which are necessary to the process of accumulation. On the other hand, there may be disembodied imported inputs which are relatively less efficient than their domestic substitutes, thereby effectively forestalling the development of domestic resources. It is therefore important to know the degree of substitution between domestic and imported factors of production, and the extent to which the import content of factor inputs may be reduced without ill-affecting the level of domestic output. Such information would not only be important for enhancing employment of domestic resources but would have implications for the balance of payments since reduced imports may permit reallocation of the limited available foreign exchange or for acquisition of other essential imports that advance the development process.

In spite of the significance of imported factor inputs of production, the available empirical studies on the demand for imports in the Caribbean have followed the traditional approach of expressing import demand as a function of real income and relative prices. For example, see Cox and Worrell (1978) and Joefield-Napier (1984) for Barbados, Gafar (1979) for Guyana and Gafar (1988) for Trinidad and Tobago. This approach implicitly assumes that all imports are either final goods for consumption or intermediate goods which are separable from primary factors (capital, land and labour) in the production process.

In recent studies on India and Pakistan, Mohabbat, Dalal and Williams (1984) and Henry (1989), respectively, reject the notion of separability of primary factors and imports and conclude as incorrect the specification of an import demand function dependent only on import prices and real aggregate output in which primary factors are the only inputs. Barbados, as indeed all other territories in the Caribbean, depend crucially on imported resources for the growth of real output. Any inability to acquire such imports will no doubt exert a stronger restraining force on the level of production in Caribbean countries than in other countries that depend relatively less on imports as inputs into productive processes. Thus, it is reasonable to consider imports as a separate factor in the production process, alongside capital, labour and land.

The objectives of this paper are two-fold: firstly to investigate the hypothesis that imports should enter as a separate factor of production in a general economy - wide production function in Barbados and, secondly to examine the substitution possibilities that may exist between imports and the primary factors of capital and labour. In this regard, a two-output, three-input transcendental cost function specification is utilised. The translog cost function allows one to test for the separability of inputs without necessarily imposing any conditions a priori as is the case with traditional import demand studies. In contrast to previous studies, real output is divided into the familiar traded and non-traded goods[1] produced by three factors of production: imported materials and the primary inputs of capital and labour.

The remainder of this paper consists of three sections: in the next section the translog cost function, as well as the related concepts of duality and separability are discussed briefly; then the estimation technique and empirical results are presented and finally some conclusions are made.

II. THE TRANSLOG JOINT COST FUNCTION

The transcendental logarithm or translog production frontier was first introduced into the economic literature by Christensen, Jorgenson and Lau (1973). Since then it has become a favoured specification in applied production studies, attractive to researchers primarily because it (i) allows for a greater variety of substitution possibilities among factors of production than the functions based on constant elasticities of substitution such as the Cobb Douglas production function; (ii) contains all forms of production structure (homotheticity, homogeneity, unitary elasticity of substitution, and homogeneity and unitary elasticity of substitution) as special cases which can be tested for and assessed using the implied restrictions derived therefrom; (iii) is self - dual so that there exist cost and production functions which are dual to each other: the structure of production can therefore be studied empirically using either a production or a cost function.

Binswanger (1974) recommends, as is adopted here, the use of the cost approach to estimate the production parameters as it is easier to implement, bypasses problems of multicollinearity inherent in production functions and allows use of the Samuelson - Shephard lemma which permits us to write the input demand functions and marginal costs in terms of relative cost and revenue shares, respectively[2].

Consider a general production function

$$Q = Q\ [K,\ L,\ M] \tag{1}$$

where Q is gross output: K, L, and M are aggregate inputs of capital, labour and imports, respectively[3]. We assume that Q can be neatly partitioned into non-traded goods (Q_{NT}) and traded goods (Q_T). Applying the duality theorem, under the assumptions of constant returns to scale and exogenously determined prices and output, the general form of the aggregate cost function can be written as

$$C = C\ (P_K,\ P_L\ ,\ P_M,\ Q) \tag{2}$$

where P_j, j=K,L,M are the price of capital, labour and imports, respectively. The unconstrained translog cost function of the general form can be represented by a logarithmic Taylor series expansion to the second term of a twice differentiable function[4]:

$$\begin{aligned} \ln C = {} & \alpha_0 + \Sigma_i\ \alpha_i \ln Q_i + \Sigma_j\ \beta_j \ln P_j \\ & + \tfrac{1}{2}\ \Sigma_i\ \Sigma_r\ \delta_{ir} \ln Q_i \ln Q_r \\ & + \tfrac{1}{2}\ \Sigma_j\ \Sigma_s\ \gamma_{js} \ln P_j \ln P_s + \Sigma_i\ \Sigma_j\ \phi_{ij} \ln Q_i \ln P_j \end{aligned} \tag{3}$$

where i, r = T = tradables, NT = nontradables; j, s = K,L,M and symmetry is imposed, that is, $\delta_{ir} = \delta_{ri}$ and $\gamma_{js} = \gamma_{sj}$. In order for the cost function (3) to correspond to a well-behaved production function, it must be positive, concave and linearly homogeneous in factor prices[5]. Sufficient conditions for the latter assumption to hold are

$$\Sigma_j \beta_j = 1; \quad \Sigma_j\gamma_{js} = \Sigma_s\gamma_{js} = \Sigma_j \Sigma_s\gamma_{js} = 0 ; \quad \Sigma_j\phi_{ij} = 0 \tag{4}$$

To maintain the hypothesis of constant returns to scale (necessary for a well behaved cost function), duality theory and the translog approximation further require the following restrictions:

$$\Sigma_i\alpha_i = 1 ; \quad \Sigma_i\phi_{ij} = 0 ; \quad \Sigma_i \delta_{ij} = 0 \tag{5}$$

Incorporating the above restrictions and differentiating logarithmically (3) with respect to each factor price and output gives the following set of input demand functions (the cost share of input) and revenue share of output equations, respectively:

$$S_L \equiv \frac{\partial \ln C}{\partial \ln P_L} = \beta_L + \gamma_{LL} \ln (P_L/P_K) + \gamma_{LM} \ln (P_M/P_K) + \phi_{TL} \ln (Q_T/Q_{NT})$$

$$S_M \equiv \frac{\partial \ln C}{\partial \ln P_M} = \beta_M + \gamma_{MM} \ln (P_M/P_K) + \gamma_{LM} \ln (P_L/P_K) + \phi_{TM} \ln (Q_T/Q_{NT})$$

$$S_K \equiv \frac{\partial \ln C}{\partial \ln P_K} = 1 - S_L - S_M \tag{6}$$

$$R_T \equiv \frac{\partial \ln C}{\partial \ln Q_T} = \alpha_T + \delta_{TT} \ln (Q_T/Q_{NT}) + \phi_{TL} \ln (P_L/P_K) + \phi_{TM} \ln (P_M/P_K)$$

$$R_{NT} \equiv \frac{\partial \ln C}{\partial \ln Q_{NT}} = 1 - R_T$$

where S_j and R_i are the cost and revenue shares obtained with the Samuelson-Shephard lemma. Because of the symmetry in the γ's, ϕ's and δ's there are just nine independent parameters in this syste Estimation of these, in conjunction with the summation conditio on the α's, β's, γ's, ϕ's and δ's will yield estimates of all t coefficients of the cost function (3) except α_0.

Furthermore Uzawa (1962) has shown that the Allen parti elasticities of substitution (AES) between inputs s and j can derived in terms of the first and second partial derivatives. Formally, we have $\sigma_{sj} = CC_{sj}/C_sC_j$ and $\eta_s = \sigma_{ss} S_s$ where $C_s = \partial C/\partial P_s$, C $= \partial^2C/(\partial C_s\partial C_j)$ and η_s is the own price elasticity of demand for t sth factor[6]. In terms of the parameters of the translog co function, Christensen and Green (1976) have shown that

$$\begin{aligned}
\sigma_{ML} &= (\gamma_{LM}/S_MS_L) + 1 \\
\sigma_{MK} &= [- (\gamma_{MM} + \gamma_{LM})/S_M(1-S_M-S_L)] + 1 \\
\sigma_{LK} &= [- (\gamma_{LL} + \gamma_{LM})/S_L(1-S_M-S_L)] + 1 \\
\eta_s &= (\gamma_{ss} + S^2_s - S_s)/S_s \quad ; \quad s = L, M \\
\eta_k &= - (S_M \sigma_{MK} + S_L \sigma_{LK})
\end{aligned} \tag{7}$$

where the last expression is derived from the fact that $\Sigma_j S_j \sigma_{sj}$ 0. Thus the AES are not constrained to be constant but may va with the values of the cost shares. Note that the elasticities substitution are non-linear functions of the estimated parameter thus their standard errors cannot be calculated exactly. Howeve under the assumption that the shares (S_j) are constant and equal the means of their estimated values, we can obtain approximate estimates of the standard error (Humphrey and Moroney, 1975);

$$SE(\sigma_{sj}) = SE(\gamma_{sj})/S_s S_j \qquad s \neq j$$

$$SE(\sigma_{ss}) = SE(\gamma_{ss})/S_s^2 \qquad s = j \tag{8}$$

For the own price elasticities of input demands the asymptotic standard errors are

$$SE(\eta_{sj}) = SE(\gamma_{sj})/S_s \qquad s \neq j$$

$$SE(\eta_{ss}) = SE(\gamma_{ss})/S_s \qquad s = j \tag{9}$$

As mentioned earlier the translog cost function is quite flexible allowing restrictions to be tested rather than imposing them a priori. The following restrictions will be tested in this paper[7]:

1. Input-output separability which requires the marginal rate of transformation between the output pair to be independent of the factor composition and the marginal rate of substitution between pairs of factors to be independent of the composition of output. The test for this, therefore, involves setting the interaction terms between output and input pairs to zero, that is,

$$\phi_{TL} = \phi_{TM} = 0 \tag{10}$$

2. Linear separability between primary factors and imports. This exists if $\sigma_{KM} = \sigma_{LM} = 1$ where σ_{sj} is the AES between inputs s and j. In terms of the parameters of the model the following restriction is imposed

$$\gamma_{LM} = \gamma_{MM} = 0 \tag{11}$$

If this holds it implies a partial Cobb-Douglas structure.

3. Complete global separability which requires

$$\sigma_{LM} = \sigma_{KM} = \sigma_{KL} = 1 \tag{12}$$

Clearly if $\sigma_{LK} = \sigma_{KM} = 1$ is rejected then complete global separability which implies a complete Cobb-Douglas function, will not hold.

4. Finally we test for the existence of nonlinear separability. This exists if $\sigma_{KM} = \sigma_{LM} \neq 1$ and involves imposing the two independent restrictions

$$\gamma_{MM} = \gamma_{LM}^2/\gamma_{LL} \quad ; \quad \beta_M = (\gamma_{LM}\,\beta_L/\gamma_{LL}) + 1 \tag{13}$$

Rejection of linear and non-linear separability hypotheses[8] indicates that no consistent indices of (K,L), (K,M) or (L,M) exists for aggregate Barbadian data. This is equivalent to assuming that the conventional multi-factor Cobb-Douglas and CES functions are rejected.

III. ESTIMATION AND EMPIRICAL RESULTS

In specifying the translog joint cost function described in equations (2) and (6), the cost and revenue shares were assumed to sum to unity at each observation. This postulate required the parametric restrictions in equation (4) which, in turn, reduced the five equation system in (6) to a three equation system. The estimates of the other two equations can be derived from the parameters of the remaining equations using the restrictions in expression (4).

Although ordinary least squares estimation of each equation (independently) will give unbiased and consistent parameter estimates, it will not be the most efficient. Efficiency of the parameter estimates could be improved if explicit consideration is taken of the correlation between the error terms across equations[9]. Since the revenue shares and the cost shares each sum to unity, the sum of these disturbance terms across the equations is zero at each observation. Furthermore, if one or more parameters are included in more than one equation, multivariate regression is the way to impose the constraint of parameter equality across equations.

Hence for efficient estimation one must use a system's approach which accounts for possible correlation between equations. This is usually accomplished using the Aitken's or generalised least-squared estimation procedure (Zellner, 1962). Zellner's procedure improves the efficiency of the estimated parameters by taking account of the fact that the correlation between equation disturbances is non-zero.

Zellner's method of estimation is operational by deleting one of the share and revenue equation (in our case we have deleted S_K and R_{NT}) from the system of equations in expression (6) and estimating the rest of the equations by three stage least squares (3SLS). The problem with this procedure is that the 3SLS estimator may not be invariant to the equation deleted but this is easily remedied by iterating the 3SLS procedure until the estimated coefficient variance-covariance matrix converges (see Zellner (1962))[10]. This is the method employed in this study. The various parametric restrictions described above are tested using the likelihood ratio statistic computed as $-2 \log [L(\Lambda_o) - L(\Lambda)] \sim \chi^2(w)$ where $L(\Lambda_o)$ and $L(\Lambda)$ are the log likelihood functions of the constrained and unconstrained cost functions, respectively, and w is the number of restrictions needed to define the null hypothesis.

Data and Empirical Results

The data required for estimation include the total cost of production, the revenue share of traded goods, the cost shares of labour and imports, the ratio of traded goods to non-traded goods, and the ratios of the price of labour and the price of imports to the price of capital services. The estimation period is 1959-1987 and a base year of 1975 is used to scale the quantity and price ratios. The Appendix provides a detailed discussion of the calculation of these variables and the data sources.

Table 1 presents estimates of the coefficients of equation (6) under different separability hypotheses; the student t-statistics (in parentheses) and the log likelihood functions are also reported. Casual comparison of the actual and fitted cost and revenue shares of all equations suggest that divergences are small and thus the models map the data quite well. Column 2 lists the estimates of the nine free parameters with the only restrictions being the assumptions of constant returns to scale, linear homogeneity in prices and symmetry, which are necessary to ensure a well behaved cost function.

First we test whether or not the Barbadian technology is separable between inputs and outputs. The test as we noted above involves imposing the two independent restrictions $\phi_{TL} = \phi_{TM} = 0$. Column 3 of Table 1 gives the resulting parameter estimates. The calculated χ^2 statistic (with 2 degrees of freedom), obtained from the log likelihood functions is 18.254. This is higher than the 1% critical level of 9.21 and so the hypothesis of input-output separability cannot be accepted. That technology is not separable between inputs and outputs in Barbados also implies that the cost minimizing bundle of inputs is not independent of the composition of final output for given factor prices. Since we have rejected the input-output separability hypothesis we do not maintain this hypothesis for subsequent estimations and tests.

Next, a test for the significance of linear separability between primary factors (capital and labour) and imports is carried out. Recall that this exists if the Allen partial elasticity of substitution (AES) between capital and imports as well as between labour and imports equals unity, or in terms of the parameters of the estimated model, $\gamma_{MM} = \gamma_{LM} = 0$. The resulting parameter estimates are shown in column 4 of Table 1. Once again, the calculated χ^2 statistics of 54.59 leads us to reject the hypothesis of linear separability between primary factors and imports. It should be noted that the rejection of linear separability implies that the hypothesis of complete global separability, (that is $\sigma_{LM} = \sigma_{KM} = \sigma_{KL} = 1$), must also be rejected. Thus, a Cobb-Douglas production function which exhibits the characteristics of global separability between inputs cannot adequately represent the aggregate production technology in Barbados.

The test for the existence of nonlinear separability between primary factors and imports requires the two independent restrictions $\gamma_{MM} = \gamma_{LM2}/\gamma_{LL}$ and $\beta_m = 1 + (\beta_L \gamma_{LM}/\gamma_{LL})$ to be imposed. The results, after the imposition of these two restrictions appear as column 5 in Table 1. The calculated χ^2 statistics is 184.88, suggesting that the hypothesis of non-linear separability between the primary factors and imports must also be rejected.

With both types of separability between primary factors and imports rejected, we cannot represent the Barbadian value added as being produced exclusively by the primary inputs of labour and capital. Thus imports must be treated as an individual input in the production process. Hence we conclude that specifying a functional relationship in which import demand depends only on import prices, aggregate output and a price index of domestic output that incorporates only primary factors may not be correct.

Knowledge of the value of some elasticities is important for decision-making. So next, we calculate and evaluate the Allen-Uzawa partial elasticities of substitution, σ_{ij}, and the own-price elasticity of demand, η_i. The numerical estimates of these calculations appear in Tables 2 and 3. It is observed that most of the σ_{ij} are positive indicating that inputs M and L and K and M are substitutes for each other, while inputs L and K are substitutes for all years except 1970 and between 1973 and 1986 inclusive, when they complement each other[11]. The elasticities of substitution between labour and services and imports are above unity and greater than the other two pairs, while estimates of σ_{KM} yield fairly rigid substitution possibilities. Burgess (1974b) demonstrates that this result ($\sigma_{LM} > \sigma_{KM}$) implies that an increase in import prices (say through an increase in tariff rates) will improve the lot of income receivers (capitalists and labourers) but will redistribute income from labourers to capitalists raising the share of the latter in national income. When import prices increase, the fact that firms may be able to substitute more labour for imports than capital for imports implies that more labour can be employed which in turn could cause a fall in real wages.

With $\sigma_{LM}>0$, adoption of production techniques which encourage the substitution of labour for expensive imports may improve the present ailing Barbadian's balance of payments. Moreover, as 'growth in wages did not keep pace with the substantial gains in productivity' (Mascoll, 1985), implementation of labour - intensive techniques may be encouraged.

In Table 3 we observe that all the own-price elasticities of demand are negative and inelastic indicating that the demand curve for each factor is negatively sloped. The own-price elasticities of labour (η_L) vary between - 0.162 and - 0.515 while those for capital (η_K) lies between - 0.022 and - 0.105. Similarly the own-price elasticity of imported inputs (η_M) ranges between -0.128 and

-0.223. Since demand for labour appear fairly inelastic, labour unions may carry a strong bargaining position in wage negotiations.

Comparable studies for the Barbadian economy are unavailable[12]. However the present results can be compared with those of Mohabbat, Dalal and Williams (1984) on India and Henry (1989) on Pakistan[13]. Like us, these authors found that the three inputs are most of the time substitutable and the demand curves for inputs are downward sloping and inelastic. All three studies rejected linear separability between primary factors and imports. But in contrast, however, Henry (1989) could not reject non-linear separability for Pakistan while Mohabbat, et al (1984) could not reject input - output separability for the Indian economy. The Barbadian result concur with those of the USA and Canada - see Burgess (1974a) and Denny and Pinto (1978), respectively.

Another major difference between Mohabbat, Dalal and Williams (1984) and Henry (1989) studies and our's relates to the capital demand elasticities. The capital demand elasticities for this study are relatively more inelastic than was obtained for India or Pakistan. This may be attributed to the fact that India and Pakistan provide a greater amount of capital goods than Barbados.

SUMMARY AND CONCLUSION

An attempt has been made in this paper to estimate an import demand function for Barbados, treating imported resources as a separate factor of production in a translog cost system. As expected the results indicate that the demand curve for the three inputs, capital, labour and imports, exhibit downward sloping characteristics and are all inelastic. Capital services exhibit the least responsiveness to price changes, followed by imported materials and labour.

The existence of separability between inputs and outputs could not be accepted, implying that factor demand is sensitive to changes in the output mix. The finding is at variance with what was found for India (Mohabbat et al, 1984) but could be attributed to the fact that there have been a significant structural shift in the output mix in Barbados between 1959 and 1987, with a much faster expanding services sector relative to sugar and manufacturing[14].

The results also show that neither linear nor non-linear separability between imports and between capital and labour exists. Thus, the Cobb-Douglas production function or the CES variety may not be the proper function for estimating import demand in Barbados. In addition one needs to be cautious in interpreting the results of an import demand function dependent on import prices and real aggregate output in which the primary factors of capital and labour are the sole inputs.

The study also finds that capital services and imports as well as imports and labour are substitutes in production. Labour services and capital appear to be complements in the latter period of the data but substitutes in the earlier years. The positive substitution possibilities between imports and primary factors tends to corroborate the conclusion of development economists[15] that foreign resources can substitute for less plentiful domestic factors to increase output in the early stages of development.

NOTES

1. Previous researchers divided real output into consumption and investment goods but these variables were not available for a sufficiently long period. Note, however, the tradable - nontradable dichotomy used here is in accordance with the recent open economy literature developed by Dornbrush (1980), inter alia. Tradable goods comprise of export agriculture, mainly sugar, manufacturing and tourism. All other activities, notably, construction, internal transport, public utilities, business and professional services, distribution and government services are considered non-tradables. This classification is used by the Central Bank of Barbados (data source) but this neat distinction can be a bit misleading as those goods listed as non-traded contain a significant traded (imported) element.

2. More formally, the Samuelson-Shephard lemma implies, for all inputs, the marginal cost of the jth input will equal the quantity demanded of that jth input at minimum cost. Thus, $MC_j = \partial C/\partial P_j = X_j$, where X_j are the cost minimizing quantities demanded, C is cost, P is input price, j = K,L,M, where K is capital, L is labour and M is imports. Thus $\partial \ln C/\partial \ln P_j = (\partial C/\partial P_j)(P_j/C) = X_j(P_j/C) = S_j$, where S_j are the related cost shares. The revenue shares can be defined in a similar way. This lemma is discussed in detail by Diewart (1971, pp. 483-4).

3. No specific allowance has been made for the technical change in the cost equation (2) but the introduction of a Hicks-neutral technical change in term (2) would leave the share equations unaltered. Hence the formulation is consistent with the existence of Hicks-neutral technical change.

4. For an extensive and explicit development of the translog as an approximation about a point, see Denny and Fuss (1977).

5. Monotonicity (positive) with respect to input prices require $\partial \ln C/\partial \ln P_j > 0$ while concavity in input prices requires that the Hessian matrix of second partial derivatives with respect to factor prices be negative semi-definite. These were checked and found to hold.

6. See Binswanger (1974) for a generalization of this result.

7. In fact, the only asumptions maintained are those necessary to achieve a well behaved cost structure, that is linear homogeneity, constant returns to scale and symmetry.

8. For detailed derivation of the restriction implied by linear and nonlinear separability see Berndt and Christensen (1973).

9. Error terms were appended for estimation purposes. One would not expect expression (6) to represent the data exactly as there may be random errors in optimisation due to inertia and management.

10. Barten (1968), on the other hand, has shown that maximum-likelihood estimates of a system of share equations with one equation deleted are invariant to which equation is omitted. Kmenta and Gilbert (1968) have demonstrated that by iterating Zellner's procedure the parameter estimate will converge to a maximum-likelihood estimates. Dhrymes (1974), has also shown that the iterating 3SLS estimator is asymtotically equivalent to the maximum-likelihood estimator.

11. This result may be explained by the change in the underlying structure of the Barbados economy since 1973. Prior to the 1973 Barbados was basically a labour intensive sugar crop economy. Technical change tended to be more labour saving during that period. After 1973, Barbados moved into service industries and manufacturing activities bringing in the process relatively more capital intensive projects. Moreover, the rapid expansion in educational facilities during this period would tend to make technical change more labour augmenting. Technically more efficient labour would tend to complement capital, as was noted for that period.

12. However, Downes (1987) employing a CES production function found that the elasticities of substitution between capital and labour in most manufacturing groups were generally less than unity between 1970 and 1977. The size of these elasticities compared favourably with the results obtained here and also with Henry (1989).

13. The reader should keep in mind that Mohabbat, Dalal and Williams (1984) and Henry (1989) like the developed countries theorists decomposed real output in consumption and investment goods while our study uses a traded - nontraded division.

14. The share of sugar in real output fell from about 40% in the late 1950's to less than 5% in 1987.

15. See for instance Chenery and Strout (1966 p. 681)

TABLE 1

ESTIMATES OF THE PARAMETERS OF THE REVENUE AND COST SHARES OF THE TRANSLOG COST FUNCTION (t-Ratios in Parentheses)

Parameters	Unrestricted Estimates	Input-Output Separability	Linear [(K,L)-M] Separability	Non-Linear (K,L)-M] Separability
γ_T	0.640 (21.935)	0.551 (21.563)	0.652 (21.113)	0.711 (16.199)
δ_{TT}	0.411 (11.730)	0.282 (10.765)	0.391 (11.579)	0.489 (8.910)
ϕ_{TL}	0.037 (4.766)	0	0.010 (1.940)	0.070 (3.888)
ϕ_{TM}	-0.010 (-0.686)	0	-0.067 (-6.430)	-0.052 (-2.076)
β_L	0.090 (14.072)	0.065 (15.156)	0.083 (11.772)	0.118 (8.709)
β_M	0.292 (20.112)	0.303 (25.147)	0.291 (10.890)	$1+\gamma_{LM}\beta_L/\gamma_{LL}$
γ_{LL}	0.039 (5.926)	0.018 (3.304)	0.006 (2.859)	0.057 (4.113)
γ_{LM}	0.003 (0.494)	0.016 (2.896)	0	-0.018 (-1.262)
γ_{MM}	0.151 (11.797)	0.121 (11.893)	0	$\gamma_{LM}^2/\gamma_{LL}$
Log Likelihood Function	198.521	189.394	171.226	106.080

TABLE 2

ALLEN PARTIAL ELASTICITIES OF SUBSTITUTION FOR SELECTED YEARS

	σ_{ML}	σ_{MK}	σ_{LK}
1959	1.076 (0.027)	0.221 (0.015)	0.193 (0.003)
1960	1.093 (0.027)	0.215 (0.013)	0.173 (0.002)
1965	1.121 (0.028)	0.194 (0.010)	0.118 (0.002)
1970	1.140 (0.035)	0.222 (0.011)	-0.047 (0.001)
1973	1.158 (0.033)	0.192 (0.009)	-0.038 (0.001)
1975	1.226 (0.036)	0.147 (0.008)	-0.213 (0.001)
1980	1.166 (0.040)	0.231 (0.010)	-0.200 (0.001)
1985	1.212 (0.034)	0.141 (0.008)	-0.136 (0.001)
1987	1.194 (0.026)	0.073 (0.007)	0.070 (0.001)

Standard errors in parentheses

TABLE 3

OWN PRICE ELASTICITIES OF DEMAND FOR SELECTED YEARS

	η_L	η_M	η_K
1959	-0.515 (0.069)	-0.223 (0.034)	-0.105 (0.046)
1960	-0.482 (0.077)	-0.219 (0.034)	-0.092 (0.044)
1965	-0.425 (0.089)	-0.206 (0.041)	-0.070 (0.042)
1970	-0.341 (0.106)	-0.210 (0.040)	-0.069 (0.042)
1973	-0.322 (0.110)	-0.196 (0.043)	-0.055 (0.041)
1975	-0.176 (0.139)	-0.163 (0.049)	-0.028 (0.040)
1980	-0.251 (0.124)	-0.209 (0.040)	-0.063 (0.042)
1985	-0.224 (0.129)	-0.162 (0.050)	-0.029 (0.040)
1987	-0.334 (0.108)	-0.128 (0.055)	-0.022 (0.040)

Standard errors in parentheses

APPENDIX

DATA CALCULATION AND SOURCES

It was assumed that the distributive shares of the inputs K,L,M, in the production function Q = Q (K,L,M) exhaust total cost. Thus the total annual costs of production were apportioned among the wage bill, the total returns to capital and the cost of imported inputs. The revenue shares were also expressed as the ratio of the value added of the respective output category (traded and non-traded) to total output. Data for the gross value added in the traded and non-traded sectors (Q_T and Q_{NT}) and their respective prices (P_T and P_{NT}), the wage index (P_L) and the import price index (P_m) were obtained from the Central Bank of Barbados.
The capital stock variable is an updated version from Boamah(1984).

The rental cost of capital was calculated so that it reflected elements of price, capital gains, and depreciation. The relationship utilized was expressed as

$$P_{kt} = r_t q_{t-1} + \delta q_t - (q_t - q_{t-1})$$

where P_k is the user cost of capital services, r is the opportunity cost of capital, q is the capital asset price, δ is the depreciation rate and $(q_t - q_{t-1})$ is the capital gain. In this study r has been proxied by the yield on Barbados Government debentures. This was obtained from the public debt department, Central Bank of Barbados. q is the implicit deflator for gross domestic capital formation. This was calculated from the values of the stock of capital at current and constant 1975 prices. Both of these series were updated versions from Boamah (1984, Table 1 and Table A.5). Finally, δ equals 8.5%, calculated as the average rate of depreciation of equipment and structures and was taken from Boamah (1984, Table 1).

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