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AN EMPIRICAL ANALYSIS QF SECTORAL INTERRELATIONSHIPS INFLUENCING FOREIGN TRADE

by

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The purpose of this study is to use a two input multi output model to estimate import, export, investment and consumption functions simlta-neously and to estimate inverse demand functions of inputs, capital and labour of the Sri Lankan economy for the period 1958 - 78. This model takes into account technological changes both exogenous and endogenous, discovers new inter- relationships so that policy formulations can be improved. The significance of the study lies in the fact that it provides new information on Sri Lanka and provide insights into the effects of edogenous technology.

This study is divided into 5 Sections. Part 1 of Section 11 will give an outline of the Sri Lankan economy. Previous works in modeling the demand for imports, supply of exports and their limitations will be presented in the second part of Section two. Section 3 contains the hypothesis to be tested and explains the reserach methodology of the study. Section 4 will give the empirical results and finally the Section 5 presents the policy implications of the study.

PROBLEM IDENTIFICATION AND THE OBJECTIVES OF THE STUDY : THE CENTRAL FOCUS OF THE STUDY :

Achieving self - reliance while generating high growth rate and higher standard of living is the main economic concern of the Sri Lankan govern-ment. Since independence in 1948 there have been many ad hoc policies undertaken and a few policies entailing long term changes but no overall intersectoral integrated program. Some of these eflorts have rested, in part, upon several studies of Sri Lanka's economic structure and develop-ment. Nevertheless, the objectives of high growth rate and higher standard of living, together with self reliance have not been successfully achieved.

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A careful diagnosis of Sri Lanka's main economic problems, namely, low per capital income (PCI), a low level o! capxital formation, continuous budget deficits, a perpetual balance of trade deficit, as well as high unemployment and increasing price levels, reveal that they are inter-related. They are, in fact, parts of a vicious circle which involves both the cause and effect of the relative slow growth rate of economic development.

There have been many assessments of how successful this economy has been in achieving economic development. Also, some efiorts have been geared toward finding what can be learned from the policies that the government has previously pursued and the problems accompanyin g them.

The earlier stdies have focused on each sector separately[2]. None of these efforts attempted to view the intersectoral influence, simultaneously in the overall sense. A method of viewing the problem that reflects their interrelationship to each other, is very important in a study of growth analysis.

SECTION TWO

Part 1 - Economy of Sri Lanka

In the last few years some policy concerns were forcused on industrial and agricultural policy. Moderate attention has been put on increasing the manufacturing industry since the 1960 s. But in overall sense, the contribution of manufacturing to the GNP has increased very slightly relative to expectations.

Relatively high emphasis was put on import substitution in the 1960's, but partly due to its heavy dependence on imported raw materials when the foreign exchange researves had been reduced to a bottom level, this policy was not successful in increasing the GNP contribution. In the late 1970's this concern was enlarged, more emphasis was put on outward looking policies, and new projects such as the Mahaweli project, Free Trade Zone (FTZ) which sought fast development were undertaken.

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1. Morawetz, D. "Economic Lessons from Some Small Developing Countries". *World Development*. v. 8, 1980, p. 337-369.
2. W. Rasaputram, *Influence of Foreign Trade on the Level and Growth of National Income of Ceylon*. Colombo Central Bank of Ceylon, 1964. Lin Youngil. "Export Industries and Pattern of Economic Growth in Ceylon".
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Investment

In the earlier studies the lack of capital formation has been considered to be one of the main hindrances to Sri Lankan economic development.[3] On the average gross fixed investment ran at about 12% of the GNP during the late 1950's. During 1960-64, this increased slightly to 15% and during 1966-70 it was 17% at current market prices. During 1971-75 this dropped to 16% and between 1976-77 it again slightly increased to 17.6%[4]. In 1978, at current market prices it reached 22.9%.

Consumption

Total consumption, the sum of private and government consumption, had increased between 1950-78 by a total of 5.0%. In the last few years of the period, over 60% of the utilised resources of the economy had been used in consumption[5]. Although consumption is one of the factors which stimulates the total demand, the pattern of extreamly high consumption through government subsidies (which continued for a significant period of time) had been an obstacle to the high growth rate of investment. Since independence almost every government had forcused on improving basic needs. Subsidized medicine, subsidiced food and free education from kindergarden to the university, have absorbed much of the government's expenditures. In a comparative study, Morawetz (1980) show that by the 1970's the food subsidy alone absorbed 18-25% of government currenr expenditure. In 1970, current expenditure on the above items was greater (some times 50-75%) than the total government capital expenditure[6]. A decline in government savings is the main outcome of such extremely high government subsidies.

Population Problem

The rapidly increasing population growth rate has been one of the hindarances to the economic development in Sri Lanka. The population growth encoruaged a rapid growth in the government social welfare spendings since 1948. The spendings increased the level of literacy and health to a record among Asian Countries. It contributed to a budget deficit and exerted an additional burden on economic development. The rapid population growth also contributed to the low per capitaincome. (PCI)

Table 9 depicts the low PCI levels in 1950, 1964, 1978 and the growth rates of PCI for the periods 1950-1964. 1964-78 and 1950-78. The low PCI is a combination of low GNP and the rapid population growth rate. The low PCI not only discourages private savings that are essential for

3. W. Rasaputram (1964) p. 8; D. Snodgrass (1966) p. 105
4. N. Balakrishnan (1979) p. 103
5. Central Bank of Ceylon *Annual Report* 1978 p. 14
6. Morawetz *opcit* p. 351

capital formation, but also encourages the dependency of the population on the state for basic social services. Consequently, further barriers were put on the economic growth rates of the Sri Lankan economy. It is worth noting here that due to the inter-relationship of economic indicators, each problem in the economy has to be viewed with regard to every other problem. Because of this reason a more flexible functional form trasnlog which allow for inter-relations among the various economic sectors is valuable in estimating import, export investment consumption and invers demand functions.

Trade Balance

Data on trade balance has shown a continuous deficit with fluctuations during this period except in 1976-77. Although from time to time, export expenditure have been depressed by the government by imposing heavy import restrictions, the increased world prices contributed a great deal since 1973 to enlarging import expenditures. When import restrictions were relaxed the import expenditures have reached a considerable higher level. Furthermore, in 1977 and 1978, due to industrial reforms, the imports of capital goods went up by 15% and 140% respectively.

Although exports have shown a moderate increase, it was not significant to compansate for the sharp increase in imports over the period, export in 1976 and 1977. The relatively low prices of major export crops has been the major reason for this gap. It is worth mentioning that although from time to time the prices of exports (coconut) rose, the economy was unable to receive the full benefit of such increases due to practical difficulties in increasing production. The fluctuations in export prices were clearly reflected by foreign exchange earnings. This has been true even prior to the period that is considered here.

Thus, following conclusions can be drawn, the foreign exchange earnings are heavily dependent upon the three major export crops, although the contribution to the GNP of these three crops has decreased over time.

The declined world export prices has shown great corelation with Balance of Trade (BOT). Even when there were increasing prices for some export commodities the economy could not gain high benefits partly due to extremly high import prices which enlarged the import bill and partly due to the failure to increase the volume of exports. In the early 1960's where the level of foreign exchange reserve fell to a rather a low level, heavy import restrictions were imposed by the government. Since the mid 1960's, external assistance has become extremly important in supporting the country's imoprts. In the early 1970's the nation struggle to escape from a perpetual foreign exchange crisis. During the late 1970's relaxation of

import restrictions along with industrial reforms caused the import expenditure to rise rapidly. It is worth while mentioning that the dependancy of the economy on a few comodities which are price elastic in demand and price inelastic in supply is a major problem for the economy. If the intersectoral influence of export is positive it is important to focus on increasing nontraditional exports. If the intersectoral influence of imports is positive a focuse on increasing investment and intermediate goods would be desirable. This study is partly aimed to find out the intersectoral influence of exports and imports.

As mentioned earlier this study utilizes the translog approach which allows for intersectoral relationships of various sectors in the economy, but exceeds previous applications by including endogenous technological changes as well as exogeneous technological changes in the model. Application of the model yields several interesting results (see section IV)

Part II Previous Literature

One of the main deficits of the former studies and policy concerns was the lack of consideration of the overall impact of changes in imports, exports, consumption, investments, and inputs namely, capital and labour on each other simultanously.

Traditional Approach :

Although there were no studies to measure all the sectors at once few studies which aimed to measure the exports and or imports of Sri Lankan economy can be seen (for details see Rasaputram W. (1964), Sirisena N.L. (1976) and Longil Lin (1965). Considering the basic similarities in model specifications, estimation techniques and functional forms previous works which include studies on Sri Lanka economy as well as the others can be devided into two groups. (1) Traditional Approach (2) Modern Approach.

In many empirical studies which have estimated import and export functions have basically focused on three issues : estimation of price elasticity, estimation of income elasticity and estimation of elasticity of substitution. In many empirical studies the importance of price elasticity of exports and imports has traditionally taken priority. The commanly used formular was the percentage change in quantities devided by the percentage change in prices.

Where $$\mathcal{E}_p = \frac{\partial q}{q} \div \frac{\partial p}{p} \quad \text{——— (1)}$$

q = the quantity of imports or exports

p = the price of imports or exports

ε_p = the price elasticity of demand or supply

Nevertheless the roll of income elast icities is of similer importance in estimating the trade balance.

The formular most often used in empirical studies is:

$$\eta_y = \frac{\partial q}{q} \div \frac{\partial y}{y} \qquad \text{——————(2)}$$

Where

y = income

η_y = the income elasticity

There has been an attempt to search for an alternative (Learner, E E and Stern, 1970). As a result, many studies have used elasticity of substitution, which measures the percentage change in relative quantities demanded divided by the percentage change inrelative prices:

$$\sigma = \frac{\partial(q_1/q_2)}{(q_1/q_2)} \div \frac{\partial(P_1/P_2)}{(P_1/P_2)} \qquad \text{——————(3)}$$

Where q_1 and q_2 are either two export goods competing each other in the world market or they are two import goods competing with each other coming from two sources in the economy in question. Under the assum ption of constant elasticity, in many empirical studies the following regres sion form is used in measuring the elasticity of substitution :

$$\ln(q_1/q_2) = a + \sigma \ln(P_1/P_2) \qquad \text{——————(4)}$$

There have been much literature on the theoritical foundation of (4) The study by Learner and Stern (1970), is an example.

Thus several functional forms and model specifications have been used to estimate import and export functions.

Modern Approach:

In his paper Kohli (1978) employed the variable profit function in deriving the export and import functions of Canada and in formulating a model of a country's technology. He utilised the translog functional form so as to avoid some of the shortcomings of the traditional approach. The assumptions made in deriving the variable profit functions are that the import and export decisions are made by profit making firms operate under the perfect competition in both commodity and factor markets, and the rental prices of domestic factors are determined by their marginal product. There are J non - negative domestic primary inputs (fixed in the short run) and I variable quantities. In estimating the demand and supply via the profit functions Kohli (1978) considered the consumption, investments and export as positive variable outputs, imports as negative output. The production posibility set. T. is defined as the set of all feasible input and output combinations. Furthermore, it is assumed that the aggregate technology satisfy constant returns to scale, non-increasing marginal rates of substitution, and for a given endowment of fixed inputs that the output of variable quantities is finite, Above all with the profit maximization, the competitive equalibrium will be the solution to the problem of maximizing GNP subject to the technology, factor endowments, and non negative prices. (See diewert, 1973)

The behavioral assumption underlying the Kohli's model is

$$\text{Max } p'y \text{ st } (x;y) \leq T \qquad p \geq o \text{ ---------- (5)}$$

Where T = technology
Y = a vector of outputs
X = a vector of domestic factor endowments
p = an output price vector

The production possibility set was used in representing a multiple input, multiple output technology. Under certain regulatory conditions of the production possibility set and the assumption of profit maximization, the multi input multi output technology was represented by a profit functions In this case a duality principle between production possibility set and profit function is assumed[8]. The contribution of Kohli's modern approach lies in the adoption of a translog functional form for the variable profit function in estimating technology in a multi input multi output model. The consideration of exgenous technology in a multi input multi output model in the variable profit function is also a further step in Kohils study. The superiority of Kohli's model over the traditional approach is as follows :

i. Instead of estimating the isolated output supplies they are estimated simultaneously.

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7. U. R. Kohli 1978 pp. 168-182
8. W.E. Diewart. 1973 pp 284 - 316

ii. By using the flexible functional form (translog), a prior assumptions on seperability, or on the degree of complementarity or a substitutability between goods and factors is avoided.

iii. There are no adhoc assumntion made in the choice of specific variable and no supplementary explanatory variable is introduces with out theoritical justification.

Furthermore, the Kohli's frame work is suitable when considering the effects of changes in various governement policy parameters.

Since Sri Lanka is a small Export - Import economy this model which relied upon the assumption of perfect competition is more suitable for Sri Lanka than it for Canada.

i. However, there are limitations to Kohli's study :
The study is limited only to exogeneous technological changes.

ii. As the prices are considered as, exogenous, the model only estimates the short run demand and supply functions.

SECTION THREE

This study seeks to develop and to apply a new method of viewing the problem noted earlier (see part I of section two) Specially, the objective is to develop a multi output multi input model of the Sri Lankan economy and to investigate the input output relationship for the period of 1950-78. The two primary factor inputs capital and labour and the consumption investment outputs are integrated together along with imports and exports to form a model for this economy. This model will allow for both output and input augmenting technological changes in the multi input, multi output frame work.

Model Specification :

As mentioned earlier this study uses the modern approach, which has been used by Kohli (1978). But includes endogenous technological change as an additional factor.

The model is based on following assumptions :

1. It is assumed that imports and exports decisions are made by profit maximizing agents.

2. Perfect competition exist in the commodity market and in the factor market.

3. Imports and exports are assumed as inputs and outputs of the technology respectively.

4. Competitive equalibrium is the solution of maximizing the GNP at any period of time subject to technology.

5. The real return for inputs is their marginal productivities.

6. This is only a partial equilibrium model.

7. The "Hicks Neutrality" in technical progress exists. Geometrically this implies an uniform change of the isoquant of the production function towards the origin leaving the slop of the isoquant unchanged.

The following hypothesis are considered in the model :

1. Exogenous technological change will produce a parellel movement in the output production frontier.

2. Exogenous technological changes will produce a parellel movement in the production isoquant frontier in input space.

3. Endogenous technological changes will produce parallel movement in the production possibility frontier.

4. Endogenous technological changes will produce parallel movements in the production isoquant frontier.
Hypothesis i-iv imply the Hicks neutral technological change.

5. A relationship between exports and other outputs will exist.

6. The elasticity of substitution of capital and labour will tend towards one for a long run steady state equalibrium.

Under this frame-work the following important inter relations between inputs and outputs overtime can be analyzed :

1. Inter - relationship between exports and either inputs (Capital and labour) or other outputs. (investments, consumptions and imports)

2. Inter - relationship between imports and either inputs or other outputs

3. Inter-relationships between the inputs and the outputs.

4. Inter-relations between investment and either inputs and the other outputs.

5. Inter-relationships between consumption and either inputs or other outputs.

The model would give statistical estimates of the following elasticities. Elasticities of transformation, elasticities of complementarity, an elasticities of intencity.

MODEL SPECIFICATIONS

A research methodology which is similar to that of Kohli's (1978) model will be used in this study. The theoritical basis for this study is the variable profit function. (For more details of this, reader is encouraged to read Diewert W. E. (1974) p. 136).

$$\pi = \pi (p;x) \text{ ———————— } (6)$$

Which relies on the duality between the profit function and the production possibility set T.

Exogenous Technology :

It is by now undoubtedly accepted the increase in output is not attributed to the capital labour ratio perse. Shifts in the production function over time have been measured by estimation methods incorporating the exogenous technical progress in to the model .

In a dynamic input output model, considering exogenous technological changes both at the input and at the out put level, the profit function can be specified by

$$\pi = \pi\{A(t)p;B(t)x\} = \text{ ———————(7)}$$

Where A (t) p and B(t) x are the output price and fixed input quantity vectors in efficiency units. The conventional measure of unexplained exogenous technical progress, time, is designated by t.

Endogenous Technology :

Although it is not a new idea that all the technological changes are not exogenous to the system, until Arrow (1962), the idea of endogenous technology has not been considered as a testable factor. The fundamental idea of Arrows (1962) study is that the acquisition of knowledge, which he had named as "learning" is the product of experience. Further improvements in productivity are obvious from the experience acquired in the production process. It is overwhelmingly important to choose the economics variable which represents that experience Accumulated gross investment has been chosen as an index by many researchers (Arrow, 1962; SimosE. 1981 a to name a few). The basic generalization of using this index is that past investment contributes to current production because of the experience that it once provided. The functional form of accumulated investment is :

$$\text{Acc } It = K_{58} + \sum_{t=1}^{2} \cdot I_t$$

Where K_{58} is the total capital stock in 1958 and the I is the gross invesment series from 58 - 78.

When the accumulated gross investment is considered as a proxy to measure the endogenous technological changes the technological function can be written as

$$E_1 = E_1 \ (\text{Acc. I}) \text{ ———— } (8)$$

Several other studies have used different proxies. According to Kaldor (1957) the proportional growth rate of capital per worker must be considered in the rate of technical progress. Thus the functional form is as follows :

$$E_2 = E_2 \ \frac{d(K/L)}{(K/L)} / dt \text{ ———— } (9)$$

Where K and L are for capital and labour.

In a later study Kaldor modified equation (9) and used the proportional growth rate of gross investments per worker.

$$\text{i.e.} \quad E_3 = E_3 \ \frac{d\ (I/L)}{(I/L)} dt \text{ ———— } (10)$$

In his study Eltis (1971) considered the proportionate growth of the share of investment in income as a form of technical change. Then the functional relationship is,

$$E_4 = E_4 \ \frac{d\ (I/y)}{(I/y)} dt \text{ ———— } (11)$$

After the recognition of the importance of real money in technological changes many studies estimated production functions with real money balances. Then the functional form is as follows :

$$E_5 = E_5 \ \frac{\left(QM_1 \right)}{P} \text{ ———— } (12)$$

Where QM_1 is the money stock narrowly defined. Chen (1976) further developed the previous idea of endogenous technological progress by considering the production of imported capital goods in total imports. Since the foreign technology plays an influential role in LDC's economic development, this proxy seems somewhat reasonable. The functional form is as follows :

$$E_6 = E_6 \ (MK/M) \text{ ———— } (13)$$

Where MK= imported capital goods.

Since the profit functions depends not only upo n exogenous technological changes but also upon endogenous technological changes, we can redefine equation (7)

$$\text{as} \quad \pi = \pi \left\{ C(E,t) \;\; p : \;\; D(E.t)x \right\} \text{———} \quad (14)$$

Where the profit functions C and D depend upon both endogenous technological change E, and exogenous technological change t.

Functional Form

After the development of the translog function in the early 1970's by Berndt and Christensen (1973), Christensen, Jorgenson and Lau (1973) this functional form has been used in several studies in estimating input-output relationship, due to its advantage over other functional forms.

Following previous works (Berndt and Christensen, 1973; Kohli, 1978; Stevenson, R, 1980; and Simos, E, 1981a) in this study three basic models of the translog variable profit function will be used according to the specifications of (6), (7) and (14). Allowing the six various variables as alternative proxies for endogenous technology, the original model 3 is, therefore further extended.

Throughout the study the fixed input vector is denoted as x, its price is denoted as w, the vector of variable quantity as y and its price as p.

Model I

$$\ln \pi = \alpha_0 + \Sigma \alpha_i \ln p_i + \Sigma \beta_j \ln x_j + \tfrac{1}{2} \Sigma\Sigma \gamma_{ih} \ln p_i \ln p_h + \Sigma\Sigma \delta_{ij} \ln p_i \ln x$$

$$+ \tfrac{1}{2} \Sigma\Sigma\Sigma \phi_{jk} \ln x_j \ln x_k \text{———} \quad (15)$$

Where $\gamma = \gamma_{hi}$ and $\phi_{jk} = \phi_{kj}$.

By definition, the variable profit function is linearly homogenous in price and thus we can write the following restrictions :

$$\Sigma \alpha_i = 1, \quad \Sigma \beta_j = 1, \quad \Sigma \gamma_{ih} = 0$$

$$\Sigma \phi_{jk} = 0, \quad \Sigma \beta_{ij} = 0, \quad \Sigma_j \delta_{ij} = 0$$

Based on eq (15) the marginal productivity conditions are

$$\frac{\partial \ln \pi}{\partial \ln Q} = \left(\frac{(\partial \pi)}{(\partial Q)}\right) \cdot \left(\frac{Q}{\pi}\right); \quad Q = P, X \qquad \text{——(16)}$$

Following Kohli (1978) via Hotelling's lemma the share equation of output i is :

$$S_i = \frac{\partial \ln \pi}{\partial \ln p_i} = p_i y_i / \pi = \alpha_i + \Sigma \gamma_{ih} \ln p_h + \Sigma \delta_{ij} \ln x_j \qquad \text{——(17)}$$

and the share equation of input j is:

$$V_j = \frac{\partial \ln \pi}{\partial \ln x_j} = w_j x_j / \pi = \beta_j + \Sigma \delta_{ij} \ln p_i + \Sigma \phi_{jk} \ln x_k \qquad \text{——(18)}$$

the linear homogeneity in prices and fixed quantities implies that

$$\Sigma S_i = 1 \quad \text{and} \quad \Sigma V_j = 1.$$

The elasticities of transformation[9] (θ) complementarity and intensity (σ) can then be estimated as follows :

$$\theta_{ih} = \frac{\gamma_{ih} + S_i S_h}{S_i S_h}, \; i \neq h \qquad \theta_{ii} = \frac{\gamma_{ii} + S_i(S_i - 1)}{S_i^2}$$

$$\sigma_{jk} = \frac{\phi_{jk} + V_j K_k}{V_j K_k}, \; j \neq h \qquad \sigma_{kk} = \frac{\phi_{kk} + V_k(V_k - 1)}{V_k^2}$$

$$\xi_{ij} = \frac{\delta_{ij} + S_i V_j}{S_i V_j}$$

Empirical Implementaion of Model 1

In this study four outputs and two inputs are employed, namely, inputs: capital (K), and labor (L), outputs : exports (X), imports (M), investments (I) and consumption (C). (In the estimation procedure the imports are considered as negative output rather than as input. This facilitates the

9. For theoretical proof see Diewert. "Application of Duality Theory," *Frontiers of Quantitative Economics*. V. II, 1974, pp. 144-145.

estimation process since import is a variable quantity while those other two inputs are fixed quantities in the short run). After imposing the restrictions mentioned above, two share equations are deleted, one from the input side and the other from the output side. (Note : The elimination of the two equations are random since the estimation techique does not depend on the particular of such elimination).

Taking the partial derivatives of equation (15) and after the deletion of the share for consumption goods and capital, for estimation purposes, we write the following equation system in estimating the parameters of

Model 1:

$$P_M Y_M/\pi = \alpha_M + \gamma_{MM}\ln(P_M/P_C) + \gamma_{MX}\ln(P_X/P_C) + \gamma_{MI}\ln(P_I/P_C) + \delta_{ML}\ln(x_L/x_K) + e_{1M}$$

$$P_X Y_X/\pi = \alpha_X + \gamma_{MX}\ln(P_M/P_C) + \gamma_{XX}\ln(P_X/P_C) + \gamma_{XI}\ln(P_I/P_C) + \delta_{XL}\ln(x_L/x_K) + e_{1X}$$

$$P_I Y_I/\pi = \alpha_I + \gamma_{MI}\ln(P_M/PC) + \gamma_{XI}\ln(P_X/P_C) + \gamma_{II}\ln(P_I/P_C) + \delta_{IL}\ln(x_L/x_K) + e_{1I}$$

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$$W_L x_L/ = \beta_L + \delta_{ML}\ln(P_M/P_C) + \delta_{XL}\ln(P_X/P_C) + \delta_{IL}\ln(P_I/P_C) + \phi_{LL}\ln(x_L/x_K) + e_{1L}$$

where the attached disturbances in each equation are the sum of possible measurement errors and stochastic error terms.

The subscripts stand for the variable outputs and the primary inputs. For simplicity, time subscripts have been omitted throughout the study.

In the second model which estimates the variable profit function (7) we redefine the variables by including the factor augmenting exogenous disembodied technological change.

Model 2

$$q_j = p_j e^{-\mu_i t}$$

$$Z_j = x_j e^{\lambda_j t} \quad \text{—(19)}$$

where p_i is the observed price of variable output while q_j is the price of the augmented by exogenous technological change output i_i x_j is the observed fixed input quantity, while Z_j is the augmented by exogenous technical chang. input quantity.

If $,u_i > 0$, exogenous technical change reousults in an outward movement of the production possibilities frontier in output space.

If $\lambda_j > 0$, exogenous technical changes results in an inward movement the production isoquant frontier in input space.

If $,u_i = ,\bar{u}$ and/or $\lambda_i = \bar{\lambda}$ implies a parallel movement in the output and/or input space of the production possibilities and/or production isoquant frontier which we have formed as Hicks neutral exogeous technical change.

The share equations of Model 2 are :

$$S_i = \alpha_i + \Sigma\delta_{ih}\ln p_h + \Sigma\delta_{ij}\ln x_j + \delta_{it}t = \frac{\partial \ln \pi}{\partial \ln p_i} = \frac{p_i y_i}{\pi} \quad \text{—(20)}$$

$$V_j = \alpha_j + \Sigma\delta_{ij}\ln p_i + \Sigma\phi_{jk}\ln x_k + \phi_{jt}t = \frac{\partial \ln \pi}{\partial \ln x_j} = \frac{w_j x_j}{\pi} \quad \text{—(21)}$$

$$\delta_{it} = -\Sigma\delta_{ih}(\mu_h - \mu_m) + \Sigma\delta_{ij}(\lambda_j - \lambda_n) \quad \text{—(22)}$$

$$\phi_{it} = -\Sigma\delta_{ij}(\mu_i - \mu_m) + \Sigma\phi_{jk}(\lambda_k - \lambda_n) \quad \text{—(23)}$$

Output $m = 1, 2, 3, 4$; Input: $n = 1, 2$

with the additional linear homogeneity restrictions :

$$\Sigma_j \delta_{it} = 0 \qquad \text{and} \quad \Sigma_j \phi_{it} = 0$$

Empirical Implementation of Model 2

After the deletion of two equations the equation system to be estimated is as follows :

$$P_M Y_M/\pi = \alpha_M + \gamma_{MM}\ln(P_M/P_C) + \gamma_{MX}\ln(P_X/P_C) + \gamma_{MI}\ln(P_I/P_C)$$

$$+ \delta_{ML}\ln(x_L/x_K) + \delta_{MT}t + e_{2M}$$

$$P_X Y_X/\pi = \alpha_X + \gamma_{MX}\ln(P_M/P_C) + \gamma_{XX}\ln(P_X/P_C) + \gamma_{XI}\ln(P_I/P_C)$$

$$+ \delta_{XL}\ln(x_L/x_K) + \delta_{XT}t + e_{2X}$$

$$P_I Y_I/\pi = \alpha_I + \gamma_{MI}\ln(P_M/P_C) + \gamma_{XI}\ln(P_X/P_C) + \gamma_{II}\ln(P_I/P_C)$$

$$+ \delta_{IL}\ln(x_L/x_K) + \delta_{IT}t + e_{2I}$$

$$W_L x_L/\pi = \beta_L + \delta_{ML}\ln(P_M/P_C) + \delta_{XL}(P_X/P_C) + \delta_{IL}\ln(P_I/P_C)$$

$$+ \phi_{LL}\ln(x_L/x_K) + \phi_{LT}t + e_{2L}$$

In Model 3 we redefine the variables introducing endogenous variable E.

Model 3

In estimating eq. (4.9) we redefine the variables as follows :

$$q_i^* = A_{oi}E^{-a_i}e^{-\mu_i t}p_i$$

$$Z_j^* = B_{oj}D^{b_j}e^{\lambda_j t}x_j \qquad \text{——————(24)}$$

where q^{i*} is the price of the augmented by both exogenous and endogenous technical change output i;Z_i^* is augmented by both technical changes in input quantities. A_{oi} and B_{oj} are the initial level of endogenous technology at output and input space respectively. a_i and b_j are the learning coefficients of outputs and inputs. E is the endogenous technological change variable measured by an index of experience. Then the equations are as follows :

$$P_M Y_M/\pi = \alpha_M + \gamma_{MM}\ln(P_M/P_C) + \gamma_{MX}\ln(P_X/P_C) + \gamma_{MI}\ln(P_I/P_C)$$
$$+ \delta_{ML}\ln(x_L/x_K) + \delta_{MT}t + \delta_{ME_1}\ln E_1 + e_{3M}$$

$$P_X Y_X/\pi = \alpha_X + \gamma_{MX}\ln(P_M/P_C) + \gamma_{XX}\ln(P_X/P_C) + \gamma_{XI}\ln(P_I/P_C)$$
$$+ \delta_{XL}\ln(x_L/x_K) + \delta_{XT}t + \delta_{XE_1}\ln E_1 + e_{3X}$$

$$P_I Y_I/\pi = \alpha_I + \gamma_{MI}\ln(P_M/P_C) + \gamma_{XI}\ln(P_X/P_C) + \gamma_{II}\ln(P_I/P_C)$$
$$+ \delta_{IL}\ln(x_L/x_K) + \delta_{IT}t + o_{IE_1}\ln E_1 + e_{3I}$$

$$W_L x_L/\pi = \beta_L + \delta_{ML}\ln(P_M/P_C) + \delta_{XL}\ln(P_X/P_C) + \delta_{IL}\ln(P_I/P_C)$$
$$+ \phi_{LL}\ln(x_L/x_K) + \phi_{LT}t + \phi_{LE_1}\ln E_1 + e_{3L}$$

The share equations can be written as follows :

$$S_i = \alpha_{oi} + \Sigma\gamma_{ih}\ln p_n + \Sigma\delta_{ij}\ln x_i + \delta_{it}t + \delta_{iE}\ln E \quad \text{——} \quad (25)$$

$$Vj = \beta_{oj} + \Sigma\delta_{ij}\ln p_i + \Sigma\phi_{jk}\ln x_j + \phi_{jt}t + \phi_{jE}\ln E \quad \text{——} \quad (26)$$

where δit and $_{\Phi}$jt are the same as in Model 2.

$$\delta_{iE} = -\Sigma\gamma_{ih}(h-m) + \Sigma\delta_{ij}(b_j-b_n) \qquad \text{——————} (27)$$

$$\phi_{jE} = -\Sigma\delta_{ij}(i-m) + \Sigma\phi_{jk}(b_k-b_n) \qquad \text{——————} (28)$$

$$\alpha_{oi} = \alpha_i - \ln A_{oi} \qquad \text{——————} (29)$$

$$\beta_{oj} = \beta_j - \ln B_{oj} \qquad \text{——————} (30)$$

If $a_i > 0$ endogenous technical changes moves the production possibilities frontier outwards in output space.

If $b_j > 0$ endogenous technical changes produce an inward shift of the production isoquant frontier in the input space.

If $a_i = \bar{a}$ and/or $b_j = \bar{b}$, endogenous technical change produces parallel movement of the production possibilities and/or production isoquant frontiers, i.e., all output and input benefit equally from the technological advancements

If $a_i \gtrless \bar{a}$, and/or $b_j \gtrless \bar{b}$ endogenous technical change is output and/or input biased.

Empirical Implementation of Model 3

Models 4,5,6,7, and 8 are variants of model 3 and replace E_1 with E_2 E_3, E_4, E_5, and E_6 respectively. Where in :

E_1 is accumulated investments.

E_2 is proportional growth rate of capital per worker.

E_3 is proportional growth rate of gross investment per worker.

E_4 is Proportion growth rate of the share investment in income.

E_5 is real money.

E_6 is proportion of imported investment goods in total imports. For convenience those six models were named as follows :

$^3(t+E_1)$, $^4(t+E_2)$, $^5(t+E_3)$,, $^6(t+E_4)$, $^7(t+E_5)$, and $^8(t+E_6)$, where t is for time.

Another 6 models are introduced here in order to be more general in selecting the best satisfactory model of Sri Lankan economy. These 6 models only allow for endogenous technology. For the convenience of identification these 6 models are described below in terms of the technology allowed in each model.

Model	Technology
$9E_1$	E_1
$10E_2$	E_2
$11E_3$	E_3
$12E_4$	E_4
$13E_5$	E_5
$14E_6$	E_6

Following the same procedure as in (14) and (24) but omitting the exogenous technology variable (t) only, we redefine the Models 9-14. Thus the model specification is :

$$q^{**} = A_{oi}E^{-ai}p_i$$

$$z^{**} = B_{oj}E^{bj}x_j \qquad \text{——————} (31)$$

where all the notations stand for the same meanings as in (24) and δ_{iE} and Φ_{jE} in the share equations are the same as in Models 3-8.

Purpose of New Variables

The aim of adding new variables is not only to enhance the profit function but also to discover whether "a priori" restrictions will help in explaining the observed data. If those restrictions do not help in explaining the observed data then it is clear that unrestricted estimates will do well in explaining data. Thus the main objective here is to estimate our parameters, subject to restrictions and to test the validity of the restrictions.[10]

In this case of adding variables, Model 1 is different from Model 2 since Model 1 is restricted in terms of exogenous technology. As there are 4 equations, namely, (i) exports, (ii) imports, (iii) investments, and (iv) labour in this estimating system, Model 1 has 4 restrictions.

Model 1 is different from Model $^{9}E_1$ - $^{14}E_6$ since Model 1 in this case is restricted in terms of endogenous technology. Once again there are 4 restrictions in the first model compared to the Models $^{9}E_1$ - $^{14}E_6$.

10 Desai Megnad. *Applied Econometrics*. New York: McGraw-Hill Co., 1976, pp. 61-65.

Model 1 is different from Model $^{3}(t+E_1)$ - $^{8}(t+E_6)$ since Model 1 does not allow for both endogenous and exogenous technology while Models $^{3}(t+E_1)$ - $^{8}(t+E_6)$ allow for both these technologies. In this case the imposed restrictions are higher than the earlier cases. Thus, there are 8 restrictions.

Also Model 2 is different from Models $^{3}(t+E_1)$ - $^{8}(t+E_6)$ since these models allow for endogenous plus exogenous technologies while Model 2 allows for exogenous technology. Thus there are 4 restrictions imposed on Model; compared to Models $^{3}(t+E_1)$ - $^{8}(t+E_6)$ separately.

In finding the best satisfying model this study has followed the following 4 steps :

Step 1: Under the rationale that the higher the maximum value of the likelihood function, the higher the goodness of fit of the equations, the models which have low maximum value of likelihood funtions are dropped. However, the selection of a low value is arbitrary from any viewpoint. Therefore, to be somewhat reasonoble this study has used the following method : Any models which have higher maximum value of the likelihood function than the average of the lowest and highest values are selected. All the other models are dropped. Under this criteria the Models $^{3}(t+E_1)$, $^{6}(t+E_4)$, $^{8}(t+E_6)$, and 12 (E_4) are selected (see Table 2).

Step 2: The second criteria of finding the best satisfying model among those selected was the test statistics. Here a likelihood ratio test is used (see Desai, M, 1976, p. 65; Simos, E., 1981b, p. 217). The likelihood ratio (λ) is the maximum value of the likelihood function for the constrained case divided by the maximum value of the likelihood function for the unconstrained case.

"For larger sample cases we have a theorem which says that-2 $\ln\lambda$ is distributed as x^2 with as many degrees of freedom as the number of restrictions. This is extremely helpful because we can compute x^2 corresponding to the computed λ and compare it to some pre-assigned critical level of x^2 (Eg., for the 05 region) as in the t-test, and if the computed x^2 is less than the critical value then we say that our restrictions are not rejected by the data.[11]

If there is a greater fall in the likelihood value of the restricted function when compared with the unconstrained case, the implication is that the restrictions are not valid. In this case-2 $\ln\lambda$ exceeds the critical value of x^2 which is consistent with the number of restriction imposed.

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11 Desai Megnad. *Ibid.*, p. 64.

Here our unrestricted models, which were selected from Step 1 are Models $^{3}(t+E_1)$, $^{5}(t+E_3)$, $^{6}(t+E_4)$, $^{8}(t+E_6)$, and the consistent restricted models are Models $^{9}E_1$, $^{11}E_3$, $^{12}E_4$, $^{14}E_6$, and 2. At 95% level of confidence in the four restriction cases the critical value of x^2 is 9.5 Except in Model $^{11}E_3$, which is restricted in terms of exogenous technology compared to Model $^{5}(t+E_3)$ all the other cases proved the restrictions to be invalid (see Table 8.) However, when Model $^{5}(t+E_3)$ is compared with Model 2 which is restricted in this case in terms of endogenous technology, it appeared that the Model $^{5}(t+E_3)$ is valid. Thus Models $^{3}(t+E_1)$, $^{5}(t+E_3)$, $^{6}(t+E_4)$ and $^{8}(t+E_6)$ which are unrestsicted are used again in the third step.

Step 3: The third criteria used to choose a best satisfying model was to check whether the parameter estimates of the endogenous technology and the exogenous technology in each equation in each model are significant or not (see Table 5) Here I have compared statistics of the parameter estimates of exogenous technology, t, and endogenous technology E in each model. The Models $^{5}(t+E_3)$ and $^{6}(t+E_4)$ are dropped out in the third step, since they had the lowest amount of signficant parameter estimates compared to the other 2 models.

Step 4: In finding the best satisfying model among Models $^{3}(t+E_1)$ and $^{8}(t+E_6)$ the following criteria were used. Expected signs of the price elasticities of demand and the price elasticity of supply in Models $^{3}(t+E_1)$ and $^{8}(t+E_6)$ as well as the substitutability of capital to labor in those models were checked. Model $^{3}(t+E_1)$ gives all the correct signs one could expect under normal circumstances, except in price elasticity of the supply of consumption (see Table 6). But the price elasticity of the supply of consumption has shown, when tested by the t-statistics, that the incorrect sign is insignificant.

Thus Model $^{3}(t+E_1)$ has been selected as the best satisfying model for the Sri Lankan economy.

It is interesting enough to show that when one uses the following two methods in finding the best model, Model $^{3}(t+E_1)$ again is the best and Model $^{8}(t+E_6)$ is the second best model.

Instead of taking the above mentioned four steps I have tested each restriction using the λ - ratio in the following manner.

Method I : Model 1 is tested with Model 2 at 95% level of confidence. Model 1 restrictions here appeared to be invalid. Then Model 2 is tested with Models $^{3}(t+E_1)$, $^{8}(t+E_6)$ separately. In this case Model 2 is restricted in terms of endogenous technology. There are four restrictions and at 95% level of confidence unrestricted Models $^{3}(t+E_1)$, $^{5}(t+E_3)$, $^{6}(t+E_4)$, $^{7}(t+E_5)$, $^{8}(t+E_6)$ appeared to be "doing well". Then these models are checked using economic criteria, ie., the expected signs of the price elasticities mentioned above. Then Model $^{3}(t+E_1)$ became the best and Model $^{8}(t-+B_6)$ became the second best.

Method II : Instead of adding exogenous technology first, in this case endogenous technology has been added first and the restrictions tested. Thus Model 1 is tested with Models $^{9}E_1$ - $^{14}E_6$ separately. In this case Model 1 is restricted in terms of endogenous technology and there are four restrictions. At 95% confidence level the unrestricted Models $^{9}E_1$, $^{10}E_2$, $^{11}E_3$, $^{12}E_4$, $^{14}E_6$ appeared to be "doing well". Then those models were tested again with relevant unrestricted (in terms of exogenous technology) models, namely $^{3}(t+E_1)$, $^{4}(t+E_2)$, $^{5}(t+E_3)$, $^{6}(t+E_4)$ and $^{8}(t+E_6)$ At 95% confidecence level with four restrictions Models $^{3}(t+E_1)$, $^{4}(t+E_2)$, $^{5}(t+E_4)$, and $^{8}(t+E_6)$ appeared to be "doing well". Then using the above mentioned economic criteria the signs were checked and the Model $^{3}(t+E_1)$ became the best model.

SECTION FOUR

EMPERICAL RESULTS

Data Dsecription :

For details of the data see Hettihewa S. (1982) and Hettihewa S. (1984)

Matrix of Elasticity

Following Kohli (1978) the structure of the technology by computing the output price and input quantity matrix of elasticities can be examined :

$$\begin{bmatrix} E_{pp} & E_{px} \\ E_{xp} & E_{xx} \end{bmatrix} = \begin{bmatrix} \delta \ln y_i / \delta \ln p_n & \delta \ln y_i / \delta \ln x_k \\ \delta \ln w_j / \delta \ln p_n & \delta \ln w_j / \delta \ln x_k \end{bmatrix}$$

where the submatrix E_{pp} indicates the own and cross price elasticities of the output supply functions, while E_{xx} indicates the own and cross inverse price elasticities of input demand. The other submatrix contain the elasticities between inputs and outputs.

Empirical Results

Table 1 presents the parameter estimation for Model $^3(t+E_1)$. Table 2 depicts the input demand cross and own price elasticities and output demand supply cross and own price elasticities for selected years 1958 - 78, in the Sri Lankan economy.

Table 1 :

Parameters Estimates of the Translog profit Function Model $^3(t+E_1)$ (t-statistics are in the parantheses).

αM	11.78 (2.10)
αX	-4.03 (-1.85)
αI	-3.95 (-1.10)
βBL	-8.94 (-3.49)
γMM	-0.02 (-0.22)
γMX	-0.03 (-0.81)
γMI	-0.05 (-0.90)
γXX	-0.19 (6.95)
γXI	-0.07 (-2.08)

γII	0.16 (2.68)
δML	-0.01 (-0.33)
δXL	0.02 (0.98)
δIL	-0.80 (-2.38)
δMT	0.05 (2.51)
δXT	-0.02 (-2.46)
δXI	0.01 (-0.72)
δME_1	-1.21 (-2.16)
δXE_1	0.43 (1.98)
δIE_1	0.40 (1.11)
ΦLL	0.02 (0.57)
ΦLT	-0.04 (-3.34)
ΦLE_1	0.94 (3.65)

Table 2 :

Price Elasticities of Demand and price Elasticities of Supply for Selected Years 1958-1978, Aggregate Sri Lankan Economy (model 3 ($t+E_1$.)

Elasticity	1958	1962	1966	1970	1974	1978
ϵMM	−1.16	−1.14	−1·09	−1.13	−1.17	−1.28
ϵMX	0.43	0.41	0.41	0.35	0.36	0.46
ϵMI	0.30	0.32	0.36	0.37	0.31	0.28
ϵMC	0.43	0.41	0.32	0.41	0.50	0.54
ϵXM	−.34	−0.34	−0.31	−0.36	−0.38	−0.43
ϵXX	−.04	−0.01	0.05	0.14	0.07	−0.09
ϵXI	−.12	0.15	−0.17	−0.17	−0.17	−0.05
ϵXC	0.51	0.49	0.44	0.40	0.47	0.57
ϵIM	−.74	−0.73	−0.66	−0.56	−0.67	−0.71
ϵIX	−.38	−0.42	−0.41	−0.26	−0.36	−0.14
ϵII	0.68	0.70	0.62	0.24	0.48	0.32
ϵIC	0.44	0.44	0.46	0.59	0.55	0.54
ϵCM	−.13	−0.11	−0.07	−0.11	−0.14	−0.22
ϵCX	0.19	0.17	0.13	0.10	0.13	0.25
ϵCI	0.05	0.05	0.06	0.10	0.07	0.08
ϵCC	−.11	−0.10	−0.11	−0.09	−0.06	−0.11
ϵLL	−.48	−0.49	−0.53	−0.51	−0.49	−0.49
ηKK	−0.52	−0.50	−0.46	−0.48	−0.51	−0.51
ηKL	0.52	0.50	0.46	0.48	0.51	0.51
ηLK	0.48	0.49	0.53	0.51	0.49	0.49
§ML	0.52	0.51	0.47	0.49	0.51	0.50

Contd. **Table 2**

Elasticity	1958	1962	1966	1970	1974	1978
$_{E}$MK	0.48	0.49	0.53	0.51	0.49	0.50
$_{E}$XL	0.54	0.54	0.50	0.53	0.55	0.53
$_{E}$XK	0.46	0.46	0.50	0.47	0.45	0.47
$_{E}$IL	-0.31	-0.34	-0.33	-0.10	-0.21	-0.12
$_{E}$IK	1.30	1.33	1.33	1.10	1.20	1.12
$_{E}$CL	0.56	0.55	0.51	0.52	0.55	0.55
$_{E}$CK	0.44	0.45	0.49	0.48	0.45	0.45
$_{E}$LM	-0.27	-0.25	-0.22	-0.25	-0.27	-0.37
$_{E}$LX	0.35	0.33	0.30	0.26	0.28	0.41
$_{E}$LI	-0.05	-0.05	-0.06	-0.03	-0.04	-0.03
$_{E}$LC	0.98	0.99	1.00	1.01	1.04	0.98
$_{E}$KM	-0.23	-0.21	-0.18	-0.21	-0.23	-0.33
$_{E}$KX	0.23	0.25	0.22	0.18	0.20	0.34
$_{E}$KI	0.25	0.25	0.24	0.29	0.27	0.29
$_{E}$KC	0.70	0.71	0.71	0.73	0.76	0.70

Table 3 :

Elasticities of Transformation, Complementarity and Intensity for Selected Years 1958 - 78, Aggregat. Sri Lankan Economy [model $^{3}(t+E_1)$]

	1958	1962	1966	1970	1974	1978
$_{\Theta}$MM	1.40	1.46	1.61	1.61	1.49	1.25
$_{\Theta}$MX	4.73	4.96	5.60	5.06	4.64	3.72
$_{\Theta}$MI	3.00	3.17	3.43	2.52	2.69	2.07
$_{\Theta}$MC	0.51	0.49	0.39	0.48	0.56	0.65
$_{\Theta}$XX	-0.14	-0.04	0.18	0.63	0.30	-0.24
$_{\Theta}$XI	-1.24	-1.46	-1.63	-1.19	-1.48	-0.38
$_{\Theta}$XC	0.61	0.58	0.53	0.46	0.54	0.68
$_{\Theta}$II	6.66	7.04	5.86	1.62	4.14	2.36
$_{\Theta}$IC	0.29	0.33	0.47	0.52	0.38	0.41
$_{\Theta}$CC	-0.14	-0.13	-0.14	-0.11	-0.07	-0.14
$_{\alpha}$LL	-1.01	-1.05	-1.24	-1.16	-1.03	-1.03
$_{\alpha}$KL	1.08	1.08	1.08	1.08	1.08	1.08
$_{\alpha}$KK	-0.99	-0.94	-0.80	-0.86	-0.96	-0.96
$_{\xi}$ML	1.08	1.09	1.12	1.10	1.08	1.06
$_{\xi}$MK	-0.92	0.92	0.91	0.92	0.92	0.94
$_{\xi}$XL	1.13	1.15	1.19	1.21	1.18	1.11
$_{\xi}$XK	0.87	0.87	0.86	0.83	0.84	0.90
$_{\xi}$IL	-0.65	-0.72	-0.78	-0.23	-0.46	-0.25
$_{\xi}$IK	2.51	2.50	2.31	1.98	2.29	2.12
$_{\xi}$CL	1.93	1.99	2.17	2.13	2.07	1.95
$_{\xi}$CK	0.84	0.84	0.85	0.85	0.85	0.84

Table 4 Exogenous and Endogenous Technological Change : Sri Lankan Economy 1958 - 78.

Differential Growth Rates of Exogenous Technological Change	*Differential Learning Elasticities of Endogenous Technological Change*
$(\mu_M - \mu_C) = -3.55$	$(a_M - a_C) = 143.06$
$(\mu_X - \mu_C) = .57$	$(a_X - a_C) = 22.94$
$(\mu_I - \mu_C) = .99$	$(a_I - a_C) = -53.07$
$(\lambda_L - \lambda_K) = -5.31$	$(b_L - b_K) = 210.6$

NOTE : The growth rates of exogenous technolgical changes are obtained by solving the simultaneous equation system in equation (22) and (23) using the Model $^3(t+E_1)$ estimated coefficients. The differential learning elasticities are obtained by solving the simultaneous equation system in equation (29) and (30).

Table 5 : T Statistics of Parameters

Model	δMT	δXT	δIT	ΦLT	δME	δXE	δIE	ΦLE
mdl $^3(t+E_1)$	2.51	-2.46	.72	-3.3	-2.1	2.0	1.11	3.6
mdl $^5(t+E_3)$	1.76	-1.98	.45	1.40	.51	2.39	-9.02	2.23
mdl $^6(t+E_4)$	2.3	3.3	.03	1.1	.08	1.80	-7.30	0.60
mdl $^8(t+E_6)$	3.2	-4.1	3.0	.43	-4.40	4.10	2.30	1.10

Table 6 Price Elasticities of Demand. Price Elasticities of Supply, and elasticity of substitution between capital and labor.

Model Elasticity	Model 3	Model 8
ϵXX	.10	-.03
ϵMM	-1.12	-.65
ϵII	.14	-.05
ϵCC	-.03	-.01
σKL	1.08	.81

Where :

ϵXX = Price elasticity of export supply
ϵMM = Price elasticity of import demand
ϵII = Price elasticity of investment supply
ϵCC = Price elasticity of consumption supply
σKL = Elasticity of substitution between capital and labor

Table 7 Log of Likelihood Function

Model	Log of Likelihood Function
1	213.9
2	219.8
$^{3}(t+E_1)$	227.1
$^{4}(t+E_2)$	220.9
$^{5}(t+E_3)$	238.6
$^{6}(t+E_4)$	240.2
$^{7}(t+E_5)$	226.5
$^{8}(t+E_6)$	229.5
$^{9}E_1$	220.1
$^{10}E_2$	214.5
$^{11}E_3$	235.5
$^{12}E_4$	234.8
$^{13}E_5$	214.1
$^{14}E_6$	222.1

Table 8 : Test Statistics

H_0	H_1	x^2 95%	x^2 99%	Restric-tions	Test Stat:	Conclusion Accepted
mdl $^3(t+E_1) = {}^9E_1$	$^3(t+E_1) \pm {}^9E_1$	9.5	13.3	4	14	H_1
mdl $^5(t+E_3) = {}^{11}E_3$	$^5(t+B_3) \pm {}^{11}E_3$	9.5	13.3	4	6	H_0
mdl $^6(t+E_4) = {}^{12}E_4$	$^6(t+E_4) \pm {}^{12}E_4$	9.5	13.3	4	10	H_1
mdl $^8(t+E_6) = {}^{14}E_6$	$^8(t+E_6) \pm {}^{14}E_6$	9.5	13.3	4	14	H_1
$^3(t+E_1) = {}^2$	$^3(t+E_1) \pm {}^2$	9.5	13.3	4	20	H_1
$^5(t+E_3) = {}^2$	$^5(t+E_3) \pm {}^2$	9.5	13.3	4	38	H_1
$^6(t+E_4) = {}^2$	$^6(t+E_4) \pm {}^2$	9.5	13.3	4	40	H_1
$^8(t+E_6) = {}^2$	$^8(t+E_6) \pm {}^2$	9.5	13.3	4	18	H_1

Note mdl = model

SECTION FIVE

POLICY IMPLICATION AND CONCLUSION

Effects of World And Internal Events :

World Events And Effects :

This study shows that export supply is price inelastic in the short run The importance of these findings for policy decisions is as follows :

I. During a peiiod of high world prices for exports the economy cannot get the full benefit.

II. During a period of low prices, the economy cannot compensate for the loss by decreasing supply.

Some earlier studies, using different estimation techniques, have found similar elasticities of export goods (Rasaputram, W. 1964) In Rasaputram's study one of the recommendations was to establish buffer stocks. Looking at the recent past it appeared that a policy of maintaining a a buffer stock has not proven to be a successful answer. When some products have long lasting low prices (tea) the question is not just how to establish buffer stocks but how to build long lasting buffer stocks.

Since the existing export supply is price inelastic, bilateral agreements appear to be one way to follow world prices (eg. Rice - Rubber pact between China and Sri Lanka). Such an agreement can be beneficial for both parties, but when they involve an exchange of agricultural products (Sri Lanka's main exports) for manufactured products the use of bilateral agreement appears to be of limited value because of the unequal price.

Certainly joint action can provide market power that a small country like Sri Lanka will not have alone. Therefore, cartel agreements appear to be a possible answer. However, because Sri Lanka's products are not highly essential items in a consumer's budget, the value of the cartel approach for Sri Lanka's basic export crops is limited.

Since the export supply is price inelastic and the majority of export come from three major crops, any answer based on price incentives are questionable. Devaluation (which has been imposed as a tool for BOP problems) may not give expected results. Encouragement of non-traditional exports, such as gems, tourism, fishing and manufactured goods. which are by nature price elastic in supply, seem desirable for the future

Some other important information revealed by the results are :

(*a*) Exports are import intensive.

(*b*) An increase in the world price of exports has a relatively larger influence on the labor share of income than the capital share.

(*c*) The cross price elasticity between exports and consumption shows that an increase in the price of exports would result in a higher consumption supply.

(*d*) Any higher price incentives for export supply such as those from a devaluation may not give the expected results because the supply of exports is price inelastic and also because higher export prices would increase the demand for imports. (For details about the role of elasticities in a devaluation see Rothwell, K., 1967, p. 299). The long-run effects of a devaluation will not be discussed here since this study deals with short - run effects.

(*e*) There is support for the notion that it is desirable to turn to additional non-traditional exports, which are commonly assumed to be price elastic in supply. It is possible to increase the export supply and to compensate for the negative effects of import expansions which derive from high export prices.

(*f*) Since labor gets relatively higher portions of the total income from any increase in exports, a non-traditional export policy would benefit the economy which is labor abundant. Although cross elasticity between the export and consumption goods is positive, when the negative cross price elasticity between export and investment is considered, the overall result contributes little towards increasing GNP.

(*g*) In an overall sense, a policy of rupee devaluation would not be a desirable policy in view of the own price elasticity of exports and cross price elasticity of export and consumption, and that of exports and investments.

(*h*) The own price elasticity of imports is negative. The importance of this for making policy decisions is :

(*i*) A heavy tax on imports would decrease non - essential imports. This could be a useful step.

(*ii*) However, a general tool to control demand for imports may not be a successful tool since it reduces the import demand for essential imports, such as machinery spare parts and raw materials which are not locally produced. Thus a devaluation of the exchange rate may not be a desirable answer.

A careful analysis of the date reveals that more than 50% of the import goods are food. Thus, a reduced volume of imports will further enhance demand for domestic goods. If these demands are for essential goods, the inflationary condition inside the country will grow worse unless locally produced substitutions are increased. Therefore, before any further devaluation, an emphasis on increasing the domestic supply of essential food items would make the results less questionable.

(*i*) The cross price elasticity of exports and imports is such that an increase of world price of imports will reduce the export supply. Also, any percentage increase in import prices will reduce the ivestment and consumption supply. This can explain the fact that investment and consumption goods industries are partly dependent on imported material. Although an increase in import price reduces the import demand, this would not be successful in terms of GNP, since the overall supply would be adversely affected.

(*j*) Cross elasticities between imports and labor share and imports and capital share show that an increase in imports will reduce the labor share sharply in relative terms.

Internal Events and Effects

(*a*) The empirical results reveal that the consumption supply is price inelastic. The importance of this for policy decision making is that price incentives to increase the domestic supply of consumption would not give the expected results. Looking at the cross elasticity between consumption and imports and between consumption and exports reveals that an increase in the price of consumption goods will have only a small desirable impact on the BOP, (i.e. the increase in import demand would be compensated for only slightly by the increase in export supply).

(*b*) The cross elasticity between consumption and investment indicates that an increase in the price of consumption goods increases the investment supply. In an overall sense, although consumption supply is price inelastic, an increase in the price of consumption goods will cause the demand for imports to increase but this will be largely offset by an increase in investment and export supplies. Also, an increase in the price of consumption goods gives rise to a greater share to labor than to capital. Thus any consumption price incentive would yield positive results for the economy although the consumption sector itself would not be increased. Other incentives (eg. subsidized fertilizer schemes, irrigation facilities to name a few), along with higher priced consumption goods, may generate an increased supply inside the economy. But, the question of consumption goods distribution has to be examined simultaneously since an increased supply of consumption goods would require some time to occur.

(*c*) The price inelasticity of investment indicates that an increase in the price of investment goods would not change the supply. It thus appears that price incentives are not a suitable answer for the investment sector. When one considers the cross elasticities overall beetween investment and imports and that of investment and the export the BOP effect is undesirable. Also the investments are import intensive, which may be due to the fact that part of the investment goods are directly imported goods. This combined with the finding that labour intensive investment goods are not heavily dependent on imported goods may provide an answer for BOP problems as well as providing a possible increase to the GNP.

(*d*) According to the differential growth rates of exogenous technological change, such change is capital saving. According to differential learning elasticities, it also apperas that endogenous technological changes are labor saving. Since the cross elasticities between exports and labor share reveal that exports are labor intensive, the nature of differential elasticities becomes important for policy making. The increase in the export sector investment would increase the labor productivity through experience.

Implications of the Results :

Past experience and this study's results provide support for a policy of restricted imports. Generally, arguments in favor of liberalized imports emphasized international competition which tends to encourage improvement of the quality of locally produced goods. However, it has also been said that unrestricted imports are harmful because small scale domestic industries which are in their infancy stage would be badly damaged.[12] Selective import restrictions appear to be a policy that can balance both arguments. According to past experience selected taxes and controls would be desirable to again maximum utilization of limited foreign exchange reserves. In this way, small scale products which can be easily produced at home will be protected from international competition. The importation of essentials which cannot be produced locally, should be encouraged. But this cannot be fully discussed here since this model does not deal with different groups of imports,

Since Sri Lanka is a labor abundant country and the increase in investment would increase the labor productivity through "experience", more investments in industries provide optimistic outcomes. A more balanced inward and outward looking policy with a labor intensive technology founded on basic, local, producible raw materials will benefit the country in the future. The results support endogenous technological changes.

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12 N. Balakrishnan, "Economic Policies and Trade in Sri Lanka" *Asian Survey* - V. 20 No: 9, 1980, p. 894.

A general devaluation policy would be blurred by the effects of price inelasticity on export supply. It might be wise to consider nontraditional goods which are supply elastic in nature. This also cannot be elaborated here since the model does not deal with different nontraditional exports separately. A cartel of world supplies may be a possible answer. The success of a policy of price control or decontrol would depend on the supply price elasticity in each sector. Since the investment sector is price inelastic in supply a decontrol price would not benefit the economy through high price incentives. Since investments are price inelastic in supply any increase in prices and any encouragement of open market price mechanisms would not benefit the economy. Therefore, encouragement of foreign capital participation which is aimed at increasing export supply without undesirable foreign ties, would beneficial, and foreign investments will be encouraged by the possibility of low costs.

The consumption sector is, by itself, inelastic according to the empirical results. Thus, incentives through higher prices would not be a possible answer. In general, government spending which is not just aimed at satisfying political interests *per se* but aimed at increasing other consumption. investment, and export supply would probably benefit the economy. Such government expenditures should now be possible because today the political leaders have come to understand the negative effects of policies adopted in order to satisfy the political interests, (Oct. 21, 1981, *The Times*, London, p. 15). Such a policy would be reinforced by the fact that consumption investment and export goods are price inelastic in supply which requires other incentives to increase the supply beyond the use of price incentives,

Concluding Remarks

This study has undertaken an empirical analysis of factor substitution input-output relationships, exogenous and endogenous (taking experience as a proxy) technological change in the Sri Lankan domestic economy for the period of 1958-78, utilizing a multi-output, two input variable profit function. The available data has yielded detailed information about input and output sectors as well as about productivity attributed to exogenous and endogenous technology.

Compared with previous models this model provided a method for more accuratel forecasting the impact of policy decisions aimed at stimulating the economic growth of Sri Lanka.

This study has yielded the following results which are of critical importance for policy decisions :

(1) The factor augmenting technical progress was biased. Also, at the output level, technical progress has been biased. This implies that differential output and input productivity depends not only upon the mere passage of time (as conventionally assumed) but simultaneously on differential output and input learning. In other words the results of Model $^{3}(t+E_1)$ indicates that the output and input productivity is attributed to endogenous technology as well as to exogenous technology.

(2) Consumption, investment, and export supplies appeared to be price inelastic.

(3) Consumption goods have been found to be import intensive.

(4) Capital and labor are highly substitutable with each other.

In addition the study :

(*i*) provided a capital stock data base that will be highly useful for future research; and

(*ii*) developed a model of the economy that reflects the interrelationship of inputs and outputs. The consideration of exogenous technological changes in this model filled the gap present in previous models. Consequently, the model provided improved insights into the economy

Table 9 : The Levels and the Growth Rates of Selected Economic Indicators from 1950-1978 in Sri Lanka

Economic Indicator		The Levels			The Growth Rates*1		
		1950	1964	1978	1950-64	1964-78	1950-78
1) Population (in millions)		7.68	10.90	14.18	2.5%	1.0%	2.0%
(2) G. D. P. (in million Rs. at 1963 prices)	*3	3545	7751.2	15825	5.0%	5.0%	5.0%
(3) G. N. P. (in million Rs. at 1963 prices)	*3	3499	7717	14300	5.6%	4.0%	5.0%
(4) PCI (in million Rs. at 1963 prices)	*3	456	708	1008	3.14%	2.52%	2.83%
(5) Total Consumption (in million Rs. at 1963 prices)	*3	2918	6732	13408	5.9%	4.9%	5.0%
(6) Imports (in million Rs. at 1963 prices)	*2	1357	1593	75143	1.0%	2.7%	1.4%
(7) Exports (in million Rs. at 1963 prices)	*2	1408	1910	24043	2.0%	18%	10%
(8) External public Debt, (in million Rs.)		75.7	373.5	14582.3	11.4%	26.2%	18.8%

Sources : Item No. 1- No. 7 :
1950, 1964 data was taken from *International Financial Statistics*, International Monetary Fund 1972 (Washington D. C.) pp. 234-237.

Item No. 8 :
Data was taken from Central Bank of Ceylon *Annual Report*, 1978, Table 12.

Notes to Table 9

*1. In finding the growth rates the following formula is used :

$$Y_t = Y_O e^{rt}$$

*2. Using import price index and export price index the current market prices of imports and exports were converted to 1963 prices.

*3. Using GNP price deflator, the current market prices were converted into 1963 prices.

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