INTEGRATING INPUT-OUTPUT AND KEYNESIAN MODELS: A CASE STUDY OF MALTA

by

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ABSTRACT

This thesis suggests one way in which a time series of input-output tables can be utilised to provide a supply dimension for a traditional Keynesian macro model. Using data for the Maltese economy for the period 1961-77, input-output tables are used to estimate for each sector a generalized Leontief cost function to permit input substitution. The empirical result that most of the relative price variables in the input demand functions are significant along with a marked improvement in forecasting ability, suggests that this modification of the traditional Leontief specification of the production function is worthwhile.

This supply dimension of the economy is linked to the demand side through a simultaneous interaction with sectoral consumption functions, allowing examination of policy questions not capable of being addressed by a traditional Keynesian demand model. The empirical results of this analysis are then used to examine some of these policy questions in the context of the Maltese economy.

DEDICATION

TO

RITA and HEIDI

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CHAPTER I

INTRODUCTION

> The two major developments in modelling an economy have been the construction of aggregative econometric models and the construction of input-output models .... The question becomes one of whether we should concentrate on a detailed analysis of final demand or of intermediate demand, or of whether we ought to try to build a more general system encompassing both the traditional econometric model and the input-output model. (Klein 1968, p. 565)

This quotation is taken from Klein's 1968 article entitled "What Kind of Macroeconometric Model for Developing Economies?" In answer to this question, Klein suggests that a model integrating input-output with Keynesian models would be most suitable. By 1978, Klein suggests that even for industrial countries the same approach should be followed.

> Yet the economic problems of today seem to be intractable when studied through the medium of simplified macro models. The new system should combine the Keynesian model of final demand and income determination with the Leontief model of interindustrial flows. (Klein 1978, p. 1)

The object of this thesis is to construct a macro model of the Maltese economy, integrating both the input-output (I-O) and Keynesian final demand models. One special characteristic of the Maltese case is the availability of 17 annual I-O tables (1961-1977). This feature provides a study which is of interest not only as a case study of Malta, but also from a wider perspective. In particular, two questions are tackled: (a) How useful is a time series of I-O tables? (b) How to combine a time series of I-O tables with a traditional final demand model?

Since this thesis is a case study of Malta, chapter II examines Metwally's (1977) model of the Maltese economy. This chapter provides not only a critical assessment of Metwally's model and results, but also identifies some questions which an alternative model should be able to address,as for example whether exports or tourism should be encouraged to expand. This type of question suggests that a disaggregated model would be more suitable than a highly aggregated model such as that of Metwally.

The third chapter is concerned mainly with question (a) above, that is with how useful a time series of I-O tables is. In the I-O literature, the major study on the usefulness of a time series of I-O tables is the work by Tilanus (1966). Since Tilanus answers this question negatively, his study is examined at some length. It is found that Tilanus' study suffers from various estimation problems. Furthermore, the specification used by Tilanus, namely linear trends in the technical coefficients, leaves much to be desired. Tilanus does not explore the possibility of relaxing some of the traditional assumptions in the I-O model, as for example the assumption that inputs are demanded in fixed proportions to output.

This issue is taken up in chapter IV where the Leontief production function is substituted by the generalized Leontief cost function, and cost-minimizing input demand functions derived. These derived input demand functions allow for factor substitution, and moreover reduce to the Leontief specification for the case of no factor substitution. Thus, this extension of the I-O model provides a generalization of the traditional I-O model and represents the supply side of the economy. The demand side of the economy is captured by setting up sectoral consumption functions. Finally, this chapter also provides a comparison between the approach suggested here and the conventional approach of linking I-O with final demand models.

Chapter V presents the regression results from estimating the complete model, identified as the generalized I-O macro model, which has 122 equations. The estimation technique used is two stage least squares with principal components in the first stage and correcting for autocorrelation. The finding that 56% of the input demand functions have a relative price variable which is significant indicates the importance of relative prices and suggests that in general, the Leontief specification is rejected in favour of the generalized Leontief form used in this study. In this chapter, ex-post forecasts for 1977 are also presented both for the I-O model and the generalized I-O macro model. Contrary to Tilanus' results, it is found that ex-post forecasts for 1977 utilising the time-series of I-O tables are superior to those of the traditional I-O model using the I-O table for 1976.

Finally, chapter VI examines some policy implications of the generalized I-O macro model. One major finding in this chapter is that the import multipliers of all sectors with respect to exports are all less than one. This result contrasts quite sharply with Metwally's (1977) result that the import multipliers with respect to exports and tourism are both greater than one. A second important result is the finding that import and employment multipliers by sector, with respect to exports, tend to be positively correlated. This result has important policy implications and is consequently examined at some length. Lastly, the multipliers derived from the model are used to analyse the effect of changes in fiscal policy.

CHAPTER II

AN ASSESSMENT OF ECONOMETRIC MODELS OF THE MALTESE ECONOMY

Introduction

There are two main econometric studies of the Maltese economy. The first was conducted by Waldorf (1969) during his stay in Malta as a U.N. adviser. The second was conducted by Metwally (1977), a visiting professor of economics at the University of Malta, for the academic year 1976-77. Since both studies present similar econometric models, and since the latter is more recent, this chapter is mainly devoted to a critical assessment of Metwally's study.

The first section of this chapter considers some of Metwally's results concerning the performance of the Maltese economy under different government economic policies. This is of interest because it turned out to be one of the most controversial aspects of his study. The second section is more directly related to the purpose of this study and considers the specification of Metwally's model.

Growth Rates of Main Economic Variables

In his chapter 2, Metwally (1977, p. 36, Table 2-1) presents a table of growth rates of main economic variables, comprising 208 regressions. He divides the period into three subperiods 1954-60, 1961-70, 1971-74, and computes regressions for these three subperiods as well as for the whole period. Metwally (1977, p. 35) states that "the wisdom of this sub-division was to evaluate the effect of different government economic policies on the performance of the Maltese economy in addition to assessing the general performance of the economy in the past two decades."

The problem with this procedure is that the subperiods have too few observations for regressions to provide reliable estimates. To see this, consider regressions conducted on the 1971-74 subperiod which has 4 observations and on the whole period which has 21 observations. Now suppose that in 1973, some random disturbance caused a wide fluctuation in the variable being estimated. In the regression based on 4 observations, each observation carries a weight of 1/4, while if the whole period is used, the weight of each observation is 1/21 . Hence, though the random disturbance does not reflect any basic relationship between the variables, it is given greater importance in the smaller sample. Moreover, since ordinary least squares (OLS) minimizes the sum of squared residuals, large residuals become relatively larger due to the squaring process implying that when the sum of squared residuals is minimized, extra care is taken to avoid large residuals. In the larger regression, not only does each observation carry less weight, but a relatively large disturbance in one direction can be counterbalanced by a large disturbance in the opposite direction since the disturbances are random. In a sample of four or six observations, such counterbalancing is highly unlikely, thereby violating one of the assumptions of the classical linear regression model which requires that the expected value of the disturbance term to be zero.

In testing whether a change of policy has caused a change in a relationship (in this case growth rates), an accepted practice is to use dummy variables. This method makes use of all the sample observations so that a more efficient use of the available data is made, and more importantly, avoids regressions on very small samples. Metwally uses this procedure himself in his estimation of the consumption function.* Why he chose to run regressions on four and six observations in chapter 2 is difficult to understand.

To show how misleading regressions on very small samples can be, regressions on two series were conducted. A procedure similar to that employed by Metwally was used, with the addition of a dummy variable, i.e.,

$$Y = A\, e^{rt+BDt} \qquad (2.1)$$

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* See for example Metwally (1977, pp. 96-97).

where D is a dummy variable to allow for a slope shift by taking values of D for normal years and 1 for abnormal years. Transformed into natural logarithms, this gives:

$$Ln\ Y = Ln\ A + rt + BDt \qquad (2.2)$$

The first variable tested is real wages and salaries for which Metwally gives the estimated growth rates 4.39% for 1954-60, 5.51% for 1961-70, 1% for 1971-74 and 4.65% for the whole period. Of particular interest is the growth rate of 1% for 1971-74 as this is much lower than for the other periods. To examine this more explicitly, let D = 1 for 1971-74 and zero otherwise. The regression results are:

$$Ln\ Y = 5.06 + 0.0421t + 0.006Dt \qquad (2.3)$$

(t-values) (12.52) (2.29)

Because the t-value for the dummy variable is significant, the estimated growth rates are, 4.2% for 1954-70 and 4.8% for 1971-74 i.e., these results show that a statistically significant increase in the growth rate of real wages and salaries occured during 1971-1974.* This result is quite the opposite to what Metwally finds who, as noted above, estimates a drop in the rate of growth of wages and salaries to 1% during this period. To examine this difference in results further, the period 1971-74

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* Adding the observation for 1975 the growth rate of wages and salaries during 1971-75 rose to 4.95% with the t-value for the dummy variable climbing to 2.8 . This shows that the estimated increase in the rate of growth of wages and salaries is stable.

was regressed alone giving a growth rate of 4.19% but an insignificant t-value so that this regression is unable to say anything on the growth rate during 1971-74.* Thus, not only did Metwally use an inappropriate technique in conducting regressions on four observations, but it appears that he even failed to test these coefficients for statistical significance. These findings are particularly disturbing, especially in view of the importance that he gives to his small sample regression results. For example in chapter 2, he comes to the conclusion that "the personal sector in Malta had its worse performance during the period 1971-1974" (Metwally 1977, p. 42) and as one of the reasons he gives the fall to 1% in the rate of growth of wages and salaries. Again in a newspaper interview he gives this same example on the fall in the growth rate of wages and salaries as an indication of the slowing down in the performance of the economy.** These examples clearly demonstrate the extent to which Metwally has been misled by his small sample regressions.

The second series considered is gross domestic product (GDP), again testing the 1971-74 period for which Metwally estimates a slowing down in the rate of growth to 4.57% from

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* Note that the estimated growth rate from this single regression is well above that reported by Metwally, suggesting a typographical error in his study. However, the estimated growth rate of 4.19% for 1971-74 still supports Metwally's claim of a slowing down in the rate of growth of wages and salaries during this period.

** See The Sunday Times of Malta, May 29, 1977, p. 16.

a high of 5.59% during 1961-70. The estimated regression is:

$$\text{Ln } Y_2 = 5.6 + 0.0519t + 0.0045Dt \qquad (2.4)$$

(t-values) (11.39) (1.265)

Since the t-value for the dummy variable is statistically insignificant, this regression states that, contrary to what Metwally finds, there is no evidence of a fall in the rate of growth of GDP, but rather GDP continued growing at a steady rate of 5.19% during 1971-74.

These results clearly support the argument given earlier that due to the small number of observations in the subperiods, the results given by Metwally (1977, pp. 35-38, Table 2-1) for the growth rates in the subperiods are unreliable.*

Model Specification

Metwally's model is given in Table 2.1 . It is seen to be a simple aggregate model consisting of five behavioural equations (two of which are tax functions) and three identities. This section is divided into three sub-sections, each dealing with a particular specification problem.

Consumption Function.

The specification of the consumption function (i.e., eq. (2.5)) used by Metwally includes a dummy variable to allow

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* The same criticism holds for Metwally's analysis of the sources of growth in the manufacturing sector in his chapter 3 as this is based on regressions on subperiods 1961-70 and 1971-75.

TABLE 2.1

METWALLY'S MODEL

$$C_t^p = a_1 + B_1 Y_t^d + B_2 D Y_t^d + u_1 \quad (2.5)$$

$$I_t^p = a_2 + B_3 \left[(C_t^p + E_t) - (C_{t-1}^p + E_{t-1}) \right] + B_4 \left[1/3\,(C_{t-1}^p + E_{t-1}) - (C_{t-4}^p + E_{t-4}) \right] + u_2 \quad (2.6)$$

$$M_t = a_3 + B_5 (C_t^p + E_t) + B_t (I_t^p + I_t^g) + u_3 \quad (2.7)$$

$$T_t^p = a_4 + B_7 Y_t^p + u_4 \quad (2.8)$$

$$T_t^E = a_5 + B_8 Y + u_5 \quad (2.9)$$

$$Y^d = Y^p - T^p - G^T \quad (2.10)$$

$$Y^p = Y - T^E + s - K - G^y - C^y + i + f \quad (2.11)$$

$$Y = C^p + C^G + I^p + I^g + E - M \quad (2.12)$$

where: C^p = private consumption

I^p = private (gross) investment

T^p = personal income tax

Y = gross national product

E = exports of goods and services

E_{t-1}, E_{t-4} = exports in periods (t-1) and (t-4) respectively

cont./

TABLE 2.1--Continued

s = subsidies

G^y = government income from enterpreneurship, interest dividends and rent

i = interest on public debt

C^g = government expenditure on current goods and services

Y^d = personal disposable income

M = imports of goods and services

T^E = tax on expenditure

Y^p = personal income

I^g = government (gross)investment

G^T = current transfers to general government

K = capital consumption

C^y = corporate profit taxes plus corporate undistributed income after tax

f = transfers from abroad

D = 0 for 1954-1968

= 1 for 1969-1974

u_i = disturbance term

for a slope shift for the period 1969-74. It is relevant to note, however, his argument leading to this specification of the consumption function.

Metwally first estimates the consumption function without the dummy variable, and gets the following results* (Metwally 1977, p. 95):

$$C^P = -4.195 + 0.911Y^d \qquad (2.13)$$
$$(-3.28) \quad (6.669)$$

$R^2 = 0.978$, $F = 788$, $DW = 0.98$

Metwally points out that the intercept of equation (2.13) is negative, and hence disagrees with economic theory. Consequently he states "We tested whether there were abnormal years which caused the function to shift and/or the slope to change" (Metwally 1977, p. 95) and proceeds to argue, somewhat unconvincingly, that the period 1969-74 was not normal in the sense that over this period, the marginal propensity to consume increased.** Thus he re-estimates equation (2.13), including

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* Metwally does not give the t-value for the constant term, nor the D.W. statistic and F-ratio for equation (2.13). The values for these statistics given above were derived in this study by regressing equation (2.13) for the period 1954 to 1974.

** One of the reasons Metwally gives for this increase in MPC is the lack of incentive to save caused by the banking crisis in 1973/74. However, this does not necessarily imply an increase in the MPC. For example, if consumers are saving the desired amount and suddenly part of their savings are destroyed, one would expect that they would try to get back to equilibrium by building their stock of savings to the desired level. That is, for a period people would tend to save <u>more</u>.

the dummy variable and finds not only that the coefficient of the dummy variable is significant and positive, but also that the intercept changes its sign.

The problem with this approach is that it appears to be the wrong solution. Metwally estimates all his behavioural equations using OLS. Though OLS is often used to estimate the coefficients of simultaneous equations, it does raise the problem of simultaneous equation bias. In the case of the consumption function, it is well known that using OLS results in an underestimation of the intercept, and overestimation of the marginal propensity to consume (MPC).* The results given in equation (2.13) suggest that not only is the intercept underestimated but also, the MPC is overestimated. Thus, the problem of the negative intercept which Metwally points out, may not be because any change in MPC has occured but rather due to the estimating technique used. In order to examine this issue more closely, equations (2.5) and (2.13) were re-estimated for the period 1955 to 1974 using two stage least squares.** The results obtained are the following:

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* See for example Johnston (1972, pp. 343-344) or Goldberger (1964, pp. 289-290).

** The estimation period was restricted to 1955-1974 so as to cover the same estimation period used by Metwally. The instruments used for the first stage of 2SLS are real exports, real government expenditure and real consumption lagged one period.

$$C_t^p = -1313.00 + 0.746Y_t^d + 0.058Y_t^d(D) \qquad (2.5)'$$

$$(-0.35) \quad (5.44) \quad (1.08)$$

$\bar{R}^2 = 0.76$, DW = 1.52 , F = 30.00 , RHO = 1.0

$$C_t^p = -1169.98 + 0.828Y_t^d \qquad (2.13)'$$

$$(-0.35) \quad (7.05)$$

$\bar{R}^2 = 0.75$, DW = 1.57 , F = 56.83 , RHO = 1.0

The first point to note is that though the intercepts of (2.5)' and (2.13)' are negative, they are both insignificantly different from zero. Second, the t-value for the dummy variable in (2.5)' is insignificant so that the empirical results do not support Metwally's hypothesis that the MPC increased during this period. Third, the estimated MPC in (2.13)' is indeed lower than that in (2.13), as theory suggests. Thus, from these results, it may be concluded that the consumption function used by Metwally (i.e., eq. (2.5)) is misspecified and in addition, it appears that it does make a difference whether 2SLS or OLS is used as an estimating technique.

It will be noticed that equation (2.13)' had to be corrected for serial correlation. The resulting rho value of 1 indicates the strong presence of serial correlation and suggests that perhaps some relevant variable is being omitted in the form of (2.13)'. One of the most commonly estimated forms of the consumption function is that suggested by the permanent income hypothesis* i.e.,

$$C_t^P = -23.24 + 0.445Y_t^d + 0.544C_{t-1}^P \qquad (2.14)$$

$$(-1.17) \quad (3.78) \quad (3.70)$$

$\bar{R}^2 = 0.99$, $F = 1422$, $DW = 2.2$

Equation (2.14) was estimated using 2SLS for the period 1955 to 1978. The results in (2.14) agree with theoretical expectations, namely the short-run MPC (0.445) is less than the long-run MPC of 0.98, while the long-run MPC is close to unity.** Furthermore, the statistical results of (2.14) are satisfactory, so that in view of the greater theoretical appeal of the form of (2.14) relative to (2.13)', the former is preferable to the latter.***

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* Actually Friedman's (1957) permanent income hypothesis requires the intercept to be zero. (See for example Evans 1969, p. 24.) Note, however, that though equation 2.14 was not constrained to pass through the origin, the t-value of the constant is insignificant.

** The long-run MPC is calculated for the no-growth situation by setting Ct = Ct-1 and solving for Ct . Evans (1969, p. 38) derives the requirement that under conditions of no-growth, the long-run MPC should be 1 . That is, under such conditions, consumers would not save any of their income in the long-run but would consume it all.

*** It is relevant to note that Metwally does estimate equation (2.14). Though both the lagged consumption and income coefficients are of the correct sign and significant, he rejects these results on the basis of the negative intercept. When he includes the dummy variable he finds that its t-value, as well as that of lagged consumption , are insignificant. Consequently he also rejects these results, though the finding that the dummy variable is insignificant should have provided some doubt about the validity of the postulated increase in MPC.

Import Function.

Consider the imports equation reproduced below, where the variables are defined in Table 2.1 .

$$M_t = a_3 + B_5(C_t^p + E_t) + B_6(I_t^p + I_t^g) + u_3 \qquad (2.15)$$

This equation states that if exports <u>or</u> consumption rise by one unit, imports rise by B_5 , i.e., both C_t^p and E_t are assumed to have the same coefficient. Similarly, for the last bracket I_t^p and I_t^g are assumed to have the same coefficient B_6 . These are rather strong assumptions on the specification of the model. Suppose, for example, that the coefficient of E_t is in reality zero. In the form of (2.7), E_t is being saddled with B_5 thereby misspecifying completely the effect of E_t on M_t . While the risk of misspecification is great, the gain from such a-priori assumptions is unclear and appears to be only in terms of less computational work. As economic theory does not provide any enlightenment on this issue one would expect Metwally to provide some strong justification for such a-priori restrictions. However, nowhere in his study does Metwally give reasons for these assumptions.

To test these assumptions and examine their rationale, several regressions were conducted, the results of which are shown in Table 2.2 . Regression (2.16) is a replica of the one used by Metwally. The estimated coefficients are close but not

TABLE 2.2

$$M_t = 43.76 + 0.23(C_t^p + E_t) + 1.45(I_t^p + I_t^g) \quad (2.16)$$

(4.9) (9.15) (13.82)

$\bar{R}^2 = 0.992$, $F = 1241$, $DW = 2.29$, $N = 21$

$$M_t = 41.7 + 0.28E_t + 0.21C_t^p + 1.58I_t^p + 1.18I_t^g \quad (2.17)$$

(3.74) (2.49) (2.44) (9.06) (5.16)

$\bar{R}^2 = 0.991$, $F = 616$, $Dw = 2.2$, $N = 21$

$$IM_t = 19.60 + 0.34I_t^p + 0.06I_t^g \quad (2.18a)$$

(2.39) (3.80) (0.78)

$\bar{R}^2 = 0.66$, $F = 16$, $DW = 1.48$, $N = 17$

$$EM_t = 61.25 + 0.70C_t^p + 0.04E_t \quad (2.18b)$$

(1.66) (5.73) (0.37)

$\bar{R}^2 = 0.94$, $F = 117$, $Dw = 1.88$, $N = 17$

where: N = number of observations

IM = imports of capital goods

EM = other imports

exactly equal to his. The main reason for this is that Metwally does not state how he is deflating investment. The problem arises here because a price index for capital goods is not published. As a proxy for this price index the consumer price index was used. Regression (2.17) is the disaggregated regression required to test Metwally's assumptions. Using a standard technique* to test the hypotheses that the coefficient of C_t^p is equal to that of E_t and the coefficient of I_t^p is equal to that of I_t^g the t-values turn out to be insignificant so that Metwally's a-priori assumptions are supported. However there are some problems with this regression which cast doubt on the reliability of these tests. The simple correlations between the independent variables are unduly high, ranging from 0.72 to 0.92 . This suggests that multicollinearity could be a serious problem. One effect of multicollinearity is to inflate the standard errors of the coefficients. This implies wider confidence intervals for the estimates so that the insignificant difference between the coefficients could be a result of this problem.

In order to examine this issue more closely, imports were divided into two components namely, imports of capital goods and other imports, and two equations estimated. The results from these regressions are given in Table 2.2, equations (2.18a) and

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* For a general description of the method used see Murphy (1973), pp. 227-29.

(2.18b).* It is interesting to note that both the investment coefficients in equation (2.18a) are considerably less than one. These results appear to be more reasonable than those given in equations (2.16) and (2.17) (where all the investment coefficients estimated are greater than one) since one would normally expect part of investment demand to be met from domestic sources. Of greater interest, however, is the result that tests on the equality of the coefficients of I_t^p and I_t^g in equation (2.18a), and of the coefficients of C_t^p and E_t in equation (2.18b) yield statistically significant t-values.** Thus, Metwally's a-priori assumptions are refuted, revealing the need for re-structuring the model.

Multiplier Analysis

One of the most serious problems with Metwally's model arises in his multiplier estimation. Table 2.3 gives the multipliers of GNP and imports with respect to exports and tourism (Metwally 1977, p. 142).

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* The data for IM_t and EM_t were obtained from the I-O tables. Since the I-O tables have been published only since 1961, the estimation period was restricted to 1961-1977.

** These t-values are 1.81 for equation (2.18a) and 3.1 for equation (2.18b).

TABLE 2.3

	GNP	Imports
Exports	0.750	1.714
Tourism	0.997	1.053

These multiplier results lead Metwally to one of his major policy recommendations: He suggests that since the GNP multiplier with respect to tourism is higher than that of exports, while the import multiplier with respect to tourism is lower than that of exports, Malta should concentrate on the tourism sector rather than the export of goods sector.

However, there are two main problems with the multipliers in Table 2.3 . First, the validity of deriving two different multipliers for exports and tourism is seriously in question. Tourism is included in the services part of the export of goods and services variable. In order to derive different multipliers for these two variables, one would expect that, at some point in his model, Metwally would have separated tourism from export of goods. Yet, an inspection of his model reveals that the export of goods and services variable is always represented as a single variable. In order to examine this issue more closely, Table 2.4 gives the reduced form of his model and the resulting reduced-form equation for GNP.*

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* The inverse matrix (A^{-1}) is represented only symbolically in Table 2.4 . It is merely the transpose of Metwally's (1977, p. 140) Table 5.2 .

TABLE 2.4

REDUCED FORM OF METWALLY'S MODEL

$$\begin{bmatrix} Y \\ Y^P \\ Y^d \\ C^P \\ I^P \\ M \\ T^P \\ T^E \end{bmatrix} = \begin{bmatrix} A^{-1} \end{bmatrix} \begin{bmatrix} C^G + I^g + E \\ s - K - G^y - C^y + i + f \\ -G^T \\ a_1 \\ B_3 \left[E_t - C_{t-1}^P - E_{t-1}\right] + B_4 \ 1/3 \left[C_{t-1}^P + E_{t-1} - C_{t-4}^P - I_{t-4}\right] + a_2 \\ a_3 + B_5 E_t + B_6 I^g \\ a_4 \\ a_5 \end{bmatrix}$$

$$Y = 1.4716(C^G + I^G + E) + 0.5548(s - K - G^y - C^y + i + f) - 0.6219G^T \quad (2.19)$$
$$- 0.3664(B_3)\left[E_t - C_{t-1}^P - E_{t-1}\right] + B_4 \ 1/3 \left[C_{t-1}^P + E_{t-1}^P - C_{t-4}^P - E_{t-4}\right]$$
$$- 1.4716(B_5 E_t + B_6 I^g) + 0.7498a_1 - 1.4716a_3 - 0.6219a_4$$
$$- 0.5548a_5 - 0.3664a_2$$

$B_3 = 0.6746$

$B_4 = 0.66$

$B_5 = 0.3225$

$B_6 = 1.249$

The multiplier for exports may be calculated by partially differentiating Y with respect to E_t , i.e.,

$$\partial Y/\partial E_t = 1.4716 - 0.3664B_3 - 1.4716B_5 = 0.75 \quad (2.20)$$

If now one wanted to derive the multiplier for tourism, one would have to take again the partial derivative of Y with respect to E_t , giving the same value. In other words, according to the specification of Metwally's model, the multiplier for tourism must be equal to that of exports.

Thus, the question that arises is how does Metwally derive different multipliers for exports and tourism? If the second term in equation (2.20) (i.e., $0.3664B_3$) is set to zero, it turns out that the value of the multiplier in (2.20) is 0.997 , which is the same as that given in Table 2.3 for tourism. Since the coefficient B_3 appears in the investment function (eq. (2.6) Table 2.1), one possible explanation is that E in the investment function excludes tourism, so that the term $0.3664(B_3)E_t$ (see eq. (2.19))would be irrelevant in calculating the multiplier for tourism. In order to examine this possibility further, the investment function (i.e. eq. (2.6)) was estimated for the period 1958-1974, assuming that E excludes tourism, and it was found that, indeed, this explanation is correct. That is, the estimated coefficients agreed with those given by Metwally for the investment function.

Thus, the preceeding discussion suggests that there is a typographical error in Metwally's model, namely E in the investment function refers to exports excluding tourism. What is more disturbing, however, is the fact that nowhere in his study does Metwally justify or even note that he is assuming that tourism has no impact on investment. Moreover, this approach appears to be a rather artificial way of deriving separate multipliers for exports and tourism. Gross private investment (I^P) is defined by Metwally (1977, p. 109) to include construction, so that an expansion of the tourism sector would certainly affect investment.* Furthermore, this assumption also explains the lower import multiplier for tourism since tourism is assumed to induce no imports via investment. But this is resolving the issue by assumption and, it seems, is arbitrary and fallacious.

The second problem with the multipliers of Table 2.3 concerns the value of the import multipliers. Note that both import multipliers are greater than one, so that for example, a £M100 increase in exports will result in an increase in imports of £M171. This result has serious implications on the foreign reserves, and suggests that there is an element of instability, with any increase in exports or tourism resulting eventually in the depletion of foreign reserves. Whether this instability is confined to Metwally's model or whether it represents the actual situation, will be thoroughly discussed in Chapter VI.

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* For example, through the construction of hotels, holiday apartments, etc.

Conclusion

The first section of this chapter dealt with Metwally's estimation of the growth rates of main economic variables during different subperiods. The method used by Metwally to examine the impact of policy changes on these growth rates is separate regressions for the subperiods. Unfortunately, however, this approach resulted in regressions on very small samples, leading to unreliable results. This was demonstrated by using the dummy variable technique to test for any changes in the growth rates of two variables during the period 1971-74. In both cases very divergent results to those of Metwally were obtained, indicating clearly the inappropriatness of regressions on very small samples.

The second section considered the specification of the model used by Metwally. The first equation considered was the consumption function. Metwally's specification of the consumption function is based on the absolute income hypotheses and includes a dummy variable to allow for a slope shift during the period 1969-74. The question of whether the dummy variable should be included is important not only because it affects the specification of the consumption function to be used in this study, but also because it raises the problem of the stability of the MPC. Consequently, this issue was examined at some length.

Metwally rationalizes the inclusion of the dummy variable mainly on the basis that excluding it leads to an underestimation of the intercept. However, what he fails to note is that the MPC appears to be overestimated and that these results agree with what econometric theory suggests if OLS is used to estimate the consumption function. Using 2SLS it was found that, indeed, this is the case and in addition that the dummy variable becomes insignificant. Furthermore, an alternative form of the consumption function was estimated i.e., including lagged consumption as an explanatory variable. The results from this regression indicate that this form does appear to fit Maltese data well so that, in view of its greater theoretical appeal, it is preferable to that implied by the absolute income hypothesis. Thus, three important results were obtained which have a bearing on the structure and estimation of a model in this study. These are (a) 2SLS appears to be a preferable estimating technique; (b) the hypotheses that the MPC changed during the period 1969-74 is rejected; and (c) a better specification of the consumption function is that suggested by the permanent income hypothesis.

The second equation considered was Metwally's import function. It was pointed out that the specification of the import equation involves some restrictions on the coefficients which are nowhere justified in Metwally's study. To test these a-priori restrictions several regressions were presented. In particular, the import variable was divided into two components namely, imports of capital goods and other imports and two separate equations estimated. In both these equations, Metwally's a-priori restrictions were rejected so that Metwally's import equation suffers from a mis-specification problem.

The specification of the import equation assumes greater importance in view of Metwally's findings that the import multipliers with respect to tourism and exports are greater than one. Metwally does not discuss the significance of this result in his study, though he does strongly recommend that sectors with a low import content should be encouraged. As was noted, an import multiplier greater than one suggests that a one unit increase in exports will cause more than a unit increase in imports, thereby leading to an unstable situation since the stock of foreign reserves would eventually run out. Whether this instability is confined to Metwally's model or whether it gives an accurate portrayal of the structure of the Maltese economy is an important question which the model in this study should be able to address.

Finally, it was shown that there is an inconsistency between the specification of Metwally's model and his result that exports and tourism have different multipliers. One possible explanation for this inconsistency was suggested, namely that the E variable in the investment function refers only to exports (i.e., excludes tourism). This hypothesis was tested by regressing the investment function, assuming that the E variable excludes tourism, and it was found that, indeed, this is the correct explanation. Two points are worth noting about this finding. First, it is particularly disturbing that nowhere in his study does Metwally justify or even state that he is assuming that tourism has no effect on investment. Second, this assumption appears to be invalid since investment includes construction which,as noted, would certainly be affected by tourism. Consequently, Metwally's multipliers for tourism and exports, as well as his policy recommendation that Malta should concentrate on the tourism sector rather than exports, are highly questionable.

This chapter has provided not only a critical assessment of Metwally's study but also identified some questions which an alternative model should be able to address, as for example whether exports or tourism should be encouraged to expand. This type of question suggests that a disaggregated model would be more suitable than a highly aggregated model such as that of Metwally. Fortunately however, Malta possesses a wealth of information in the form of input-output (I-O) tables which have been published annually since 1961. The object of the next two chapters is to explore the possibility of utilizing this time series of I-O tables.

CHAPTER III

THE INPUT-OUTPUT MODEL

Introduction

The Central Office of Statistics in Malta has been publishing I-O tables annually since 1961. This time-series of I-O tables has not been utilized by any previous study on the Maltese economy. Indeed, despite the fact that it represents a wealth of information not usually available for most other countries, the government economic planning division uses mainly the latest I-O table which is usually, at least, three years old. Thus, the question that arises is how can a time series of I-O tables be utilized, especially in the context of a macro model? The answer to this question is the main theme of both this chapter and chapter IV.

This chapter will first give a brief summary of the I-O model and then examine the relevant literature with the object of finding out what use has been made of a time-series of I-O tables.

Input-Output Analysis

The inter-industry accounting system is shown in Table 3.1. This table may be divided into four quadrants.

(I) Quadrant I shows the inter-industry transactions. Each entry x_{ij} , indicates the amount of commodity i used by sector j . However in Table 3.1 , intra-industry transactions are excluded so that the main diagonal of Quadrant I is blank.

(II) Quadrant II comprises the final use of commodities and services broken down by major types of use. This quadrant is usually referred to as final demand.

(III) Quadrant III contains inputs which are primary in the sense of not being produced by any industry in the system. Thus, this quadrant is usually referred to as primary inputs.

(IV) Quadrant IV contains the direct input of primary factors to final use.

The open-static, input-output analysis proceeds as follows:

(a) It is assumed that the production functions are of a form that the demand for each input is proportional to output of that sector, i.e.,

$$x_{21} = a_{21}X_1 , \qquad x_{12} = a_{12}X_2$$

or in general $$x_{ij} = a_{ij}X_j$$

(b) Final Demand (i.e., C + I + G + E) denoted by Y is assumed to be exogenously determined.

TABLE 3.1

Output → / Input ↑	1	2	3	....	n	C	G	I	E	Total X
1	-	x_{12}	x_{13}	....	x_{1n}	C_1	G_1	I_1	E_1	X_1
2	x_{21}	-	x_{23}	....	x_{2n}	C_2	G_2	I_2	E_2	X_2
3	x_{31}	x_{32}	-							
		(Quadrant I)					(Quadrant II)			
n	x_{n1}	x_{n2}	....		-	C_n	G_n	I_n	E_n	X_n
M	M_1	M_2	....		M_n	C^m	G^m	I^m	E^m	M
W	W_1	W_2	....		W_n	-	-	-	W^e	W
		(Quadrant III)								
P	P_1	P_2	....		P_n	-	(Quadrant IV)			P
T	T_1	T_2	....		T_n	T^c	-	T^i	T^e	T
Total X	X_1	X_2	....		X_n	C	G	I	E	

(c) From the identities,

$$\begin{array}{l}
0 + x_{12} + x_{13} + \dots + x_{1n} + C_1 + G_1 + I_1 + E_1 = X_1 \\
x_{21} + 0 + x_{23} + \dots + x_{2n} + C_2 + G_2 + I_2 + E_2 = X_2 \\
\vdots \\
x_{n1} + x_{n2} + x_{n3} + \dots + 0 + C_N + G_N + I_N + E_N = X_N
\end{array}$$

and substituting for x_{ij} from (a) gives

$$\begin{array}{l}
0 + a_{12}X_2 + a_{13}X_3 + \dots + a_{1n}X_N + C_1 + G_1 + I_1 + E_1 = X_1 \\
a_{21}X_1 + 0 + a_{23}X_3 + \dots + a_{2n}X_N + C_2 + G_2 + I_2 + E_2 = X \\
\vdots \\
a_{n1}X_1 + a_{n2}X_2 + a_{n3}X_3 + \dots + 0 + C_N + G_N + I_N + E_N = X_N
\end{array}$$

or $$(I - A)\, X = Y$$

Where A is the nxn matrix of technical coefficients

X is the nx1 column vector of gross output

Y is the nx1 matrix of Final Demand

Given assumption (b), the system can be solved for gross output by sector, i.e.,

$$X = (I - A)^{-1}\, Y \qquad (3.1)$$

A variant of the I-O model presented above is to endogenise imports by assuming,

$$M_1 = m_1X_1 \;,\quad M_2 = m_2X_2 \;,\quad \text{or in general} \quad M_j = m_jX_j$$

The identities in (c) are now changed by treating imports as a column vector to be deducted from gross output, i.e.,

$$
\begin{array}{l}
-m_1X_1 + a_{12}X_2 + a_{13}X_3 + \ldots + a_{1n}X_n + C_1 + G_1 + I_1 + E_1 = X_1 \\
a_{21}X_1 - m_2X_2 + a_{23}X_3 + \ldots + a_{2n}X_n + C_2 + G_2 + I_2 + E_2 = X_2 \\
\vdots \\
a_{n1}X_1 + a_{n2}X_2 + a_{n3}X_3 + \ldots - m_nX_n + C_n + G_n + I_n + E_n = X_n
\end{array}
$$

or

$$(I + M - A)X = Y \qquad (3.2)$$

$$X = (I + M - A)^{-1}Y \qquad (3.3)$$

where

$$M = \begin{bmatrix} m_1 & 0 & \cdots & 0 \\ 0 & \ddots & & \vdots \\ \vdots & & \ddots & \vdots \\ 0 & \cdots & \cdots & m_n \end{bmatrix}$$

i.e., M is a diagonal matrix with import coefficients on the main diagonal and zeros elsewhere.

Once the inverse is computed one can calculate not only the direct and indirect effects of an increase in final demand on each gross output but also the effect on employment and capital (if data are available). For example, by substituting employment L for W in Table 3.1 and assuming,

$$L_1 = l_1X_1 \;, \quad L_2 = l_2X_2 \;, \quad \text{or in general} \quad L_j = l_jX_j$$

the change in employment can be derived. Let the elements of the inverse matrix be

$$\begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nn} \end{bmatrix} = R = (I - A + M)^{-1}$$

Then if Y_1 changes by 1 unit

$$\begin{bmatrix} \Delta X_1 \\ \vdots \\ \Delta X_2 \end{bmatrix} = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nn} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ \vdots \\ 0 \end{bmatrix} = \begin{bmatrix} r_{11} \\ \vdots \\ r_{n1} \end{bmatrix}$$

Hence, $\Delta L_1 = l_1 \Delta X_1$, or in general $\Delta L_j = l_j \Delta X_j$

so that $\Delta L = \Delta L_1 + \Delta L_2 + \ldots\ldots + \Delta L_n$

A caveat is perhaps due here on the role of prices in the I-O system. In the original theoretical model developed by Leontief, the technical coefficients are regarded as relating to the physical quantities of commodities used in producing a given physical quantity of another commodity. As indicated in the previous section, this formulation neglects the effect of price variables. Indeed by assuming that the production functions are of the form,

$$X_j = x_{ij}/a_{ij} \qquad (i = 1, \ldots\ldots n)$$

there is the assumption that no substitution between inputs takes place.

Leontief (1951, pp. 38-40) defends this approach on the basis that a large proportion of what economists usually call substitution is due to the use of large aggregates, such as consumption, in which a change in the proportion of automobiles and foodstuffs consumed, for example, would cause a change in the proportions of inputs of labour and capital used. By using a finer sector breakdown this type of substitution should be reduced. With regard to true substitution in a given productive process, Leontief suggests that there may be a high degree of complementarity among inputs, so that changes in relative prices will affect their proportions only slightly.

In practice, the entries in the I-O table are not recorded in physical units but rather in money values. The relationship between technical coefficients derived from money and physical units may be seen as follows. Let the coefficient derived from physical units be a_{ij} while that from money values be $\bar{a}_{ij}$. Then;

$$a_{ij} = x_{ij}/X_j \ , \qquad \bar{a}_{ij} = p_i x_{ij}/p_j X_j$$

or

$$a_{ij} = \bar{a}_{ij}\ p_i/p_j$$

$$= \bar{a}_{ij} \qquad \text{if} \quad p_i/p_j = 1$$

That is, if one interprets the units of x_{ij} and X_j as those purchasable for one dollar at base year prices, then technical coefficients derived from money values would be equivalent to those derived from data in physical units.

In the I-O system there is also a theory of price determination. This is usually usually developed as follows.* The columns of the I-O matrix (i.e., Quadrant I, Table 3.1)

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* See I-O Tables and Analysis - U.N. (1973); Leontief (1966), pp. 143-145; Chenery and Clark (1965), pp. 60-62.

together with primary inputs (Quadrant III, Table 3.1) account for all expenditures of each sector. Since there must be a balance between payments received and expenditures made, the following system of equations holds.

$$
\begin{aligned}
P_1X_1 &= x_{11}P_1 + x_{21}P_2 + x_{31}P_3 + \dots + x_{n1}P_n + M_1 + W_1 + P_1 + T_1 \\
P_2X_2 &= x_{12}P_1 + x_{22}P_2 + x_{32}P_3 + \dots + x_{n2}P_n + M_2 + W_2 + P_2 + T_2 \\
&\vdots \\
P_nX_n &= x_{1n}P_1 + x_{2n}P_2 + x_{3n}P_3 + \dots + x_{nn}P_n + M_n + W_n + P_n + T_n
\end{aligned}
$$

Dividing each equation by its own output level and denoting $(M_j + W_j + P_j + T_j)/X_j$ by V gives

$$
\begin{aligned}
P_1 &= a_{11}P_1 + a_{21}P_2 + a_{31}P_3 + \dots + a_{n1}P_n + V_1 \\
P_2 &= a_{12}P_1 + a_{22}P_2 + a_{32}P_3 + \dots + a_{n2}P_n + V_2 \\
&\vdots \\
P_n &= a_{1n}P_1 + a_{2n}P_2 + a_{3n}P_3 + \dots + a_{nn}P_n + V_n
\end{aligned}
$$

or in matrix form

$$P = A' P + V \tag{3.4}$$

where P is the nx1 vector of prices, A' is the transpose of the familiar technical coefficients matrix and V is the nx1 vector of V_j's. Each equation describes the balance between the price received and payments made by each endogenous sector per unit of its product; V_j represents the payments made by sector j -

per unit of its product - to all primary sectors.* Assuming the latter to be exogenous, the system can be solved for prices i.e.,

$$P = (I - A')^{-1}V \qquad (3.5)$$

Input-Output as a One Element Sample

The main purpose of this chapter is to examine the possibilities of extending the I-O model through the use of a time series of I-O tables. However, it is important to recognize at the outset that the I-O model is really a model based on a one element sample. Furthermore, one may view the assumptions made as necessary for the model to be based on such a one element sample. Thus these observations cast the assumptions of the I-O model not as desirable simplifications of reality but rather as due to the sheer unavailability of degrees of freedom.

Though the lack of time-series data is a compelling enough reason for restricting the model, yet there is a second reason as to why Leontief adopted such a model. This is that at that time, econometrics was still in its infancy. The following statement made by Leontief in a 1952 article clearly demonstrates this point (Leontief 1952, p. 3).

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* These payments to the primary sectors may be considered as value added per unit of output if imports are endogenised or deducted from the export column so as to have net exports.

> And even then, in their desperate search for sufficiently large "samples", the proponents of indirect statistical inference have found themselves driven toward the treacherous shoals of time series analysis. There they face the fatal choice between strongly auto-correlated short series and series covering a longer span of years, which expose the investigator to the even more fundamental danger of assuming invariance in relationships which actually do change and even lose their identity over time.

Though the problems of autocorrelation and structural change are indeed relevant issues in any empirical analysis based on a time series, yet, econometrics has developed techniques to deal with these problems. For instance, the Cochrane-Orcutt (1947) method may be used to correct for the autocorrelation error imparted to the estimates of least-squares regressions.* In the case of structural change, dummy variables may be used to allow for the shift of a function over time.** Furthermore, the criticism of structural change is probably even more applicable to the I-O system since the most recent table is usually several years old. For example, when Leontief made the above statement (i.e., 1952) the most recent I-O table available for the U.S. economy was that for 1939.

As the proponents of indirect statistical inference gained respectability, there was no corresponding move by I-O analysts in general to expand the model into this direction. The

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* See also Koutsoyiannes (1973), pp. 194-224.

** See for example Koutsoyiannes (1973), pp. 273-275.

emphasis has been directed at obtaining larger and larger tables in the hope that a finer classification of industries would provide a more stable estimate of the technical coefficient. Naturally the most limiting factor hindering an expansion of the system in the direction indicated here has been the miniscule supply of time series data. However, this limiting factor must be laid at the door of an inadequate demand for such data. In fact, even when a time series of I-O tables was available, the analysis tended to adhere so rigidly to the original assumptions of the I-O model that an inefficient use of the data was made. This is the topic of the next section.

Tilanus' Experiments

One of the major empirical studies on a time-series of I-O tables is the study by Tilanus (1966) of thirteen I-O tables (1948-60) for the Netherlands. Tilanus has the practical object of finding a way to correct for coefficient changes in making predictions of intermediate demands. Tilanus compares the predictions of intermediate demands derived from a number of different methods both with each other and with the observed values. Of particular interest to this study are the results that he gets by fitting linear trends to individual technical coefficients and extrapolating. Not only is this the only approach he uses which makes use of all the data available, (except for the method of averaging the coefficients over the whole period), but he comes to the rather surprising conclusion that a time series of I-O tables is of practically no use. Indeed he finds that projections of intermediate demands for the four years 1958-1961, using an extrapolated matrix based on annual data for the period 1948-1957, compares unfavourably with alternative projections using the 1957 matrix without adjustment. As these results run counter to the main theme of this study, Tilanus' results will be examined in some detail.*

The first point that should be noted is that in general one would expect the projections based on a time series of I-O tables to do no better than those based on the latest single I-O table if the elements of an I-O table are subject to only a random walk. This is because in the presence of a random walk in say the technical coefficients, the best estimates of these coefficients in period (t+1) would be those of period (t) so that for the purpose of forecasting, very little would be gained by analysing a time series of coefficients (except perhaps confidence intervals). However, Tilanus finds that in regressing the technical coefficients on a time trend, there is extensive evidence of positive auto-correlation. For instance, the median Von-Neumann ratio of the technical coefficients is less than 1.5 (Tilanus 1966, p. 49)

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* It is relevant to note that Tilanus' results have been quite influential in discouraging attempts to explore the usefulness of a time-series of I-O tables. For example, Miernyk in the 1975 London I-O Conference is reported to have said "He reminded those present of Tilanus' experiments on projecting coefficients from time series data (without any promising results)." Gossling (1977, p. 44).

Once serial correlation is present, then in general one would expect that a time series analysis should provide better predictions than if just one observation is used since this implicitly assumes that the disturbances are random. Thus, one reason for Tilanus' conclusions to the contrary may be due to the fact that he does not correct for autocorrelation. That is he proceeds to make predictions based on the extrapolated matrix as if autocorrelation were not present. He does this notwithstanding the fact that he specifically notes that the significant t-values for the large majority of trend coefficients cannot be trusted due to autocorrelation.

The appropriate approach would have been for Tilanus to apply some corrective technique as the Cochrane-Orcutt (1947) method. This would have provided more accurate estimates; though autocorrelation leaves the ordinary least squares coefficients unbiased, they no longer have best linear unbiased properties. Furthermore, predictions would also have to be adjusted since in the presence of autocorrelation predictions based on ordinary least squares are inefficient.*

A more satisfactory approach to the problem of autocorrelation is to investigate whether autocorrelation is due to a misspecification problem. Lecomber (1975) for instance suggests that a non-linear approach to estimating the trend of the technical coefficients might provide better predictions.

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* See for example Johnston (1972), pp. 265-266.

However, it should be pointed out that though Tilanus' linear extrapolation of the technical coefficients is linear in coefficients, it is non-linear in flows. Tilanus uses the following functional form;

$$a^t_{ij} = \bar{a}_{ij} + b_{ij}T + v^t_{ij} \qquad (3.6)$$

where T is a time trend and v^t_{ij} is assumed $N(0, \sigma^2_{ij})$, $\text{cov}\,(v^t_{ij}, v^s_{ij}) = 0$ for $t \neq s$. However in original flows (3.6) becomes:

$$x^t_{ij} = \bar{a}_{ij}X^t_j + b_{ij}T(X^t_j) + u^t_{ij}X^t_j \qquad (3.7)$$

Equation (3.7) is clearly non-linear. Furthermore, (3.7) is only one possible model. Other probability models are equally possible since on a-priori grounds it is usually impossible to specify the appropriate functional form. For example an equally simple model would be;

$$x^t_{ij} = A_{ij} + B_{ij}X^t_j + C_{ij}T + u^t_{ij} \qquad (3.8)$$

Suppose (3.8) is the appropriate form with the disturbance term conforming to the usual assumptions i.e.,

$$u^t_{ij} \text{ is } N(0, \sigma^2_{ij}) \quad \text{and} \quad \text{cov}(u^t_{ij}u^s_{ij}) = 0 \text{ for } t \neq s$$

Then if (3.6) or implicitly (3.7) is used, one way in which the misspecification of the model could show up would be through the presence of autocorrelation since in general,

$$\text{Cov} \quad (u^t_{ij}X^t_j)(u^s_{ij}X^s_j) \neq 0$$

Other simple alternatives to (3.7) and (3.8) are equally possible.* However Tilanus does not try any alternative models to (3.6). He suggests that (3.6) is the simplest possible model with its great virtue being that it is linear (Tilanus 1966, pp. 42-43). As noted above, this depends on whether one views the relationship in terms of coefficients or flows. Given that (3.6) does not perform well, he leaves unexplored the possibility that other formulations might do better.

A further problem which falls under the heading of mis-specification is that Tilanus uses coefficients derived from current money values in his regressions. He defends this procedure on the basis that value coefficients appear to be "on the whole, at least as stable, or even more stable over time than volume coefficients." (Tilanus 1966, p. 37). But this is a rather weak argument. First, it is difficult to judge whether (3.6) will give better results if the regressions are conducted in terms of value or volume coefficients, without actually trying out (3.6) under the two schemes. Apparently he does not do this. Second, the presupposition that the technical coefficients should be stable over time is a too-rigid adherence to the assumption of the one-element sample I-O model. Indeed, this approach leads to an inefficient use of the data available in view of the fact that the assumptions

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* See for example Klein (1953), p. 134.

of the one-element sample model are necessary in order to make possible an analysis based on such a one-element sample.

Though the preceding criticisms of Tilanus' methods cast doubt on his conclusions regarding the usefulness of a time series of I-O tables, an even more fundamental problem remains. It turns out that in his regressions of the technical coefficients over time, Tilanus does not use the conventionally-defined technical coefficients but rather what he calls aggregate-production coefficients defined as follows:

$$x^t_{ij} = \bar{a}_{ij}(X^t_1 + X^t_2 + \ldots . + X^t_n) \qquad (3.9)$$

The reason for this formulation is that Tilanus wants to analyse the distribution of technical coefficients for all industries. He argues that a coefficient of say 3% representing a flow of 7 million guilders, cannot be put on the same pile with a coefficient of the same magnitude for another sector, representing a flow of 214 million guilders (Tilanus 1966, p. 38) As Bacharach (1970, p. 13) points out; "like ordinary input-output coefficients, aggregate production coefficients make flows of widely different sizes comparable, but unlike input-output coefficients they are large if and only if the correspnding flows are large in the economy." But surely this is not the only difference from ordinary I-O coefficients. In particular (3.9) states that if the output of <u>any</u> sector rises by 1 unit, x_{ij} will rise by $\bar{a}_{ij}$ units. That is these aggregate production coefficients can no longer be identified with the direct effect of an increase in output of the directly consuming sector, but include the indirect effects due to an increase in the output of any other sector. Furthermore, in the form of (3.9), all sectors are presumed to have an equal effect on the (x_{ij})th flow.

Tilanus does not offer any rationalization of these assumptions. Indeed the only usefulness of working with aggregate-production coefficients rather than ordinary coefficients appears to be that it allows the coefficients to be summarized in a table, according to size. In order to examine further the significance of (3.9) consider a 2 by 2 I-O table. In such a table the balance equations would be:

$$x_{11} + x_{12} + Y_1 = X_1 \qquad (3.10)$$

$$x_{21} + x_{22} + Y_2 = X_2$$

In conformity with (3.9) let $x_{ij} = \bar{a}_{ij}(X_1 + X_2)$. Substituting in (3.10) gives:

$$\bar{a}_{11}(X_1 + X_2) + \bar{a}_{12}(X_1 + X_2) + Y_1 = X_1$$

$$\bar{a}_{21}(X_1 + X_2) + \bar{a}_{22}(X_1 + X_2) + Y_2 = X_2$$

or,

$$(1 - \bar{a}_{11} - \bar{a}_{12})X_1 - (\bar{a}_{11} + \bar{a}_{12})X_1 = Y_1$$

$$-(\bar{a}_{21} + \bar{a}_{22})X_1 + (1 - \bar{a}_{21} - \bar{a}_{22})X_2 = Y_2$$

$$\begin{bmatrix} (1 - \bar{a}_{11} - \bar{a}_{12}) & -(\bar{a}_{11} + \bar{a}_{12}) \\ -(\bar{a}_{21} + \bar{a}_{22}) & (1 - \bar{a}_{21} - \bar{a}_{22}) \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} \qquad (3.11)$$

$$(I - \bar{A})X = Y \qquad \text{where} \qquad \bar{A} = \begin{bmatrix} (\bar{a}_{11} + \bar{a}_{12}) & (\bar{a}_{11} + \bar{a}_{12}) \\ (\bar{a}_{21} + \bar{a}_{22}) & (\bar{a}_{21} + \bar{a}_{22}) \end{bmatrix}$$

Solving for X gives:

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \frac{1}{D} \begin{bmatrix} (1 - \bar{a}_{21} - \bar{a}_{22}) & (\bar{a}_{11} + \bar{a}_{12}) \\ (\bar{a}_{21} + \bar{a}_{22}) & (1 - \bar{a}_{11} - \bar{a}_{12}) \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}$$

Where $D = 1 - \bar{a}_{21} - \bar{a}_{22} - \bar{a}_{11} - \bar{a}_{12}$

Consider now an increase in Y_1 by 1 unit and a decrease in Y_2 by 1 unit.

$$X_1 = \frac{1 - \bar{a}_{21} - \bar{a}_{22} - \bar{a}_{11} - \bar{a}_{12}}{1 - \bar{a}_{21} - \bar{a}_{22} - \bar{a}_{11} - \bar{a}_{12}} = 1$$

$$X_2 = \frac{-(1 - \bar{a}_{21} - \bar{a}_{22} - \bar{a}_{11} - \bar{a}_{12})}{1 - a_{21} - a_{22} - a_{11} - a_{12}} = -1 \qquad (3.12)$$

Thus if Y_1 increases by 1 unit while Y_2 decreases by 1 unit, according to (3.12), X_1 will increase by 1 unit and X_2 will decrease by 1 unit. This result implies that the indirect effects from a unit increase in Y_1 and a unit decrease in Y_2 cancel out. This property is not common with the usual I-O model and indeed is rather difficult to justify. In general one would not expect such symmetry to hold in reality.

Tilanus conducts his analysis on a time series of coefficients in two chapters. In his chapter 3, he analyzes the properties of the linear trends. It is in this chapter that he finds the disturbances of these linear trends strongly autocorrelated. The analysis in this chapter is wholly in terms of aggregate-production coefficients. In his chapter 7, Tilanus uses linear regressions of the coefficients over the period 1948-57 to predict intermediate demands for 1958-61 and compares squared prediction errors with those obtained from using various averages of coefficients and also from the single 1957 I-O table. Tilanus does not state whether, in this chapter, he is using ordinary coefficients or aggregate-production coefficients. The impression that one gets is that in fact he is using aggregate-production coefficients since he refers to his results in chapter 3 on the presence of autocorrelation. In fact he does not give t-statistics or Von-Neumann ratios for his linear trends in this chapter. If in fact he is using aggregate-production coefficients then two things are worth noting. First, in view of the rather undesirable properties of (3.9) noted above it is not too surprising that the results are generally speaking, poor. Second, it will be noted from (3.11) that the elements of the matrix of aggregate-production coefficients ($\bar{A}$) are linear combinations of the $\bar{a}_{ij}$'s . Tilanus (1966, pp. 54, 126) uses the following to predict intermediate demand

$$Z = \left[(I - A)^{-1} - I\right] f \qquad (3.13)$$

where Z is the n x 1 column of intermediate demand

f is the n x 1 column of final demand

Thus in (3.13), the element of the A matrix must also be a linear combination of the aggregate-production coefficients. However Tilanus gives no indication that this is the case.

If on the other hand, the analysis in his chapter 7 is in terms of ordinary I-O coefficients, then the results obtained in his chapter 3 are irrelevant since they pertain to a different model. In this case one would have to examine anew the properties of the linear regressions in his chapter 7. As these are not provided, very little can be said on how meaningful his forecasts are.*

Conclusion

The main purpose of this chapter was to present a brief summary of the I-O model and to examine some of the empirical studies utilizing a time series of I-O tables.

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* It should be noted that in a recent study Frenger (1978) analyzes some of Tilanus' results by using 13 annual I-O tables for the Norwegian economy. His approach parallels that developed in the next chapter, and essentially involves the introduction of relative prices as explanatory variables in the regressions on the technical coefficients. One limiting aspect of Frenger's study is that he considers only three sectors i.e., construction, metals and textiles. He finds that though the Leontief hypothesis is generally rejected, the forecasting performance of his model is "somewhat mixed". Relative to the forecasts (for the year 1961) obtained from using the I-O model and the I-O table for 1960, his model gives superior forecasts only for the construction sector.

The major empirical work on a time-series of I-O tables was seen to be the study by Tilanus (1966). As was noted, Tilanus finds that predictions using an extrapolated matrix based on a time-series of I-O tables compare unfavourably with those obtained from using the latest I-O table. Since this result runs counter to the main theme of this study Tilanus' results were examined at some length.

Several problems with Tilanus' approach were identified. These may be summarised as follows. First, it was pointed out that despite strong evidence of autocorrelation in his regressions of the technical coefficients on a time trend, he neither corrects for autocorrelation, nor adjusts his predictions.

Second, it was noted that Tilanus estimates only linear time trends of the technical coefficients. He leaves unexplored the possibility of getting better estimates through other functional forms, or through the inclusion of other explanatory variables in his regressions.

Third, it was pointed out that Tilanus uses aggregate production coefficients in estimating the linear trends. The implications of these coefficients were examined and it was found that they imply some restrictions not usually imposed in the I-O model. Furthermore, it is not clear from his study whether his forecasts are based on these aggregate-production coefficients or the traditional technical coefficients.

These considerations cast doubt on Tilanus' conclusions regarding the usefulness of a time series of I-O tables.

In particular, it appears that Tilanus' study has adhered too rigidly to the assumptions of the traditional I-O model. Indeed, one would expect that the availability of a time series of I-O tables would allow the relaxation of some of the traditional assumptions. This issue will be examined more closely in the next chapter.

CHAPTER IV

INPUT-OUTPUT AS A SIMPLE MACRO MODEL

Introduction

In the previous chapter it was stated that the availability of a time-series of I-O tables allows the relaxation of some of the traditional assumptions of the I-O model. The purpose of this chapter is to explore this avenue more closely, with the aim of constructing a macro model based on a time-series of I-O tables.

The first section presents an alternative specification to the Leontief production function allowing for input substitution. The second section examines ways of linking the I-O model with Keynesian final demand models. Finally, the third section provides a synthesis of the two previous sections in the form of a macro model, characterized by both a supply and demand dimension.

The Generalized Leontief Cost Function

As noted in the previous chapter, one of the basic assumptions of the I-O model is that inputs are demanded in fixed proportions to output. The production function giving rise to these input demand functions, usually identified as the Leontief production function, has the following form (Dorfman, Samuelson and Solow 1958, p. 209; Chenery and Clark 1959, p. 39):

$$X_j \leqq (x_{1j}/a_{1j}\ , \ x_{2j}/a_{2j}\ , \ \ldots \ , \ x_{nj}/a_{nj}) \qquad (4.1)$$

$$\text{for} \quad j = 1,\ldots.n$$

For the two input case, the Leontief production function for sector 1 reduces to:

$$X_1 \leqq (x_{11}/a_{11}\ , \ x_{21}/a_{21}) \qquad (4.2)$$

This implies two conditions, namely, $X_1 \leqq x_{11}/a_{11}$ and $X_1 \leqq x_{21}/a_{21}$. Let $X_1 = 1$. Then these two conditions may be represented diagrammatically as shown in Fig. 4.1 .

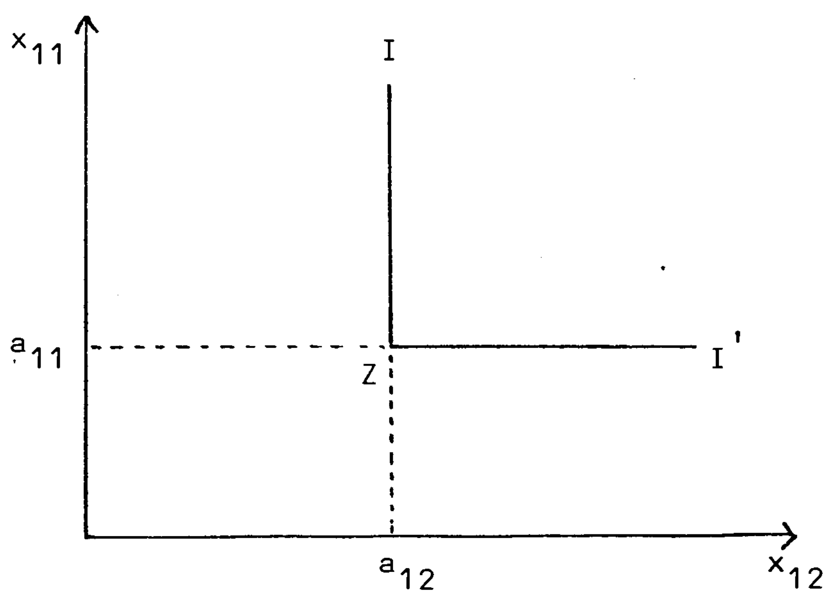

Fig. 4.1

IZI' gives the various combinations of inputs that may be used to produce one unit of output. Thus, it represents the isoquant for one unit of output of sector 1. However, so long as both inputs are not free, Z is clearly superior to any other point on IZI'; the cost-minimizing entrepreneur would choose point Z since this represents the minimum amount of both inputs necessary to produce one unit of output. Generalizing this argument leads to the following equations:

$$x_{ij} = a_{ij}X_j \; ; \quad j = 1,\ldots n \; ; \; i = 1,\ldots n \tag{4.3}$$

Thus, equations (4.3) may be interpreted as the cost-minimizing input-demand functions implied by the Leontief production function.

In the traditional theory of the firm the derivation of the cost-minimizing input-demand functions is not as simple as above. The production function assumed is such that the isoquants are convex to the origin. In contrast to the Leontief isoquant, there is not a point on the isoquant which may be discerned as superior by just looking at the isoquant. The entrepreneur requires additional information in the form of the relative price of the inputs, to determine the cost-minimizing combination of inputs.

Since the scope of this section is to extend the I-O model by allowing for factor substitution, the question that arises is what kind of production function should be specified? Once a production function is specified, the cost-minimizing input-demand functions may be derived and used to supplant equations (4.3).

An alternative, and more elegant approach, is to specify instead, the functional form of the cost function. Due to the duality that exists between production and cost functions,* if producers minimize input costs then the cost function contains sufficient information to completely describe the production function: that is, if the cost function satisfies some restrictions (see below), then one can be sure, without explicit specification of any production function that there exists a well behaved** production function (Baumol 1977, pp. 370-372; Diewert 1971). Furthermore, through a result known as Shephard's Lemma (Diewert 1971, p. 495), the cost-minimizing input-demand functions may be easily derived as the partial derivatives of the cost function with respect to the prices of the factors. This is one major advantage of using this alternative approach as it is impossible, in general, to solve the constrained cost-minimization problem under the first approach. A second advantage is that the functional form of the cost function used in this study yields input demand functions which are linear in parameters. This facilitates considerably the estimation of these parameters by linear regression techniques.

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* A result established by Shephard (1953) and refined by Uzawa (1964), Shephard (1970) and Diewert (1971).

** i.e., a standard production possibility set.

Diewert (1971) has developed what he calls a generalized Leontief cost function defined as follows:

$$C = h(X) \sum_{i}^{n} \sum_{j}^{n} b_{ij} p_i^{1/2} p_j^{1/2} \qquad (4.4)$$

where p_i is the price of input i, X is the selected output level and h(X) is a function of X that is continuous, monotonically increasing and such that h(0) = 0, with h tending toward infinity with X . It is also postulated that the parameter values satisfy $b_{ij} = b_{ji}$.

It should be noted that, first, this cost function is linearly homogenous in prices i.e., multiplication of each p_i by the same constant k multiplies the entire function C, exactly by $(k^{1/2})(k^{1/2}) = k$. Second, the function increases monotonically and continuously with X by the assumed properties of h(X) . Third, provided the parameters b_{ij} satisfy a certain set of inequalities (see below), the function will be concave in prices. Under these general conditions (Baumol 1977, p. 367), by the duality between cost functions and production functions, one may be sure that there exists a well-behaved production function which corresponds to (4.4).

To illustrate further the properties of this cost function consider the case of two factor inputs, and let h(X) = X . In this case the cost function (4.4) reduces to:

$$C = b_{11}p_1X + 2b_{12}p_1^{1/2}p_2^{1/2}X + b_{22}p_2X \qquad (4.5)$$

The average cost function of (4.5) is:

$$AC = b_{11}p_1 + 2b_{12}p_1^{\frac{1}{2}}p_2^{\frac{1}{2}} + b_{22}p_2 \tag{4.6}$$

which is equal to marginal cost. Moreover both average and marginal costs are constant as output increases. These conditions imply constant returns to scale (Bilas 1971, p. 149), a direct result of the assumption that $h(X) = X$. Using Shephard's Lemma, the input demand functions may be derived by differentiating (4.5) in turn with respect to relative prices: i.e.,

$$\partial C/\partial p_1 = x_1 = b_{11}X + b_{12}(p_2/p_1)^{\frac{1}{2}}X \tag{4.7}$$

$$\partial C/\partial p_2 = x_2 = b_{22}X + b_{12}(p_1/p_2)^{\frac{1}{2}}X \tag{4.8}$$

The first point to note is that if $b_{12} = 0$ in (4.7) and (4.8) or more generally $b_{ij} = 0$, for $i \neq j$ in (4.4), then the input demand functions reduce to the Leontief specification. This, of course, is why Diewert calls his relationship a generalized Leontief cost function.

The second point to note is that in (4.5) the condition $b_{ij} = b_{ji}$, for $i \neq j$ has been imposed. This condition, called the symmetry constraint, is a result derived by Samuelson (1947), among others, and states that: "The change in the kth factor with respect to a change in the jth price, output being constant, must be equal to the change in the jth factor with respect to the kth price, output being constant; a result which is not intuitively obvious" (Samuelson 1947, p. 64).

Finally, there are two properties which the cost function should satisfy to be consistent with economic theory: (a) monotonicity of cost with respect to prices and (b) concavity of the cost function with respect to prices.* These properties may hold globally, meaning for all positive prices, or locally at specific prices (Woodland 1975, p. 177; Diewert 1971, pp. 501-503).

If all $b_{ij} \geqq 0$, then both conditions would be satisfied.** If $b_{ij} \geqq 0$ for $i \neq j$ (eg. b_{12} in (4.7) and (4.8)), then concavity is satisfied for all prices and output levels (Parks 1971, p. 135). Since this allows for the case where $b_{ij} < 0$ for $i = j$, subject to satisfying condition (a), consider the case where $b_{11} < 0$ in (4.7) and (4.8), and let $X = 1$. The input demand functions implied in this case are the following:

$$x_1 = b_{11} + b_{12}(p_2/p_1)^{\frac{1}{2}} \; ; \quad x_2 = b_{22} + b_{12}(p_1/p_2)^{\frac{1}{2}} \qquad (4.9)$$

The demand for input x_1 will be zero if $b_{12}(p_2/p_1)^{\frac{1}{2}} \leqq b_{11}$ since a negative input is not defined. Geometrically, this implies that the isoquant intersects the x_2 axis as shown in Fig. 4.2 .

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* Condition (a) ensures that an increase in prices increases costs while condition (b) requires that the isoquants be convex.

** Parks (1971, p. 131) notes that this rules out complementarity. In the same context Woodland (1975, p. 173) points out that "if these parameter restrictions do not hold then the cost function defined by 2.1 [4.4 above] may still provide a second order approximation to the 'true' cost function. Further, all of the required properties of a cost function may still hold locally, say at each of the observed sample points."

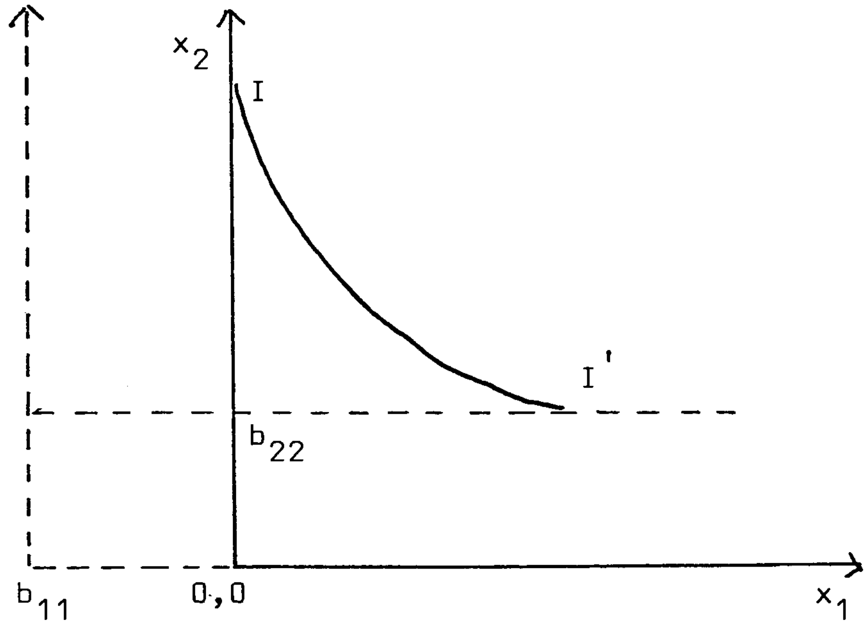

Fig. 4.2

Hence in this case the first input x_1 is nonessential in the sense that if its price rises sufficiently relative to the second input, then x_1 will not be used by a cost minimizing producer (Diewert 1971, p. 504).

Parks (1971)* extends the generalized Leontief cost function in two directions. First he allows for other than constant returns to scale by specifying a cost function which is quadratic in output: i.e.,

$$C = X \sum_i^n \sum_j^n b_{ij} p_i^{\frac{1}{2}} p_j^{\frac{1}{2}} + X^2 \sum_i^n p_i a_i \qquad (4.10)$$

This has a marginal cost function which is linear, i.e.,

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* Woodland (1975) also makes use of these extensions by Parks.

$$MC = \sum_{i}^{n} \sum_{j}^{n} b_{ij} p_i^{\frac{1}{2}} p_j^{\frac{1}{2}} + 2X \sum_{i}^{n} p_i a_i \qquad (4.11)$$

The second variation that Parks makes is to introduce a time trend to allow for technical change. He proposes the following two alternative specifications (where T denotes the time trend):

$$C = X \sum_{i}^{n} \sum_{j}^{n} b_{ij} p_i^{\frac{1}{2}} p_j^{\frac{1}{2}} + X^2 \sum_{i}^{n} p_i a_i + TX \sum_{i}^{n} p_i t_i \qquad (4.12)$$

$$C = X \sum_{i}^{n} \sum_{j}^{n} b_{ij} p_i^{\frac{1}{2}} p_j^{\frac{1}{2}} + X^2 \sum_{i}^{n} p_i a_i + T \sum_{i}^{n} p_i t_i \qquad (4.13)$$

(4.12) allows for changes in the marginal cost over time while (4.13) allows for shifts in total cost over time, without affecting marginal cost.

To examine how the I-O model is altered by the introduction of the generalized Leontief cost function, consider the case of a two-sector I-O table given in Table 4.1 . In this table, the inputs of each sector are identified by the prefix A for sector 1 and B for sector 2. Also, the primary inputs from imports and labour are denoted by X_3 and X_4 respectively, the output of sectors 1 and 2 by XA and XB, while R stands for gross profits and T for taxes on expenditure. The rest of the notation is consistent with that used in the previous chapter.

Since there are four possible types of inputs, a generalized Leontief cost function is set up for each sector (eq. (4.14) and (4.15)), with four prices and outputs as arguments.

TABLE 4.1

	1	2	C	I	G	E	
1	AX_1	BX_1	C_1	I_1	G_1	E_1	XA
2	AX_2	BX_2	C_2	I_2	G_2	E_2	XB
M	AX_3	BX_3	C_3	I_3	G_3	E_3	M
L	AX_4	BX_4	-	-	-	-	L
R	R_1	R_2	-	-	-	-	R
T	T_1	T_2	-	-	-	-	T
			C	I	G	E	

where C_i = Consumption of good i

I_i = Investment of good i

G_i = Government expenditure on good i

E_i = Exports of good i

R_i = Gross Profits

$$CA = XA \sum_i \sum_j Ab_{ij}(P_i)^{\frac{1}{2}}(P_j)^{\frac{1}{2}} \qquad i = 1,\ldots 4;\ j = 1,\ldots 4 \qquad (4.14)$$

$$CB = XB \sum_i \sum_j Bb_{ij}(P_i)^{\frac{1}{2}}(P_j)^{\frac{1}{2}} \qquad i = 1,\ldots 4;\ j = 1,\ldots 4 \qquad (4.15)$$

$$AX_i = XA \sum_{j=1}^{4} Ab_{ij}(P_j/P_i)^{\frac{1}{2}} \qquad i = 1,\ldots 4 \qquad (4.16)$$

$$BX_i = XB \sum_{j=1}^{4} Bb_{ij}(P_j/P_i)^{\frac{1}{2}} \qquad i = 1,\ldots 4 \qquad (4.17)$$

$$AX_1 + BX_1 + C_1 + I_1 + G_1 + E_1 = XA \qquad (4.18)$$

$$AX_2 + BX_2 + C_2 + I_2 + G_2 + E_2 = XB \qquad (4.19)$$

In (4.14) and (4.15) both industries are assumed to be characterized by constant returns to scale. Assuming cost minimizing behaviour and imposing the restrictions $b_{ij} = b_{ji}$ for each sector, input demand equations are derived, as shown by equations (4.16) and (4.17). Equations (4.18) and (4.19) are the equilibrium conditions where the left hand side represents the demand for each good and the right hand side the supply of each good, respectively.

The assumption that for both sectors constant returns apply, implies that the supply curve of each good is infinitely elastic. That is, both industries can supply any amount of output at the ruling price, as shown in figures 4.3 and 4.4 .

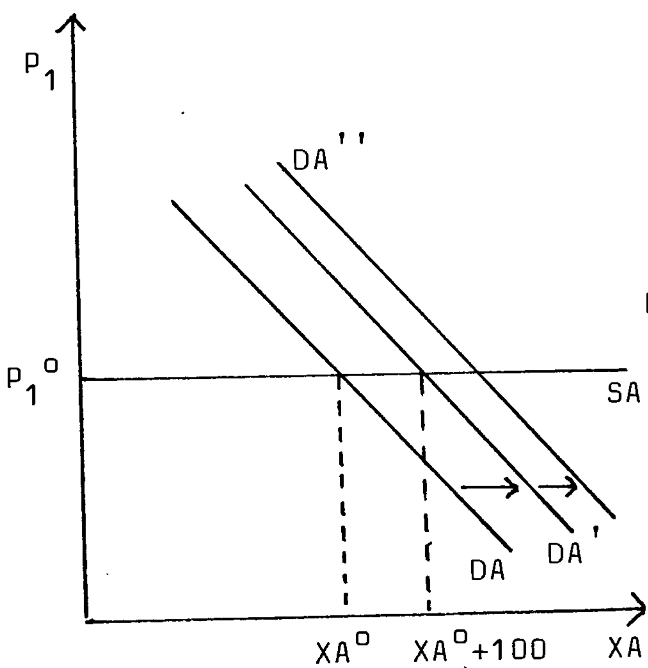

Fig. 4.3

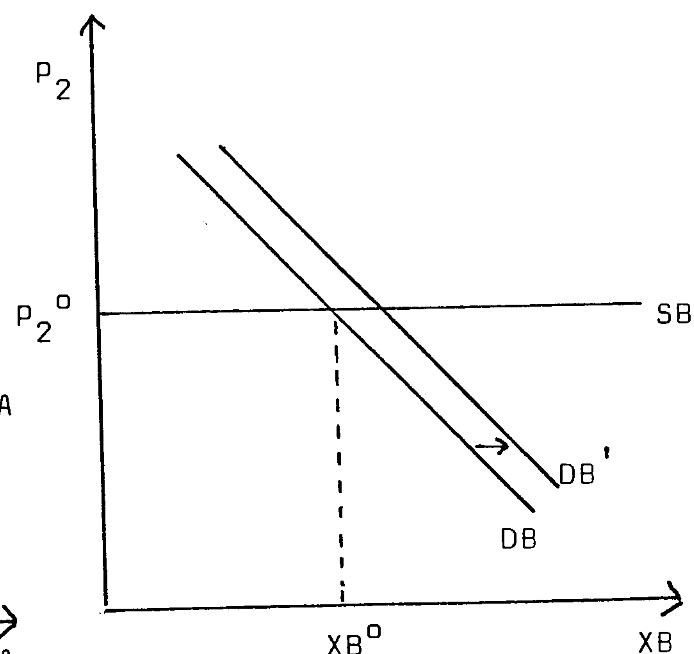

Fig. 4.4

The demand for each good is made up of two components. The final demand for each good (i.e., $C_i + I_i + G_i + E_i$) is assumed to be exogenous, while the intermediate demand is determined by the input demand equations (i.e., AX_i and BX_i for i = 1, 2 in equations (4.16) and (4.17)). If it is assumed that $Ab_{ij} > 0$ and $Bb_{ij} > 0$ for $i \neq j$, then an increase in P_i in (4.16) and (4.17) will lead to a lower demand for that good since the (P_j/P_i) ratio will become smaller. Thus the demand curves are downward sloping.

To examine the interactions implied by this model consider the following example. Suppose E_1 , that is part of the exogenous demand for XA , increases by 100 units. This will shift DA to DA' by 100 units to $XA^o + 100$. However, this is only the first round effect. Since more of XA is produced, more inputs will be required so that DA' shifts to say DA'' and DB to DB'. These shifts will in turn cause further shifts in both demand curves with the process continuing until new equilibrium positions for both XA and XB are reached.

A general expression for the equilibrium values of gross outputs may be derived in the same way as in the traditional I-O model. In the example of Table 4.1, the input demand functions (i.e., equations (4.16) and (4.17)) are used to substitute for AX_1, AX_2, BX_1 and BX_2 in the equilibrium equations (4.18) and (4.19). This yields two equations in the two unknowns XA and XB so that the model can be solved. In matrix notation the solution may be represented as follows:

$$X = (I - B)^{-1}Y \tag{4.20}$$

where X is a vector with XA and XB as elements, B is a 2 by 2 matrix with its elements being $\sum Ab_{ij}(P_j/P_i)^{\frac{1}{2}}$ and $\sum Bb_{ij}(P_j/P_i)^{\frac{1}{2}}$ from the input demand functions, and Y is a two element vector with $Y_1 = C_1 + I_1 + G_1 + E_1$ and $Y_2 = C_2 + I_2 + G_2 + E_2$. Thus, given relative prices and final demand Y, gross output by sector can be determined through (4.20). Once gross outputs are determined, employment and imports by sector can be determined through their respective input demand functions in (4.16) and (4.17).

From the previous chapter, the solution of the traditional I-O model is as follows:

$$X = (I - A)^{-1}Y \tag{4.21}$$

where A is the matrix of technical coefficients derived from the assumption that inputs are used in fixed proportions to output.

Note that the inverse matrix in (4.20) (i.e., the multipliers) will differ from the inverse in (4.21) by the extent to which the Ab_{ij}'s and Bb_{ij}'s (for $i \neq j$) in (4.20) differ from zero. In other words, this generalization of the I-O model as represented by (4.20) reduces to the traditional I-O model if there is no factor substitution. Furthermore, so long as some of these parameters are not equal to zero, then due to the specification of the input demand functions which are multiplicative in relative prices and output, the multipliers in (4.20) will change with any change in relative prices. Thus, as relative prices are likely to change from period to period, a new inverse matrix will have to be calculated every period.

The benefits of using (4.20) rather than the traditional I-O model may be summarised as follows. First, this generalization of the I-O model allows for factor substitution. This brings the I-O model more in line with economic theory, and permits a direct test of the traditional assumption of no factor substitution.

Second, the estimation of input demand functions allows the calculation of elasticities of substitution between each pair of inputs. For instance Parks (1971, p. 135) uses the Allen partial elasticity of substitution defined as follows:

$$\sigma_{ij} = C\, C_{ij}/C_i C_j \qquad (4.22)$$

where C = total cost for a particular sector

$C_i = \partial C/\partial P_i$

$C_{ij} = \partial^2 C/\partial P_i \partial P_j$

Thus if the price of the ith factor rises relative to the jth factor,(4.22) gives a measure of the extent of input substitution.

Third, this model provides a more general equilibrium specification of the economy than in the traditional I-O model where input demands are insensitive to price changes. Consider once more the simple model in Table 4.1 . An increase in the price of sector 1 leads to a lower intermediate demand for its output. That is BX_1 and AX_1 should fall so that XA falls. To the extent that the output of sector 2 is substituted for that of sector 1, the output of sector 2 should rise. However this is not necessarily the case since sector 1 would demand less of all inputs as the output of sector 1 has fallen. Thus the demand for XB may rise or fall according as the substitution effect is stronger or weaker than the effect through the demand for the product. Similarly for imports and employment, the net effect may go either way.

Fourth, this model also provides a test of the conclusion reached by Tilanus (1966), that a time series of I-O tables compares unfavourably with using only the latest I-O table. This is of interest since it appears from the literature that the study by Tilanus has been quite influential in discouraging attempts to collect annual I-O tables.

Finally, perhaps the most significant difference is from an application standpoint. Characteristically, I-O tables are published with a lag. In the case of Malta, this lag is 3 years. Thus if the traditional model is used for policy analysis, there is the very fundamental criticism that the table used might be outdated. Recognizing this deficiency and also recognizing that in fact technical coefficients do change over time, I-O theorists have devised several methods of adjusting, updating and projecting technical coefficient matrices. Unfortunately, these methods tend to be too mechanical. For instance, the basic method is the R.A.S. or biproportional technique,* due to Stone (1963) and his associates. In the R.A.S. procedure, it is hypothesised that direct input coefficients are subject to a substitution effect - i.e., substitutions of one input for another - and a fabrication effect - i.e., more or less value added to the inputs. It is further assumed that these effects act evenly over rows and columns via a substitution multiplier (R_j) and a fabrication multiplier (S_j). The R.A.S. method involves "determination of the (unique) set of values for R_j and S_j which, when applied to an observed base year co-efficient matrix A , generates a second matrix A^* whose elements are consistent with a pair of vectors u^* and v^* representing the observed values of total intermediate output and input by industry in the update year" (Allen and Lecomber 1975). The procedure may be summarised as:

$$A^* = R\ A\ S \qquad (4.23a)$$

such that

$$(A^* \bar{x}^*)i = X^*i = u^* \qquad (4.23b)$$

and

$$(A^* \bar{x}^*)'i = X^{*'}i = v^* \qquad (4.23c)$$

where x^* is the vector of gross industrial output in the update year, $A^*\bar{x}^* = X^*$ is the estimate of the inter-industry

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* Various modifications of the R.A.S. procedure abound in the literature as for example, those suggested by Almon (1968), Friedlander (1961), Matuszewski (1964), and Theil (1967).

flow matrix for the update year, and i is the unit summation vector. The bar above a vector indicates a diagonal matrix.

Thus, given the vector of gross industrial output (x^*) and the vector of total intermediate output (u^*) and input (v^*) in the update year, the R_i and S_j multipliers may be calculated through an iterative technique. Once these multipliers are determined, not only will (4.23a) provide an update of the base year technical coefficient matrix, but also these multipliers may be used to project the changes in the technical matrix into the future. For example:

$$A^{**} = \bar{R}\, A^{*}\, \bar{S} \tag{4.23d}$$

where A^{**} is the projected technical coefficient matrix.

Lecomber (1975) has pointed out that the biproportional assumption has no special economic significance. Miernyk (1975) goes even further and says that

> R.A.S. substitutes computational tractability for economic logic. There is no reason to believe that input coefficients will change in a uniform manner along rows and columns; indeed, there is every reason to believe the opposite. (Miernyk 1975)

In the system (4.20), however, all that is required to update the model are price indices for the various inputs. Thus the generalization of the Leontief I-O model suggested in this section allows the updating of the I-O model in a more satisfactory manner, utilizing econometric methods employing economic theory rather than mechanical techniques.

Endogenising Consumption

In the generalised I-O model of the previous section, as in the traditional I-O model, the multipliers implied by the inverse matrices are not complete multipliers. In particular, though the interconnections between industries are taken into consideration, the income propagation process is short circuited by the assumption of exogenous consumption of final goods and services. The object of this section is to extend further the I-O model by integrating it with Keynesian demand models.

The traditional approach for dealing with this problem of the exogeneity of consumption in I-O analysis is to treat households as another industry with labour services as output and consumption as input. By making the assumption of constant input coefficients for consumption i.e., $C_i = c_i C$, a new inverse matrix can be derived which is supposed to reflect complete multipliers.

However, two problems arise with this approach. First, consumption is not done by workers alone but also by the recipients of profits. Second, and more importantly, consumers are not technologically-determined production processes, but rather choice making organisms. The effect of this is that the inverse matrix multiplier may embody an element of instability.

Instead of treating households as an industry, a natural alternative is to introduce the Keynesian consumption function in its disaggregated form. Miyazawa (1960) for example, makes consumption by sector depend upon total income or value added. Thus consumption demand D, can be written as:

$$D = ck(I - A)X \qquad (4.24)$$

where D = a column vector of consumption demand

c = a column vector of consumption coefficients

k = a row vector of ones

To clarify (4.24) further consider the two sector case as represented in Table 4.2 . Equation (4.24) will now reduce to:

$$\begin{bmatrix} d_1 \\ d_2 \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} 1 - a_{11} & a_{12} \\ a_{21} & 1 - a_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$$

$$= \begin{bmatrix} c_1 \left[(1 - a_{11} - a_{21})X_1 + (1 - a_{22} - a_{12})X_2\right] \\ c_2 \left[(1 - a_{11} - a_{21})X_1 + (1 - a_{22} - a_{12})X_2\right] \end{bmatrix} \qquad (4.25)$$

As can be confirmed from Table 4.2 , the terms in the square brackets for c_1 and c_2 represent the sum of value added for both sectors 1 and 2 (i.e., $Y_1 + Y_2$). Substituting D in (4.32) by (4.24) and writing C for ck yields:

$$(I - A + M)X = C(I - A)X + F \qquad (4.26)$$

Solving for X gives:

$$X = \left[(I - C)(I - A) + M\right]^{-1}F \qquad (4.27)$$

Thus (4.27) represents the I-O model adjusted to include Keynesian consumption functions.

TABLE 4.2*

	1	2	C	E	G	I	M	
1	x_{11}	x_{12}	d_1	E_1	G_1	I_1	M_1	X_1
2	x_{21}	x_{22}	d_2	E_2	G_2	I_2	M_2	X_2
Y	Y_1	Y_2						Y
	X_1	X_2	C	E	G	I	M	

$$x_{ij} = a_{ij}X_j \tag{4.28}$$

$$M_i = m_iX_i \tag{4.29}$$

$$x_{11} + x_{12} + d_1 + E_1 + G_1 + I_1 - M_1 = X_1 \tag{4.30}$$

$$x_{21} + x_{22} + d_2 + E_2 + G_2 + I_2 - M_2 = X_2 \tag{4.31}$$

$$(I - A + M)X = D + F \tag{4.32}$$

where M_i = Imports of good i

d_i = Consumption of good i

X_i = Gross output of good i

x_{ij} = Inter-industry flow from sector i to sector j

$F_i = E_i + G_i + I_i$

For the rest of the notation see Table 4.1

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* Note that the system in Table 4.2 has already been described in Chapter III. See for example equation (3.2) in Chapter III which is equivalent to equation (4.32) above, where Y in equation (3.2) is now defined as D + F in equation (4.32).

Klein (1968) goes even further by suggesting that the I-O system could be closed by specifying final demand for each sector i as follows:

$C_i = h_i(GNP - T)$	consumer demand	(4.33)
$I_i = f_i(GNP)$	private capital formation	(4.34)
$E_i = l_i(X_w)$	net exports	(4.35)
$G_i = g_i(N)$	government purchase of goods and services	(4.36)

where X_w = World Trade

N = Population

T = Taxes less transfer payments and other public items

The major problem confronting this approach is that data on the disaggregated components of final demand are usually not available except for years for which an I-O table has been computed. It would require much "statistical faith" to base estimates of behavioral demand relations on one-element or very small samples. On the other hand, data on the aggregated components of final demand (i.e., consumption, capital formation etc.) are available in much bigger samples. This has led to an alternative approach of integrating I-O with final demand models, first implemented in the Brookings Econometric model (Fisher, Klein and Shinkai 1965).*

To facilitate the exposition of this approach consider once more the case of the two sector I-O table which is

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* See also Preston (1972) No. 7, pp. 14-20; and Seguy and Ramirez (1975).

reproduced in Table 4.3 . Note that Table 4.3 has some changes in notation. In particular, final demand is divided into two components D_1 and D_2 , as is value added (i.e., W_1 for wages and W_2 for gross profits).

Consider equations (4.38) to (4.46) given in Table 4.3 . Equations (4.38) to (4.41) in Table 4.3 are the familiar equations of the I-O model and hence require no further elaboration. Equations (4.42) state that the delivery of good i to final demand category j , is a constant proportion of the total final demand category j . For example, let D_1 (and its subdivisions F_{11} and F_{21}) stand for consumption. Then, according to (4.42) the consumption of,say,good 1 is a constant proportion of aggregate consumption. Aggregating final demand by sector gives equations (4.42) which may be represented in matrix notation as (4.43) where F is a column vector with F_1 and F_2 as elements, H is a 2 by 2 matrix with its elements being the h_{ij}'s and D is a column vector with its elements being D_1 and D_2 . Equations (4.44) and (4.45) define income arising from each sector (i.e., value added) as gross output minus intermediate input. These are also represented in matrix notation as (4.46) where B is a 2 by 2 diagonal matrix with its diagonal elements being $1 - \sum a_{i1}$ and $1 - \sum a_{i2}$. Substituting (4.41) and (4.43) into (4.46) yields:

$$Y = B(I - A)^{-1}HD \qquad (4.37)$$

Recall that the elements of D in (4.37) are the components of final demand aggregated by final demand category, as for

TABLE 4.3

	1	2	D_1	D_2	Total Final Demand by Sector	TOTAL
1	x_{11}	x_{12}	F_{11}	F_{12}	F_1	X_1
2	x_{21}	x_{22}	F_{21}	F_{22}	F_2	X_2
W_1	Y_{11}	Y_{12}				W_1
W_2	Y_{21}	Y_{22}				W_2
Total Value Added by Sector	Y_1	Y_2				
TOTAL	X_1	X_2	D_1	D_2		

$$x_{ij} = a_{ij}X_j \tag{4.38}$$

$$\Sigma x_{1j} + \Sigma F_{1j} = X_1 \tag{4.39}$$

$$\Sigma x_{2j} + \Sigma F_{2j} = X_2 \tag{4.40}$$

$$X = (I - A)^{-1}F \tag{4.41}$$

$$F_{ij} = h_{ij}D_j \tag{4.42}$$

$$F = HD \tag{4.43}$$

$$Y_1 = \Sigma Y_{i1} = X_1 - \Sigma a_{i1}X_1 \tag{4.44}$$

$$Y_2 = \Sigma Y_{i2} = X_2 - \Sigma a_{i2}X_2 \tag{4.45}$$

$$Y = BX \tag{4.46}$$

example aggregate consumption of goods and services, aggregate exports etc. These are usually the type of variables used in final demand models. Thus given a macro model explaining D , equation (4.37) establishes the required link between final demand models and the I-O model.

To illustrate further, let some exogenous component in D , say aggregate exports, increase by 1 unit. The purpose of the H matrix in (4.37) is to distribute this increase in exports among the various sectors. The inverse matrix will then give the amount by which gross output of each sector must increase to satisfy both the direct and indirect requirements. The purpose of the B matrix is then to translate this increase in gross outputs into an increase in income by sector. Since some components of D (eg., consumption) are a function of income (through the final demand block of the model), a second round effect is implied as these components in D respond to a change in income. This process continues until a new equilibrium level for all variables is reached.

Thus, given the technical coefficients matrix A, the matrix of industrial distribution of final demand H and a final demand model explaining the behaviour of D , a link has been established between final demand spending categories (D's) and value added or income arising by sector (Y's) - a link that takes into account the structure of industrial interdependence in the economy.

Note that this approach has in effect circumvented the problem of estimating behavioural demand equations on one-element samples by, instead, estimating these equations in the aggregate. However the problem of the stability of the H and A matrices remains. In (4.37) it has been implicitly assumed that the A and H matrices remain constant over time. Yet this is not so in actual life.

Since time series data for Y and D are usually available, one way to handle the changing coefficient problem is as follows.* Using time series data for D and given an I-O table from which the A and H matrices can be derived, a series of Y vectors can be estimated from (4.37) on the assumption that the A and H matrices remain constant.** These predicted values of Y can then be compared to the actual values and a column vector of residuals for each sector can be constructed. As the factors which make for changes in A and H are the same that give rise to the observed errors, an indirect way of allowing for changes in A and H is to model these residuals.

There are different ways in which to model these residuals. One way, following the approach of Fisher, Klein and Shinkai (1965) is to use autoregressive models. Preston (1972, p. 19) uses two such models:

(1) $U_{it} = f(U_{it-1}\ , T) + e_{it}$ $\qquad i = 1,...n$

(2) $U_{it} = f(U_{it-1}\ , U_{it-2}\ , T) + e_{it}$ $\qquad i = 1,...n$

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* An alternative approach is given in Preston (1975).

**Implicitly, through the assumed constancy of A, B is also assumed to remain constant.

where U_{it} are the computed residuals, T is a time trend variable and e_{it} are random disturbances.

The Generalized Input-Output Macro Model

A more direct approach to tackling the problem of changes in the A and H matrices discussed in the previous section, is to model these directly. This is usually not feasible due to data limitations. However, since a time series of I-O tables is available for this study, this alternative route is possible. One way of modelling the A matrix, through the generalized Leontief cost function, has already been suggested in the first section. To model the H matrix, the route suggested by Klein (1968) is chosen; that is, behavioural equations are set up for the final demand components by sectoral category.

The equations of the complete model, to be identified henceforth as the generalized I-O macro model, are listed below (eq. 4.16 to 4.53). To simplify,only the two sector case is represented.* Furthermore, it is assumed that exports (E_i), government expenditure (G_i), investment (I_i) and taxes on expenditure (T_i) are determined exogenously. Equations (4.16) to (4.19) are reproduced from Table 4.1 and refer to the input demand functions(eqs. 4.16, 4.17) and the equilibrium conditions (eqs. 4.18, 4.19).

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* The I-O table relevant to this case is shown in Table 4.1

The Generalized I-O Macro Model

$$AX_i = XA \sum_{j=1}^{4} AB_{ij}(P_j/P_i)^{\frac{1}{2}} \qquad i = 1,\ldots 4 \qquad (4.16)$$

$$BX_i = XB \sum_{j=1}^{4} Bb_{ij}(P_j/P_i)^{\frac{1}{2}} \qquad i = 1,\ldots 4 \qquad (4.17)$$

$$AX_1 + BX_1 + C_1 + I_1 + G_1 + E_1 = XA \qquad (4.18)$$

$$AX_2 + BX_2 + C_2 + I_2 + G_2 + E_2 = XB \qquad (4.19)$$

$$C_i = ac_i + bc_i YD + nc_i C_i(-1) + dc_i(P_i/P) \qquad i = 1,\ldots 3 \qquad (4.47)$$

$$W_1 = (AX_4)P_4 \quad , \quad W_2 = (BX_4)P_4 \qquad (4.48)$$

$$R_1 = XA - T_1 - W_1 - \sum_{i=1}^{3} AX_i \qquad (4.49)$$

$$R_2 = XB - T_2 - W_2 - \sum_{i=1}^{3} BX_i \qquad (4.50)$$

$$YP = \sum_{i=1}^{2} R_i + \sum_{i=1}^{2} W_i + INVF + TRAF + TRAGP + GOVD \qquad (4.51)$$

$$- GOVY - GOVR - CAPC - CORPY$$

$$TAXY = t_1 + t_2 YP \qquad (4.52)$$

$$YD = YP - TAXY - TRAPG \qquad (4.53)$$

cont./

XA = Gross output of sector 1

XB = Gross output of sector 2

AX_i = Input i of sector 1

BX_i = Input i of sector 2

P = Consumer price index

P_i = Price index for good i

C_i = Consumption of good i

$C_i(-1)$ = Lagged consumption of good i

I_i = Investment of good i

G_i = Government expenditure on good i

E_i = Exports of good i

T_i = Taxes on expenditure of good i

W_i = Wages of sector i

R_i = Gross profits of sector i

YP = Personal income

YD = Disposable income

TAXY = Income tax

INVF = Net investment income from abroad

TRAF = Transfers to persons from abroad

TRAGP = Transfers from government to persons

GOVD = Interest on government debt

GOVY = Government income from entrepreneurship

GOVR = Government rent, interest and dividends

CAPC = Capital consumption

CORPY = Corporate undistributed income

TRAPG = Transfers from persons to government

Equation (4.47) gives the consumption functions by sectoral category. Since these are disaggregated consumption functions, a relative price variable (P_i/P) is included. A lagged consumption term ($C_i(-1)$) is also included to capture the effect of permanent income. The case of i = 3 in (4.47) refers to consumption of imports.

The treatment of imports in this model is somewhat different from that implied by (4.37). In equations (4.37), aggregate imports are included in D so that an aggregate import function is estimated and distributed to the sectors through the matrix H (i.e., based on the proportionality assumption between sectoral imports and total imports).* However, in the generalized I-O macro model, imports are divided into two broad types: there are imports used by the sectors as inputs. These are determined through the input demand functions (AX_3 , BX_3). There are also imports directly consumed, that is, without further processing. These are determined through the consumption function for imports (i.e., C_3).

There is also a substantial difference in the determination of income between the generalized I-O macro model and that suggested by (4.37). Recall that income or value added is determined as a residual from equations (4.44) and (4.45) (Table 4.3), i.e.,

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* The inclusion of imports as an extra column in final demand is shown in the I-O table given in Table 4.2 . Imports may also be combined with exports to produce net exports.

$$Y_j = X_j - \sum_{i=1}^{2} a_{ij}X_j \qquad j = 1, 2 \qquad (4.54)$$

Dividing (4.54) by output yields:

$$Y_j/X_j = 1 - \sum_{i=1}^{2} a_{ij} \qquad j = 1, 2 \qquad (4.55)$$

That is (4.54) implicitly assumes that value added by sector is a constant proportion of output by sector, since the right hand side of (4.55) is a constant.

However, the generalized I-O macro model distinguishes two types of income. The first is income from employment. This is determined as follows. The demand for labour is determined through the input demand functions i.e., AX_4 and BX_4 in equations (4.16) and (4.17). Once the demand for labour by sector is known and given the wage rate by sector, income from employment may be determined (i.e., equations (4.48)). Thus in contrast to the system in (4.37) where employment is determined indirectly by setting up a relationship between value added and employment, the demand for labour comes out directly from the input demand functions in the generalized I-O macro model. Furthermore this type of income does not depend on the proportionality assumption (i.e., (4.55)) implied by (4.37). The second type of income, gross profits, is determined in the same way as in (4.54), that is, as output minus all other inputs (eqs. (4.49) and (4.50)). However, it does not necessarily remain a constant proportion of output by sector since the

a_{ij}'s in (4.55) are being modelled and thus may change due to say, a change in relative prices.

The rest of the equations in the generalized I-O macro model are quite self-explanatory. Equation (4.52) is an income tax function while equations (4.51) and (4.53) define personal income and disposable income respectively.

Thus it appears that the generalized I-O macro model does offer some distinct advantages over the system in (4.37). Not only does it model the A and H matrices in (4.37) directly but it also provides a more satisfactory treatment of employment, income and imports.

Conclusion

The main object of this chapter was to construct a macro model based on a time series of I-O tables. The approach adopted was to consider first how the assumptions of the traditional I-O model could be relaxed when a time series of I-O tables is available.

The first section dealt with the proportionality assumption of the I-O model; that is, the assumption that inputs are demanded in fixed proportions to output. The Leontief production function was substituted by the generalized Leontief cost function, and cost-minimizing input demand functions derived. The benefits of substituting these input demand functions for the fixed proportion ones in the I-O model may be summarised as follows. First, these generalized input demand functions not only allow for factor substitution but also reduce to the Leontief specification for the case of no factor substitution. Thus, the fixed proportion assumption is a special case of this alternative formulation enabling a direct test of the traditional assumption. Second, elasticities of substitution between each pair of inputs may be computed. Third, this extension of the I-O model provides a more general equilibrium specification of the economy in the sense that more interactions are implied than in the traditional I-O model where input demands are insensitive to price changes. Fourth, this specification also provides a test of the conclusion reached by Tilanus (1966) that a time series of I-O tables compares unfavourably with using only the latest I-O table. This is important because the study by Tilanus appears to have been quite influential in the I-O literature. Finally, in contrast to the R.A.S. technique, this extension of the I-O model provides a way of updating and projecting I-O tables which utilizes econometric methods employing economic theory rather than mechanical techniques.

The second section dealt with the assumption of exogenous final demand in the traditional I-O model. This assumption was seen to lead to incomplete multipliers, that is, multipliers which exclude the income propagation process. One solution to this problem that was discussed is the integration of I-O with Keynesian final demand models. A major problem with this approach, however, is the lack of time series data on the final demand section of the I-O table. The approach used in various models is to make an assumption of proportionality similar to the one that is made for the technical coefficient matrix. This allows a macro model, which usually deals with the aggregated components of final demand to be linked with the I-O model. The problem that arises is that the stability of both the technical coefficients matrix and the final demand coefficients matrix is somewhat suspect since these coefficients do change over time. The usual approach to this problem is to model the errors produced by using constant coefficients.

An alternative method that was suggested for dealing with coefficient changes is to model these coefficients directly. This is usually not feasible due to data limitations. However, since a time-series of I-O tables is available for this study, this alternative route is possible. One way of modelling the technical coefficient matrix is to use the generalized Leontief cost function. This represents the supply side of the economy. With regard to the final demand coefficient matrix, this is partially modelled by setting up consumption functions by sectoral category. This represents the demand side of the economy. The complete model, identified as the generalized I-O macro model, was presented in section three.

In addition to modelling directly the technical coefficient matrix and the final demand coefficient matrix, some further advantages over the conventional approach of integrating I-O with macro models, were noted. First, employment is determined directly through the input demand functions, rather than indirectly by linking value added to employment in the conventional approach. Second, in the traditional approach income or value added by sector is implicitly assumed to be a constant proportion of output by sector. In this model, income is divided into two broad types: (a) income from employment which is determined via the labour demand functions and the given average wage by sector. Thus this type of income does not depend on any proportionality assumption. (b) Gross profits is determined in the same way as in the traditional approach, that is as gross output minus total inputs. But here again, since inputs are not assumed to remain a constant proportion of output, no proportionality assumption is implied. Finally, imports are also determined differently. In this model, imports are divided into two broad types. There are imports used by sectors as inputs. These are determined via the import demand functions. There are also imports directly consumed. These are determined through a consumption function for imports.

In conclusion, the generalized I-O macro model presented in this chapter does offer some distinct theoretical advantages over the traditional I-O model and the conventional approach of linking I-O with macro models. It remains to be seen, however, how the model behaves empirically. This is the subject of the next chapter.

CHAPTER V

EMPIRICAL ESTIMATION OF THE GENERALIZED I-O MACRO MODEL

Introduction

This chapter deals with the empirical estimation of the generalized I-O macro model and is divided into 4 sections. The first section presents some modifications of the model, made necessary due to data constraints. The second section discusses briefly the data available while the third section presents the regression results. The fourth section provides ex-post forecasts for 1977 using both the traditional I-O model and the generalized I-O macro model.

Empirical Form of the Model

In the previous chapter it has been implicitly assumed that one of the inputs given in the I-O table is the capital input. However, the Maltese I-O tables, as well as the I-O tables of most other countries, do not contain such information. Moreover, though a Census of Production has been conducted every year since 1961, the derivation of some index of capital utilization is well beyond the resources of this study.

Thus, input demand functions for capital cannot be estimated so that the model will not be able to address questions relating to capital requirements.* Furthermore, to the extent that capital is a substitute for the other inputs, the input demand functions to be estimated in this study may be subject to a specification bias.**

The lack of capital data suggests that the model should be constrained to the short-run; that is the capital stock should be assumed fixed. This assumption has some implications on the model presented in the previous chapter. In particular, the supply curve of each sector will no longer be perfectly elastic: Under constant returns to scale and assuming a competitive market with given prices of inputs, if an input is fixed, the law of variable proportions suggests that the variable factors will exhibit diminishing returns (Koutsoyannis 1979, p. 83). In other words, for each increase in output by 1 unit, the proportion of the variable inputs to the fixed input must increase, leading to an increasing marginal cost and thus an upward slping supply curve.

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* This issue is discussed further in Chapter VI.

** It should be noted, however, that under the assumption made below that firms have some reserve capacity available, this specification bias would not arise. It is only when this reserve capacity is used up that it becomes relevant to consider the substitutability of capital for the other inputs.

The previous discussion is consistent with traditional microeconomic theory which assumes that each firm is designed to produce optimally only a single level of output, thereby leading to a U-shaped cost curve. However, this traditional theory of cost curves has been questioned by various writers both on theoretical a-priori and on empirical grounds. "As early as 1939, Stigler suggested that the short-run average variable cost has a flat stretch over a range of output which reflects the fact that firms build plants with some flexibility in their productive capacity." (Koutsoyannis 1979, pp. 114-115). The difference between the traditional and modern theory of costs is shown in Figures 5.1 and 5.2 .

In Fig. 5.1 , the short-run average variable cost curve (SAVC) is assumed to be U-shaped. This implies that each plant is designed without any flexibility; it is designed to produce optimally only a single level of output (i.e., X_2 in Fig. 5.1). If the firm produces at a smaller level of output, say X_1 , then it has excess capacity equal to the difference $X_2 - X_1$. This is not only undesirable, since it leads to higher unit costs, but also <u>unplanned</u>. In contrast, Fig. 5.2 assumes that the SAVC curve has a flat range between say X_1 and X_2 . This reflects the view that plants are designed with some flexibility. The firm anticipates using its plant sometimes closer to X_1 and at others closer to X_2 . This range of output over which

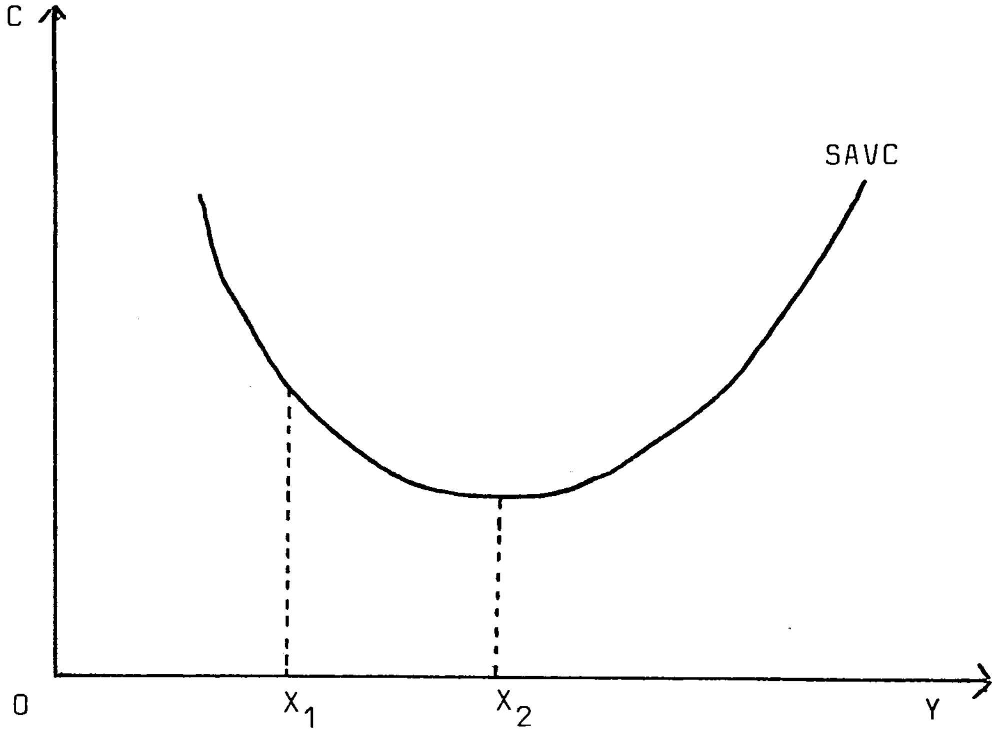

Fig. 5.1

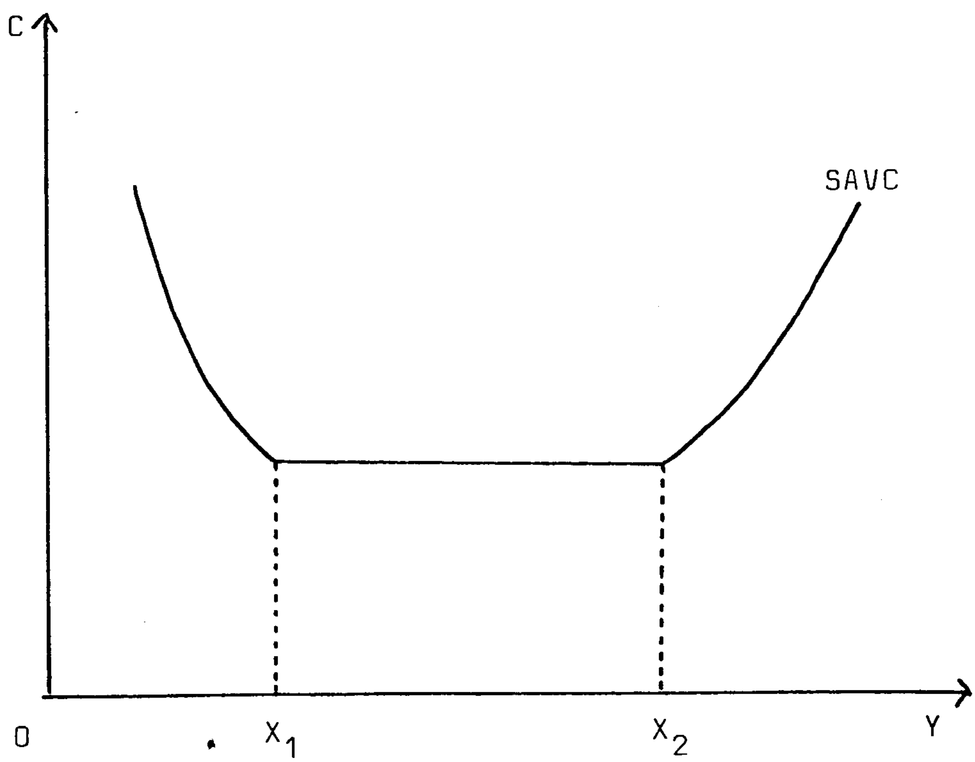

Fig. 5.2

costs are constant reflects the reserve capacity of plants and is distinguished from excess capacity in the traditional theory by being planned.

This so called "modern" view of the theory of costs appears to have been borne out by many empirical studies.* For example, Koutsoyannis (1979, p. 139) after reviewing various statistical cost studies comes to the conclusion that: "The evidence from most statistical studies is that the short run AVC is constant over a considerable range of output." In view of such support this more flexible approach is adopted in this study. Thus though a capital variable is not introduced in the input demand functions, the assumption that firms have a reserve capacity implies that the perfectly elastic supply curve of the previous chapter is still tenable. That is, it is assumed that firms are within the flat portion of the SAVC curve in each time period. Since in this range of output average variable costs are constant and equal to marginal costs, then each sector is characterized by constant costs even in the short-run. To capture changes in the reserve capacity and/or changes in technological progress a time-trend variable is introduced in the input demand functions.

As a consequence of the short-run specification of the model, a further modification is necessary. Recall that the

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* A comprehensive summary and critique of a wide range of statistical cost studies is given by Johnston (1960).

inputs of each sector, as given in the I-O table, are total inputs. For example, the labour input into a sector refers to total employment by that sector. Since part of this input, say administrative staff, could be relatively fixed or unrelated to output in the short-run, a constant term is introduced in the input demand functions. Thus, the modified form of the input demand functions is as follows:

$$x_{ij} = a_{ij} + X_j \sum_{q}^{n} b_{iq,j}(P_q/P_i)^{\frac{1}{2}} + t_{ij}TR \qquad (5.1)$$

$$i = 1,\ldots n; \; j = 1,\ldots n$$

where x_{ij} is the output of sector i used as an input by sector j , P_i is the price index of sector i , X_j is the gross output of sector j and TR is a time trend variable.

The second data constraint that one runs into in estimating the generalized I-O macro model using Maltese data is related to the symmetry constraint. In the previous chapter it was noted that the symmetry constraint implies some cross-equation restrictions, namely that $b_{iq,j} = b_{qi,j}$ for $i \neq q$ in the input demand functions. Since the model is simultaneous, some systems method such as three-stage least squares (3SLS) with the cross-equation restrictions imposed, would be most appropriate. Because the model is large (76 behavioural equations) and the sample is small (17 observations) restricted 3SLS could not be used.* Instead two-stage least squares (2SLS) with principal

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* The computer programme used in this study is the TROLL system. The 3SLS option requires that: "There must be at least as many

cont./

components in the first stage, is used. Since 2SLS is a single-equation technique, however, the cross-equation restrictions cannot be utilised. Thus, in estimation, the symmetry constraint is not imposed in this study.

It is relevant to note that in empirical tests, the symmetry constraint has not fared very well. Both Parks (1971) and Frenger (1978), who use the generalized Leontief cost function, find that the symmetry constraint is rejected in favour of unconstrained cross-price coefficients. Parks offers the following rationale for this result:

> The asymmetry found in the data may be accounted for in part by the fact that the underlying theory refers to individual firm behavior whereas the data represents the aggregation over a large number of firms. Nevertheless the finding that the data is not entirely consistent with the symmetry of the model should be considered in light of the fact that the same data would produce an even stronger rejection of any production specification whose form is more restrictive than the one considered here. Alternative forms such as the Cobb-Douglas, CES, and Leontief place even stronger restrictions on the substitution possibilities and therefore the relative price coefficients with which they correspond. (Parks 1971, p. 134)

Finally, the last modification of the model on account of data constraints has to do with the number of parameters to be estimated in each input demand function. The I-O tables

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dates in the regression bounds as there are coefficients in the model, or as there are stochastic equations in the model. There must also be at least as many dates as there are preliminary regressors." (NBER, 1976, p. 26). Clearly, none of these conditions are satisfied by the model in this study.

used in this study have been aggregated into twelve sectors so that there are potentially 12 intermediate inputs plus two primary inputs (labour and imports), or in all 14 inputs in each sector. This implies that as equation (5.1) stands, a total of 16 coefficients have to be estimated.* This would leave too few degrees of freedom as the total time span is 17 years.** Accordingly, some method of decreasing the number of parameters to be estimated in each input demand function is desirable. Since all the relative price variables in each input demand function have the same denominator (i.e., P_i in eq. (5.1)), one way of restricting the number of parameters is to weight the P_q's as follows:

$$x_{ij} = a_{ij} + b_{ij}X_j + c_{ij}X_j \sum_{\substack{s=1 \\ s \neq i}}^{n+2} W_{sj}(P_s/P_i)^{\frac{1}{2}} + t_{ij}TR \qquad (5.2)^{***}$$

$$\text{for } i = 1, \ldots n + 2; \quad j = 1, \ldots n$$

where W_{sj} is the ratio of the sth input to total inputs of sector j for the base year. Thus for example, in the two

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* That is 14 $b_{iq,j}$'s plus the constant and the time trend coefficient.

** In practice it turns out that none of the sectors demand inputs from all the other sectors. However, if the specification in (5.1) is used, the degrees of freedom for several sectors do become uncomfortably small.

*** Note that (5.2) has some changed notation from (5.1). The b_{ij}'s now refer to the coefficient of the output variable while the c_{ij}'s to the relative price coefficient. Also note that n refers to the number of sectors while i ranges from 1 to n + 2 so as to include the primary inputs i.e., labour and imports.

sector case, the demand for input 2 by sector 1 is;

$$x_{21} = a_{21} + b_{21}X_1 + c_{21}X_1(W_{21}P_1^{\frac{1}{2}} + W_{31}P_3^{\frac{1}{2}} + W_{41}P_4^{\frac{1}{2}})/P_2^{\frac{1}{2}} + t_{21}TR \qquad (5.3)$$

where $W_{i1} = x_{i1}/\sum_{1=1}^{n+2} x_{i1}$ in the base year. This weighting scheme of the P_j's is of course, only an empirical approximation to the more general system in (5.1).*

<u>Data</u>

As noted earlier, this study is based on 17 annual I-O tables of the Maltese economy, covering the period 1961 to 1977. In the published tables, the economy is divided into 23 sectors. However, partly to make this study more manageable and partly to counterbalance some changes in the classification of sectors, the published tables were aggregated into twelve sectors, as follows:

	Sector	I-O Sector Classification
Agriculture and Fisheries	1	1
Food, Flour Mills, Beverages & Tobacco	2	3+4+5

* The empirical approximation suggested above was tested for Sector 3A by estimating the input demand functions in both the unconstrained (i.e. following the scheme of equation (5.1)) and constrained forms (i.e. according to the weighting scheme of equation (5.3)) and conducting an F-test on the set of linear restrictions in each equation. (See Murphy 1973, p. 232; Kennedy 1979, p. 55 for a general description of the test.) In 6 out of the 7 input demand functions estimated, the F-value was insignificant at the 0.01 level of significance. However, it should be noted that the estimates of the C_{ij} coefficients in equation (5.3) may be sensitive to alternative weighting schemes.

	Sector	I-O Sector Classification
Textiles & Wearing Apparel	3A	6+8
Footwear & Leather	3B	7+11
Metals, Machinery & Transport Equipment	4	14+15+16
Mining, Quarrying & Non-Metalic Minerals	5	2+13
Furniture & Fittings, Printing & Chemicals	6	9+10+12
Construction	7	18
Miscellaneous	8	17
Other Industries (Public Administration etc.)	9	23
Gas, Water & Electricity	10	19+20+21
Services (Transport & Communications, Shiprepairing, Distributive Trades, Tourism, Insurance, Banking, etc.)	11	22

where the first column of sector numbers identifies the reference number of the sectors used in this study, while the second column gives the sector number in the published tables (National Accounts of the Maltese Islands 1969-1978, p. 12).

In order to identify the notation to be used in later sections, a schematic form of the 12 sector I-O table of the Maltese economy is given in Table 5.1*. Note that the inter-industry flows are identified by a lower-case x with the number before the point indicating the supplying sector and the number following the point, the purchasing sector.

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* The actual table for the year 1977 is given in Appendix A Table A2 .

TABLE 5.1

	1	2	3A	3B	4	5	6	7
1	-	x1.2		x1.3B				
2	x2.1	-						
3A			-					
3B				-				
4	x4.1	x4.2	x4.3A	x4.3B	-	x4.5	x4.6	x4.7
5		x5.2		x5.3B		-	x5.6	x5.7
6		x6.2	x6.3A	x6.3B	x6.4		-	x6.7
7		x7.2	x7.3A	x7.3B	x7.4	x7.5	x7.6	-
8	x8.1		x8.3A					
9								
10		x10.2	x10.3A	x10.3B	x10.4	x10.5	x10.6	x10.7
11	x11.1	x11.2	x11.3A	x11.3B	x11.4	x11.5	x11.6	x11.7
	M1	M2	M3A	M3B	M4	M5	M6	M7
	W1	W2	W3A	W3B	W4	W5	W6	W7
	P1	P2	P3A	P3B	P4	P5	P6	P7
	T1	T2	T3A	T3B	T4	T5	T6	T7
	X1	X2	X3A	X3B	X4	X5	X6	X7

TABLE 5.1--Continued

8	9	10	11							
			x1.11		C1	G1		S1	E1	X1
					C2	G2		S2	E2	X2
					C3A	G3A		S3A	E3A	X3A
					C3B	G3B		S3B	E3B	X3B
x4.8		x4.10	x4.11		C4		I4	S4	E4	X4
		x5.10	x5.11		C5		I5	S5	E5	X5
x6.8			x6.11		C6	G6	I6	S6	E6	X6
x7.8		x7.10					I7	S7	E7	X7
–					C8	G8		S8	E8	X8
	–	x9.10			C9	G9			E9	X9
x10.8		–	x10.11		C10	G10		S10	E10	X10
x11.8	x11.2	x11.10	–		C11	G11	I11		E11	X11
M8		M10	M11		MC	MG	MI	MS	ME	M
W8	W9	W10	W11						WE	W
P8	P9	P10	P11							P
T8		T10	T11		TC		TI		TE	T
X8	X9	X10	X11		C	G	I	S	E	

A few characteristic features of the Maltese I-O table are worth noting. First, the published tables exclude intra-industry transactions so that the main diagonal of the inter-industry section of Table 5.1 is blank. Second, the number of inter-industry transactions given in Table 5.1 is 57 or 45% of the total number of cells. However, 11 of these transactions are discontinuous* and hence input demand functions for these variables cannot be estimated for the entire period. The approach adopted in this study is to treat these somewhat unstable flows as exogenous.** Thus in all, 46 inter-industry transactions are considered in this study. Finally, the classification of Imports is by purchaser. For example, M1 indicates imports purchased as an input by sector 1.

The change in the classification of some sectors took place in 1974, with the aim of bringing the definitions more in line with the U.N. system of classification. While the gain from such a change appears marginal, the potential loss through

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* That is, observations are not available for all years.

** The discontinuous inter-industry transactions are x4.1 x8.1 x1.3B x5.3B x7.3B x5.6 x6.8 x7.10 x1.11 x4.3B x9.10 . Several of these variables are relatively small. In fact some are so small that the rounding error probably dominates. For example, x7.3B in 1977 was £M1,000 (see Appendix A, Table A1). Since the variables are measured in units of thousands, in any previous year where the transaction was smaller than £M500, the flow would be set to zero. In other cases, the discontinuity could be due to new connections appearing. The largest flow, and thus potentially most serious in assuming that these variables are exogenous, is x9.10 which in 1977 represented a flow of £M480,000. However, in this case, the transaction is between Public Administration and the Gas, Electricity and Water sector. Since the latter is a government corporation, the assumption of exogeneity appears well suited.

discontinuity of a series could be quite considerable and hence ill-advised. Fortunately, in this instance, the changeover affected only a few sectors, and aggregation tended to iron out most of the difference. For example, the greatest change took place in the definition of Textiles and Wearing Apparel sectors. However, combining these two sectors together gives a discrepency between the old and new systems of 4.8%.* So as to allow for this discrepancy, a dummy variable for the period 1974-77 is introduced in the equations.

Since price indices for the various sectors of the I-O table are not available, the required price indices had to be constructed in this study. For most sectors, this was quite a formidable undertaking, the details of which are given in Appendix A.** In brief, the price indices used in this study were derived as follows: (a) The price index for sector 1 (Agriculture and Fisheries) was built up from the Production Account of Agriculture in combination with published price indices for Fruit and Vegetables. (b) The price indices for sectors 2 to 8 and 10 were derived from the Index of Industrial Production. (c) For sectors 9 (Public Administration) and 11 (Services) proxy variables were used. In the former case, the "all items" category, while in the latter case, the "services" category of the Index of Retail Prices, were chosen. (d) For

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* See The Annual Abstract of Statistics (to be identified as A.A.S. in the rest of this study), for the year 1975, Tables 2 and 2A, pp. 128-129.

** Appendix A gives details of the methods used to derive the price indices for sectors 1 to 8 and 10.

Imports, the published price index for imports was used.

In all the above cases, one price index was derived for each sector. This is a common practice in view of the difficulty in getting a price index for each cell of the I-O table.* In the case of labour, however, it is possible to get an average wage per sector by using employment per sector published in the A.A.S.** and the wages and salaries per sector given in the I-O table. Thus, in this study, 12 wage indices are used.

Finally, all the price indices used in this study are assumed to be exogenously determined. This appears to be a reasonable simplification in view of the openness of the Maltese economy: In 1977 total domestic final demand for locally produced goods and services was £M192 million, while the total value of exports (excluding those directly supplied by imports) was £M187 million.*** In other words, the export market is almost as large as the domestic market for final goods and services. On the input side, the total value of intermediate inputs was £M53 million. This figure already has an import content since to produce this output, the local industries require imports as one of their inputs. Nonetheless, the total value of imports demanded as input in 1977 was £M159 million. Thus, these figures clearly indicate the extreme openness of the Maltese economy, providing considerable justification for the assumption that prices are determined outside the system.

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* For example Tilanus (1966) uses the same procedure.

** See for example A.A.S. (1977), Table 2, p. 83.

*** These figures are derived from Table A2, Appendix A.

With regard to wages, one might argue that consideration of the domestic labour market is necessary for the determination of wages. However, it turns out that wages in Malta are largely determined by the government. Though not often recognised as such, Malta has been living under perpetual wage (and price) controls. Indeed the increases in wages given by government to take care of both inflation and productivity increases are imposed, by law, on the private sector. Thus, the assumption that wages are determined exogenously appears to be a reasonable approximation to reality.

Statistical Results

The complete model has 122 equations and is given, with the estimated coefficients and various statistics in Appendix B. Of the 122 equations, 40 are identities, leaving 82 behavioral equations. These behavioral equations may be divided into the following categories: (a) 46 are intermediate input demand functions (b) 23 are primary input demand functions (c) 12 are consumption functions and (d) 1 income tax function.

The estimation of the behavioral equations and the simulation of the model was done using the TROLL system. As the consumption functions include a lagged consumption term, the estimation period was restricted to 1962-1977. All the behavioral equations were first regressed using 2SLS with principal components in the first stage. The total number of exogenous variables used to estimate the principal components was 69 and included all the exogenous variables in the model except relative prices and the unstable variables indicated in the previous section.* Seven principal components were estimated accounting for 95% of the variance of the instruments.**

The results from the first regression-run indicated the presence of serial correlation of the errors in most of the input demand functions: The DW statistic clearly rejected the presence of autocorrelation in only 8 of the 69 input demand functions. In order to correct for this problem a Hildreth-Lu autoregressive transformation was combined with 2SLS.*** The method used is that suggested by Eisner and Pindyck (1973). This method is a more general alternative to the one suggested by Fair (1970) for combining GLS and 2SLS and essentially involves first transforming each equation by its GLS A matrix and then applying

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* Relative prices were not used as instruments in the estimation of principal components because in most equations they enter multiplicatively with an endogenous variable (see eq. (5.2)). Klein (1974, p. 203) suggests that such composite variables should be treated as new endogenous variables. TROLL follows this approach so that in the first stage of 2SLS the composite term is regressed on the instruments or in this case, the principal components.

** It is interesting to note that in the Wharton Annual and Industry Forecasting Model, which is based on 16 annual observations, Preston (1972, p. 161) also finds that seven principal components explain 95% of the variance of the predetermined variables.

*** The TROLL version of Hildreth-Lu performs a grid search for rho (the grid was set to 10 in this study) and then a binary search around the optimum grid value till the rho value changes by less than .01 .

2SLS. Since the variance covariance matrix of the error term is not known, the same procedure is applied iteratively. That is, the instrumental variable substitution is repeated for each iteration. Thus, each of the 61 input demand functions with a low DW statistic was re-estimated using this approach, with the result that in most cases, the DW statistic climbed above the upper critical value. As may be seen in Table 5.2, which summarizes the statistical results of Appendix B, 70% of the input demand functions have a DW statistic (marked by an asterisk) which is above the upper critical level at 5% level of significance. The rest of the input demand functions have a DW statistic which falls in the indeterminate range.

Several of the estimated coefficients in the input demand functions turned out to be statistically insignificant. Since the model is to be simulated, and since in some cases, as for example the constant term, it is an empirical question whether a variable should be included or excluded, it was decided to "purge" the input demand functions of as many insignificant coefficients as possible. The following methodology was used. First, in the case of the dummy variable, all the insignificant dummies were dropped. The dummy variable was introduced to allow for any change in the sectoral classification after 1974. Thus, an insignificant dummy was taken as an indication that there was no significant change in the classification of that variable. As may be seen in Table 5.1 , this procedure left 16 input demand functions with a significant dummy variable.

TABLE 5.2

INPUT-DEMAND FUNCTIONS

	Constant	Output	Relative Prices, Output	Time	Dummy	DW	$\bar{R}^2$	F-Ratio
	T-Values							
Rx2.1		-3.06	2.69	7.88	2.71	1.76*	(0.994)	(131.10)
Rx11.1	1.01	2.69	-0.89	-3.97		1.80*	0.440	4.91
RM1	11.45	-0.71	1.69	-7.83		1.59	0.940	79.55
L1	0.79	-1.83	4.35	0.86		2.01*	0.595	8.33
Rx1.2	12.58	-2.90	2.64	3.87		1.84*	0.750	15.99
Rx4.2	8.18	-3.41	1.99	2.84		1.58	0.696	12.45
Rx5.2	8.55	-1.37	0.80	2.56		2.06*	0.643	10.02
Rx6.2	4.03	-2.20	1.03	4.52		2.04*	0.463	5.30
Rx7.2	6.39	-2.78	1.89	4.14		2.13*	0.587	7.64
Rx10.2		0.16	0.92	3.09		1.76*	(0.993)	(37.61)
Rx11.2	5.69	-10.76	14.17			2.03*	0.991	862.51
RM2	3.31	2.07	-2.22	3.30		2.06*	0.791	19.98
L2	32.21	2.80		1.89		1.83*	0.942	123.50
Rx6.4	1.41	-5.26	6.65		-4.51	2.49	0.913	53.34
Rx7.4	-1.27	-0.08	-1.13	5.53		1.85*	0.778	18.51

cont./

TABLE 5.2--Continued

	Constant	Output	Relative Prices, Output	Time	Dummy	DW	$\bar{R}^2$	F-Ratio
			T-Values					
Rx10.4		-4.22	4.86	4.72		1.70	(0.970)	(63.01)
Rx11.4		-2.14	6.67			1.67*	(0.988)	(230.53)
RM4	-4.69	8.41		3.92	-5.90	1.95*	0.987	391.24
L4		-2.00	2.24	3.95	-3.19	1.18	(0.939)	(13.10)
Rx4.5	1.47	2.81		-1.47		2.03*	0.497	8.40
Rx7.5	1.63	-1.39	2.00	-0.84		2.05*	0.560	6.93
Rx10.5	-0.37	-0.18	-0.59	5.84		1.91*	0.914	54.47
Rx11.5		1.58	1.35		2.45	1.99*	(0.989)	(314.13)
RM5	0.31	0.83	0.36	-0.81		1.33	0.773	18.04
L5	6.47	-4.79	6.55	-4.76		1.52	0.858	31.17
Rx4.6		-0.12	0.75	5.10	-4.09	1.47	(0.981)	(50.17)
Rx10.6		-1.41	3.48	4.04	3.60	1.91*	(0.997)	(400.92)
Rx11.6	6.74	-8.42	10.26	6.53		2.24*	0.986	352.74
RM6	6.21	-2.19	3.81	3.82	-2.61	2.13	0.980	189.67
L6	4.28	-2.37	3.10	8.43	-2.98	1.84	0.963	99.93
Rx4.7	-1.47	3.28	-1.34	0.87		1.85*	0.738	15.06
Rx5.7	2.74	5.11				1.86*	0.684	33.42
Rx6.7	4.46	0.98		-3.38		1.58*	0.437	6.82

cont./

TABLE 5.2--Continued

	Constant	Output	Relative Prices, Output	Time	Dummy	DW	$\bar{R}^2$	F-Ratio
			T-Values					
Rx10.7	1.59	-1.92	1.87	1.77		1.77*	0.619	9.10
Rx11.7	-2.10	4.46	2.52	-2.71		1.90*	0.910	51.44
RM7		2.89	1.80	-3.44		1.90*	(0.987)	(44.00)
L7	2.36	-1.09	6.48	-3.31		1.84*	0.933	71.13
Rx4.8	0.60	1.75	-0.82	-2.71		1.79*	0.407	4.45
Rx7.8	-0.89	3.53	-2.94	1.14		1.78*	0.530	6.62
Rx10.8		-1.15	2.06			1.73*	(0.822)	(13.64)
Rx11.8	-1.31	-7.81	9.97	-2.09		2.35	0.952	100.37
RM8	0.36	0.12	0.24	0.44		1.27	0.704	12.90
L8		2.33		1.92	2.43	1.68	(0.977)	(32.95)
L9	11.76	1.85		0.58		1.56*	0.934	107.38
Rx5.10		-2.04	4.01	-2.48		1.56	(0.782)	(7.42)
Rx11.10		-3.34	4.90	-1.65	-2.94	1.94*	(0.926)	(23.04)
Rx5.11		-5.16	5.59		6.24	2.67	(0.982)	(159.42)
Rx10.11	2.09	-2.92	2.79	6.34		1.85*	0.894	43.09
RM11		-0.60	1.06	2.96		1.84*	(0.973)	(12.77)
L11	23.04	1.63		4.18		1.74*	0.914	81.04
Rx4.3A		-3.50	3.31	4.46	7.49	2.23	(0.983)	(62.81)

cont./

TABLE 5.2--Continued

	Constant	Output	Relative Prices, Output	Time	Dummy	DW	$\bar{R}^2$	F-Ratio
			T-Values					
Rx6.3A		-3.26	5.51			1.95*	(0.987)	(160.52)
Rx7.3A	1.73	-2.06	2.53	0.93		1.80*	0.768	15.32
Rx8.3A		-6.74	7.56		29.66	1.38	(0.999)	(4985.09)
Rx10.3A		0.23	-0.69	2.28	3.06	1.95*	(0.982)	(32.66)
Rx11.3A		7.71		-2.92		1.76*	(0.971)	(103.43)
RM3A		20.12		-4.59		2.37*	(0.999)	(1402.71)
L3A		2.72		2.48		2.17*	(0.960)	(77.85)
Rx6.3B	1.49	-3.84	4.20	1.32		1.64	0.812	16.80
Rx10.3B		-2.21	3.70	1.70	4.96	2.16*	(0.990)	(79.60)
Rx11.3B		-1.20	4.70			2.00*	(0.991)	(348.88)
RM3B		4.52	2.21			2.13*	(0.998)	(898.61)
L3B	1.84	-8.39	11.87	5.49		1.44	0.989	473.20

All the other equations were re-estimated, excluding the dummy variable.

Second, of the other four variables in the input demand functions, output was regarded as necessary on theoretical grounds. This is equivalent to starting from the premise that the demand for inputs depends at least on the output of that sector or in other words the Leontief hypothesis. Thus, the output variable was always included irrespective of its t-value. For the other three variables, that is the constant, relative prices times output, and the time trend, any t-value less than one in absolute value, was regarded with some suspicion.* In such cases, the equation was re-estimated, excluding such variables in turn and, the resulting coefficients, t-values and R^2, compared with the results from the regressions including all the variables. If there was no appreciable change in these values, this was taken as evidence that the excluded variable does not exert any significant influence on the dependent variable and hence was dropped from the equation. In some cases, excluding a variable resulted in considerable change in the regression results. In these instances, such variables were not dropped: The low t-value was considered as probably due to multicollinearity, and hence the regression results were regarded as not

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* The t-value less than one criterion was chosen on the basis that any t-value greater than 1 tends to increase the $\bar{R}^2$. (See Aigner (1971) p. 91). It is recognised, however, that a higher $\bar{R}^2$ does not necessarily imply better simulation results.

being able to distinguish clearly the separate influence of each variable. A clear example of this is in the case of RM8 (see Table 5.2) where though all the t-values are less than 1, the F-ratio is significant.

Note that the most common variable excluded from the equations is the constant term. In all, the constant term was excluded in 24 equations, indicating that these inputs are all variable inputs. Since these equations were estimated with a zero intercept, the usual R^2 no longer carries the same meaning and can in fact lie outside the 0 - 1 interval (Kennedy 1979, p. 26). The problem that arises is that the usual division of the sum of squares total into sum of squares explained and sum of squares unexplained is no longer valid, or in general; (Aigner 1971, p. 87)

$$\sum(Y - \bar{Y})^2 \neq \sum(\hat{Y} - \bar{Y})^2 + \sum e^2 \qquad (5.4)$$

However, the "raw" moment version of (5.4) still holds i.e.,

$$\sum Y^2 = \sum \hat{Y}^2 + \sum e^2 \qquad (5.5)$$

so that a raw moment R^2 may be computed as,

$$Rr^2 = 1 - \sum e^2 / \sum Y^2 \qquad (5.6)$$

Thus in Table 5.2, for the case where the intercept is excluded from the equations, the raw moment R^2 as defined in (5.6) is given.* The zero intercept regression also raises another

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* These raw moments R^2 are enclosed in brackets in Table 5.2 .

problem, namely that the F-statistic is no longer valid (White 1977, p. 30). To overcome this problem, the F-statistic given in Table 5.2 is calculated from the equation including the intercept.*

Of the 69 input demand functions estimated, 6 turned out to have an insignificant F-statistic. In order to avoid the possible transmission of large errors by these variables to other equations in the simulation process, these variables were considered as exogenously determined.** Thus in all, 63 input demand equations were used in the model, and it is these equations that are summarised in Table 5.2 .

One of the major questions that Table 5.2 provides an answer to concerns the Leontief hypothesis. Under this hypothesis, inputs are assumed to be demanded in fixed proportions to output, and hence one would expect only the output variable to be significant in Table 5.2 . However, the results in Table 5.2 provide a strikingly different picture. Out of the

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* These F-statistics for the zero intercept case are also enclosed in brackets in Table 5.2 .

** These variables are L10 M10 x4.10 x4.11 x6.11 and x7.6 . The estimated equations of these variables are given in Appendix B. Note that L10 M10 and x4.10 are all inputs of sector 10 (i.e., Electricty, Gas and Water). Since sector 10 is a government corporation, the assumption of exogeneity appears more reasonable. For instance, M10 refers to imports by sector 10, comprising mainly fuel oil used by this sector. The value of this input has become increasingly dependant, in recent years, on the negotiations by the government of Malta with foreign suppliers. For example, the value of M10 between 1975 and 1976 fell from £M3.422 million to £M0.927 million , probably as a

cont./

63 input demand functions given in Table 5.2 , the t-value for the relative price (times output) variable is positive and significant in 56% of the equations. This clearly indicates that relative prices do play an important role in the demand for inputs. It is also an important result of this study in view of the controversy that the exclusion of a relative price term has generated in I-O analysis. Furthermore, both the constant term and time trend are significant in many equations, suggesting that these are also relevant variables in the determination of demand for inputs. Thus in summary, the results in Table 5.2 reject the Leontief hypothesis in favour of the more general specification used in this study.

It is interesting to enquire whether the estimated input demand functions imply cost functions which are consistent with economic theory. In chapter IV, it was pointed out that the cost function should satisfy two conditions, namely; (a) monotonicity of costs with respect to prices and (b) concavity of the cost function with respect to prices. Condition (a) requires that the partial derivatives of the cost function with respect to prices be greater than or equal to zero. Since the input demand functions are defined as these partial derivatives, an equivalent requirement to satisfy condition (a) is that the estimated

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result of an oil deal between the governments of Malta and Libya. Clearly, there is little point in trying to estimate a behavioral equation for such an input.

input demand functions be non-negative (Frenger 1978, p. 278). All the input demand functions estimated in this study are positive at each sample point so that condition (a) is satisfied. Though this requirement might appear to be easy to satisfy since one would expect that the demand for an input to be non-negative, yet it is not always satisfied in other studies. For example, Woodland (1975, p. 177) finds that out of ten sectors, two sectors (Mining and Finance) do not satisfy the monotonicity condition for all observations.

In chapter IV it was pointed out that condition (b) requires that all the relative price times output coefficients be non-negative. As may be seen in Table 5.2 , only two of these coefficients are negative and significant (i.e., RM2 and Rx7.8). This represents only 3% of the input demand functions given in Table 5.2 in contrast to 56% which are positive and significant. This result compares quite favourably with those of other studies. For example, in his study Frenger (1978, p. 278) found many of these coefficients negative.* As another example, Woodland (1975, p. 177) finds that for 4 out of 10 sectors the concavity condition was not satisfied.** In contrast, the

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* In the construction sector alone, Frenger's (1978, Table A3, p. 303) regression results indicate that 17% of his relative price coefficients are negative and significant.

** These sectors are Fishing, for which local concavity was not attained at any sample point, and Forestry, Manufacturing and Finance, for which local concavity was not attained at some observation points (Woodland 1975, p. 177).

concavity condition is satisfied in 10 out of 12 sectors in this study.*

Finally, the statistical results of the consumption functions are summarised in Table 5.3 . The estimation procedure used was 2SLS with principal components in the first stage. In six equations, the dummy variable turned out to be significant, and hence was retained in these equations. In all equations except RC3A RC3B and RC5 , the significant t-values have the correct sign. That is, positive for the constant term, income and lagged consumption, and negative for the relative price variable.

In the case of RC3A RC3B and RC5 , the significant t-values with an incorrect sign are as follows: (1) RC3A - the constant term and relative prices; (2) RC3B - relative prices and lagged consumption; (3) RC5 - lagged consumption. One common feature of these three equations is that they form a very small percentage of aggregate consumption. For example, in 1977, this percentage value for RC3A RC3B and RC5 was 1.49%, 0.61% and 0.08% respectively. Thus, for all practical purposes, these three equations are of very little importance to the model.

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* These sectors are: Sectors 1, 3A, 3B, 4, 5, 6, 7, 9, 10 and 11.

TABLE 5.3

CONSUMPTION FUNCTIONS

	Constant	Income	Relative Prices	Lagged Consumption	Dummy	DW	$\bar{R}^2$	F-Ratio
			T-Values					
RC1	1.22	3.34	-0.31	0.58		1.80	0.847	28.62
RC2	1.56	-0.09	-1.44	4.40		2.08	0.923	65.41
RC3A	-3.60	2.30	2.80	4.15	-7.09	1.86	0.914	40.91
RC3B	1.41	-0.03	2.73	-2.67	4.01	2.51	0.886	30.14
RC4	-0.69	4.66	-2.23	1.22	-1.77	1.59	0.735	11.41
RC5	0.83	6.19	-1.80	-3.16	16.66	2.05	0.991	396.79
RC6	2.91	3.91	-4.74	3.35		2.53	0.978	222.90
RC8	-1.86	4.58	-0.50	1.73	-7.97	1.56	0.911	39.49
RC9	-1.65	2.83	1.46	5.76		2.31	0.975	193.66
RC10	3.91	4.46	-4.54	3.22		1.77	0.978	225.38
RC11	3.57	2.46	-3.59	4.35	-4.92	2.24	0.836	17.61
RMC	3.06	2.72	-2.44	1.78		1.66	0.756	16.48

Ex-Post Forecasts

The statistical results of the previous section indicate that the generalized Leontief formulation of the input demand functions is more appropriate than the traditional I-O specification. However, it remains to be seen whether the forecasting ability of the former outperforms that of the latter. To examine this issue more closely, root-mean square (RMS) percent errors of ex-post forecasts for 1977 are presented in Table 5.4 .

The I-O forecasts were obtained as follows. First, the model was set up based on the proportionality assumption between inputs and outputs. Second, the I-O coefficients were derived from the 1976 I-O table. Third, the model was solved using data for the exogenous variables (i.e., Final Demand) from the 1977 I-O table. This provided ex-post forecasts for the endogenous variables which were then compared with the actual values given in the 1977 I-O table. The first column of Table 5.4 gives the resulting RMS percent errors.

Since the forecasts from the I-O model were made on the assumption of an exogenous final demand, forecasts using the generalized Leontief I-O macro model were also made under this assumption, so that both models depend on the same exogenous variables. Thus, any difference in forecasting ability between the two models is purely due to the different hypotheses about the input demand functions. The input demand functions of the generalized Leontief model were re-estimated for the period

TABLE 5.4

EX-POST FORECASTS FOR 1977[1]

	I-O	Generalized Leontief	
	1976 I-O	OLS (1961-76)	2SLS (1962-76)
Rx10.11	2.72	16.76	19.21
Rx10.2	13.06	3.83*	3.59* **
Rx10.3A	40.36	26.92*	27.57*
Rx10.3B	8.44	6.30*	5.31* **
Rx10.4	8.08	11.05	16.04
Rx10.5	17.53	16.32*	15.49* **
Rx10.6	32.29	20.23*	14.73* **
Rx10.7	18.93	15.27*	15.49*
Rx10.8	24.06	20.10*	20.37*
Rx11.1	13.36	12.08*	11.80* **
Rx11.10	5.44	29.29	5.25* **
Rx11.2	5.68	0.61*	0.21* **
Rx11.3A	10.33	7.01*	4.30* **
Rx11.3B	39.92	25.06*	25.17*
Rx11.4	13.40	6.09*	8.05*
Rx11.5	6.78	22.73	13.94 **
Rx11.6	29.58	0.45*	6.36*
Rx11.7	1.06	20.37	0.91* **
Rx11.8	29.29	31.07	17.96* **
Rx1.2	2.61	7.21	7.80 **
Rx2.1	6.40	9.01	6.38* **
Rx4.2	11.60	46.17	15.25 **
Rx4.3A	33.26	9.23*	1.39* **
Rx4.5	29.44	42.85	34.96 **
Rx4.6	1.54	16.98	18.14
Rx4.7	29.60	65.52	63.29 **
Rx4.8	77.17	15.02*	1.41* **

cont./

TABLE 5.4--Continued

	I-O	Generalized Leontief	
	1976 I-O	OLS (1961-76)	2SLS (1962-76)
Rx5.10	32.51	57.33	50.30 **
Rx5.11	125.48	157.45	132.46 **
Rx5.2	6.84	14.35	10.49 **
Rx5.7	3.58	0.88*	0.07* **
Rx6.2	22.68	20.79*	12.81* **
Rx6.3A	51.47	71.69	57.05 **
Rx6.3B	8.41	9.86	9.85 **
Rx6.4	83.59	67.63*	65.79* **
Rx6.7	12.48	93.13	71.37 **
Rx7.2	10.95	11.05	9.70* **
Rx7.3A	47.19	39.30*	39.29* **
Rx7.4	128.17	84.34*	62.71* **
Rx7.5	27.19	13.08*	9.81* **
Rx7.8	69.96	77.96	86.98
Rx8.3A	59.49	29.31*	33.45*
L1	30.64	8.68*	0.18* **
L11	14.20	1.47*	1.35* **
L2	3.61	2.43*	2.93*
L3A	13.01	14.27	11.25* **
L3B	14.53	7.78*	3.11* **
L4	8.83	0.19*	6.27*
L5	39.54	26.17*	25.81* **
L6	6.45	5.87*	2.05* **
L7	127.00	22.00	20.75* **
L8	7.55	12.65	19.94
L9	2.64	4.15	4.46

cont./

TABLE 5.4--Continued

	I-O	Generalized Leontief	
	1976 I-O	OLS (1961-76)	2SLS (1962-76)
RM1	28.36	28.47	20.38* **
RM11	7.11	1.20*	1.19* **
RM2	7.89	15.48	4.69* **
RM3A	9.96	9.99	2.66* **
RM3B	0.49	2.33	1.30 **
RM4	8.55	4.61*	7.53*
RM5	12.30	40.60	15.28 **
RM6	15.34	10.63*	14.30*
RM7	10.16	44.61	41.77 **
RM8	5.42	30.02	28.90 **
Asterisks(%)		52%	67%
Mean	25.01	24.53	20.14
Median	13.06	15.27	12.81
St deviation	29.50	27.78	24.44
Errors(%)	9.82	7.64	5.44

[1] Note: All figures are root mean square percent errors.

1962-76, using 2SLS with principal components in the first stage and correcting for autocorrelation. The model was then simulated for the period 1961-77, thereby yielding ex-post forecasts for the year 1977. The RMS percent errors of these ex-post forecasts for the generalized Leontief model are given in the last column (2SLS) of Table 5.4 .

The cases where the RMS percent errors are smaller for the generalized Leontief model than for the I-O model are marked by a single asterisk in the 2SLS column. In all, 67% of the variables have a lower RMS percent error in the 2SLS column relative to the I-O column. In other words, the forecasts of the generalized Leontief model outperform those of the I-O model in 2 out of every 3 cases. As a further indication of the difference between the two results, some summary statistics are presented at the end of Table 5.4 . It is seen that the mean RMS percent error of 2SLS is 20 while that of I-O is 25. Similarly, the standard deviation of 2SLS is smaller (24) than that of I-O (29). The median is given more as a descriptive measure of each distribution rather than for comparative purposes. It states, for example, that in 2SLS, half the RMS percent errors are less than or equal to 12.8%.

The measures given so far to compare the prediction performance of both models could provide a misleading picture. This is because in comparing the two means, for example, there is the implicit assumption that all variables are equally important.* Yet, in actual fact, there is great disparity in the value of some variables. For instance, the value of RM11 in 1977 was £M87.244 million while that of Rx6.7 was £M3 thousand. Obviously, a 5% error in the former has greater significance for the model than the same percentage error in the latter. One way of allowing for this problem is to weight the RMS percent errors of Table 5.4 by the value of the variable to the total value of all variables predicted.* Since only one year is predicted, this approach is equivalent to taking the ratio of the sum of the absolute errors to the total actual value of all variables.** As may be seen in Table 5.4 , this percentage error for I-O is 9.82 while that of 2SLS is 5.44 . In other words, the error of I-O is almost twice that of 2SLS. Though this result is consistent with the previous measures given in that the generalized Leontief 2SLS predictions are superior to I-O, yet it suggests that the other measures give a somewhat conservative estimate of the superiority of 2SLS relative to I-O. The problem is, as mentioned above, that

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* Frenger (1978) also adopts a similar weighting scheme of the prediction errors.

** This may be seen as follows; let ER_i stand for the absolute error of variable i and A_i for the actual value of variable i . Then,

$$(ER_1 / A_1) A_1 / \Sigma A_i + (ER_2 / A_2) A_2 / \Sigma A_i + \ldots + (ER_n / A_n) A_n / \Sigma A_i = \Sigma ER_i / \Sigma A_i$$

Note that the RMS for variable i is defined, in this case as;

$$RMS_i = \sqrt{(ER_i / A_i)^2} = ER_i / A_i$$

there is considerable discrepency in the size of some variables. Furthermore, the cases where the I-O forecasts are superior (33% of the total) appear to be concentrated on the smaller variables. For example, the total value of these variables in 1977 was 18% of the total value of all variables given in Table 5.4 . On the other hand, the 67% of the variables with a lower RMS in 2SLS represented a combined value of 82% of the total value of all variables. Thus, while the ratio of variables with a lower RMS is 2 to 1, the ratio of the values is almost 5 to 1, in favour of 2SLS. Due to this problem, the absolute percentage error is judged to give a better indication of the forecasting performance of both models though all the measures given indicate that the forecasting ability of generalized Leontief 2SLS estimates is considerably superior to that of the I-O model.

It is of interest to enquire how ordinary least squares (OLS) forecasts compare to both the I-O and 2SLS forecasts. For this reason, the generalized Leontief model was re-estimated for the period 1961-76, using OLS, and the model simulated so as to provide ex-post forecasts for the year 1977. The RMS percent errors are given in Table 5.4 , where a single asterisk indicates a lower RMS than for I-O.

The summary results given at the end of Table 5.4 provide several interesting insights. First, 52% of the OLS RMS percent errors are smaller than those of I-O. This indicates that according to this criterion, OLS does only marginally better than I-O. The mean RMS percent error also provides a similar result, though the standard deviation suggests that the dispersion of the OLS RMS percent error is less than that of I-O. However, the absolute percentage error is 22% lower than that of I-O, indicating that the gain in forecasting ability is not as marginal as might be inferred from the other three statistics.

Second, 2SLS is seen to be considerably superior to OLS by all measures. In particular, the RMS percent errors of 2SLS are lower than those of OLS in 73% of the variables,* while the total absolute percentage error is 29% lower. This result is of interest not only because it provides a small sample comparison of the forecasting performance of OLS and 2SLS, but also because various relevant studies ignore the simultaneous equation problem in estimation. Tilanus (1966), Parks (1971) and Frenger (1978), all use OLS as an estimating technique. The results of this study however, indicate that the forecasting performance is improved by using 2SLS. Indeed, the use of OLS may be one reason why Tilanus (1966) finds that I-O forecasts better than his linear trends in the technical coefficient model. (Another reason is, of course, the specification of the input demand functions.) Similarly, in the case of Frenger (1978), his "mixed" results in forecasting performance may be due in part to the use of OLS.

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* These variables are indicated by a double asterisk next to the 2SLS column.

Finally, the results in Table 5.4 indicate a further problem with the results of Tilanus. In comparing the forecasting performance of I-O with those of his linear trend model, (as well as other models), Tilanus basis most of his conclusions on a comparison of the median of various models. However, the results in Table 5.4 show that the median of both I-O and 2SLS is almost the same (13%) while that of OLS is higher than the I-O median. These results suggest that the median is a poor guide as a measure of forecasting performance. Indeed, it is quite possible that a model has a higher median prediction error while it still forecasts better than another model with a lower median. Since Tilanus does not provide any other measures of forecasting performance (except upper and lower quartiles), his conclusions are somewhat suspect.

Conclusion

The first section of this chapter dealt with various data constraints encountered in estimating the generalized I-O macro model using Maltese data. First, it was pointed out that the lack of data on capital utilization implies that the model to be estimated must be interpreted as a short-run model. However, it was argued that the effect of this constraint is minimised if it is assumed that firms have some reserve capacity available. This assumption, which appears to have been borne out by several empirical studies, implies that, under constant costs, the specification of a perfectly elastic supply curve is still tenable even in the short-run. The second data constraint encountered is related to the symmetry condition. Due to the size of the model and the small sample available, the symmetry condition could not be imposed in the estimation of the input demand functions. Finally, a weighting scheme for the relative price variables was suggested, thereby reducing to one the number of relative price parameters to be estimated in each input demand equation.

The second section of this chapter provided a brief description of the data used in this study. The various sectors were identified and the methods used to derive the price indices discussed. Furthermore, it was pointed out that due to the extreme openness of the Maltese economy, prices were assumed to be exogenousely determined.

In the third section, the regression results were presented. The finding that 56% of the input demand functions have a relative price (times output) variable which is positive and significant clearly indicates the importance of relative prices. Thus, in general, the Leontief specification is rejected in favour of the generalized Leontief form used in this study. Moreover, all the estimated cost functions satisfy the monotonicity condition, while 10 out of the 12 cost functions satisfy the concavity condition. As pointed out, these results compare favourably with other similar empirical studies.

Finally, the third section provided a comparison of ex-post forecasts for the year 1977, using the traditional I-O model and the generalized Leontief specification, the latter estimated by both OLS and 2SLS. Comparing first 2SLS forecasts with those of the I-O model, it was found that 67% of the variables had a lower RMS percent error in the 2SLS forecasts relative to the I-O forecasts. Furthermore, the mean RMS percent error of 2SLS was found to be 20% while that of I-O was 25%. The standard deviation of 2SLS was also found to be smaller (24) than that of I-O (29). These measures indicate that the forecasts of the generalized Leontief specification using 2SLS are superior to those of I-O. However, due to the considerable disparity in the size of some variables, these measures could provide a sleading picture since they implicitly assume that all variables are equally important. Consequently, an alternative measure was suggested which essentially takes the sum of the absolute errors to the total actual value of all variables. This percentage error of I-O forecasts was 9.82 while that of 2SLS was 5.44 . In other words, on this criteria, the error of I-O was found to be almost twice as large as that of 2SLS. This result reinforces those of the other measures and suggests that 2SLS does considerably better than I-O.

The comparison between the OLS forecasts and the other two forecasts (i.e., I-O and 2SLS) provided several interesting insights. First, while 52% of the OLS RMS percent errors were found to be smaller than those of I-O, the absolute percentage error was 22% lower than that of I-O, indicating that the gain in using OLS was not as marginal as might otherwise be inferred. Second, the 2SLS forecasts were also found to be considerably superior to OLS: In 73% of the variables the RMS percent error of 2SLS was lower than that of OLS while the absolute percentage error was found to be 29% lower. These results are of interest not only because they provide a small sample comparison between OLS and 2SLS, but also because several other relevant studies use OLS as an estimating technique. Finally, it was noted that the median RMS percent error of OLS was higher than that of I-O, despite the fact that the other measures indicate that OLS is superior to I-O. This result is of interest because Tilanus (1966) relies mainly on the median in reaching the conclusion that forecasts from a time series of I-O tables compare unfavourably with those of the latest I-O table. However, the results in this study indicate that the median is a poor guide to the forecasting performance of a model, suggesting that the results by Tilanus provide inconclusive evidence.

The main emphasis of this chapter has been the testing of the generalized Leontief I-O macro model, both in terms of the statistical significance of the results and in terms of the forecasting performance of the model. However, very little has been said about the practical implications of the model. The object of the next chapter is to examine some of the policy implications of the model, with particular emphasis on the multiplier properties.

CHAPTER VI

POLICY IMPLICATIONS

Introduction

The main purpose of this chapter is to examine some of the properties and policy implications of the generalized Leontief I-O macro model. With this aim in mind, the first section presents the historical simulation of the model as a whole, while the second section analyses some of the properties of various multipliers implied by the model. In order to examine both the initial and long-run effects of changes in exogenous variables, multipliers are calculated for the period 1973 to 1977. Finally, the fourth section deals with some of the policy implications of the various multipliers derived.

Ex-post Simulation

In the previous chapter, various ex-post forecasts were presented. However, ex-post simulation for the whole period and for the complete model was not presented. Consequently, the results of the ex-post simulation for the period 1963 to 1977 are presented in Appendix C and summarised in Table 6.1 .

TABLE 6.1

SUMMARY OF HISTORICAL SIMULATION

	WRMS		WRMS
Sector 1	11.036	Sector 6	7.225
Sector 2	7.743	Sector 7	12.936
Sector 3A	12.930	Sector 8	25.675
Sector 3B	10.538	Sector 9	5.190
Sector 4	9.555	Sector 10	7.617
Sector 5	7.588	Sector 11	11.167

Consumption	(WRMS)	10.0874
Gross Profits	(RMS)	11.7400
Employment	(RMS)	1.9100
Disposable Income	(RMS)	5.5000
Construction	(RI7, RMS)	12.4700

In Appendix C, the RMS percent error of each endogenous variable is given. However, as was noted in the previous chapter, there is considerable disparity in the size of these variables, so that a clearer idea of the performance of the model over the period may be obtained if the RMS percent errors are weighted. The weighting scheme adopted was to multiply each RMS percent error by the ratio of the value of each variable to the total value of the inputs used by the sector in the base year (1964). The resulting weighted RMS are denoted by WRMS and are summarised by,sector, in Table 6.1 .

A few points are worth noting about the results in Table 6.1 . First the highest WRMS occurs in Sector 8. This sector is the miscellaneous sector and hence acts as a residual category. Thus, the result that Sector 8 has the worst WRMS is perhaps, to be expected. Second, of the rest of the sectors, 5 have a WRMS less than 8% while 6 have a WRMS less than 13%. These results are judged to be within "tolerable" limits. Finally, Table 6.1 also gives the WRMS for consumption (10.08%) and the RMS for various other aggregate variables used in the model. Note that employment (or total wages and salaries since the wage rate per sector is assumed exogenous) has the lowest RMS (1.91%), while disposable income has an RMS of 5.5%. The finding that these two variables have a low RMS is important since the multiplier analysis of the next section will concentrate mainly on employment and income multipliers. Thus, in general, the results of Table 6.1 suggest that the historical simulation of the generalized I-O macro model gives satisfactory results.

Multiplier Analysis

Before deriving various multipliers, some modifications of the model were considered necessary. The first modification concerns the assumption that investment is determined exogenously. Since the major part of the output of the construction sector is classified as investment, the assumption of the exogeneity of investment is particularly damaging in this case: it virtually rules out any interactions between the construction sector and the rest of the economy, thereby causing all the multipliers to be underestimated. In order to avoid this problem, the following simple investment function for the construction sector was estimated:

$$RI7 = 4.671 + 0.079\ RYD + 22.581\ D10 - 19.323\ PIX7/PH \qquad (6.1)$$
$$(0.120)\ (5.879) \qquad (5.769) \qquad (-1.432)$$

$\bar{R}^2 = 0.88$, $F = 36.96$, $SSR = 659.77$, $DW = 2.18$

where RI7 = Investment in construction

RYD = Real disposable income

D10 = 1 for 1967-72 , zero otherwise

PIX7 = Price index for construction

PH = Housing price index from the Index of Retail Prices.

The formulation of (6.1) is similar to that used by Evans and Klein in the Wharton Econometric Forecasting model (1968) except that they include the difference between the long-term and short-term interest rates as a variable in the equation. In the case of Malta, however, this variable has remained practically unchanged over the period of estimation so that it was not included in the equation. In 1967 Malta experienced a building boom resulting mainly from foreigners' demand for property.* The effect of this building boom appears to have

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* See for example, The Annual Report of the Central Bank of Malta, 1969.

fizzled out by 1972, largely as a result of various restrictions imposed by the government on the acquisition of property by foreigners. To reflect this autonomous increase in demand for the construction sector's output, a dummy variable has been included in equation (6.1).

The second modification of the model prior to the estimation of the multipliers concerns sector 9, which comprises mainly public-administration, public health and educational services, etc. Since this sector relates mainly to government, it was assumed to be exogenously determined in the estimation of the multipliers. Thus, to the extent that government responds to an increase in economic activity by providing more services, the multipliers estimated in this section will underestimate the actual multipliers.

The procedure used to estimate the various multipliers presented in this section was as follows. First, the model was simulated for the period 1973 to 1977 using historical data for all exogenous variables.* This provided what may be called a "controlled" solution for the endogenous variables. Second, an exogenous variable (mainly exports by sector), was increased by 1 unit and the model re-simulated for the same period. This provided a "shocked" solution for the endogenous variables.

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* All simulations in this study are dynamic in the sense that simulated (rather than actual) values for endogenous variables in a given period are used as inputs when the model is solved in future periods.

Finally, the multipliers were obtained simply by taking the difference between the shocked and controlled solutions.

Tables 6.2, 6.3 and 6.4 give employment, import and income multipliers with respect to exports by sector. The upper half of Table 6.2 gives the employment by sector multipliers.*
For example, the row L1 gives the increase in employment by sector 1 due to an increase in exports of sector 1 by 1 unit. Similarly, the row L2 gives the increase in employment by sector 2 due to an increase in exports of sector 2 by 1 unit. The lower half of Table 6.2 gives the total increase in employment as a result of an increase in exports of a sector. Thus, the row RE1 gives the total increase in employment due to a sustained increase in exports of sector 1. Table 6.3 gives the import multipliers and is divided in the same way as Table 6.2 . That is, the upper half gives the import multipliers by sector with respect to exports by sector, while the lower half gives the total import multipliers with respect to exports by sector. Finally, Table 6.4 gives the income multipliers with respect to exports by sector.

As already noted in chapter IV, multipliers calculated from a nonlinear model will be slightly different for every time period. This makes it difficult to distinguish precisely

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* The employment multipliers given in Table 6.2 are with respect to a £M100,000 real increase (i.e., in constant pounds) in exports.

TABLE 6.2

EMPLOYMENT MULTIPLIERS

Employment by Sector

	1973	1974	1975	1976	1977
L1	4.78	5.00	4.57	4.28	4.09
L2	4.55	4.55	4.55	4.54	4.52
L3A	27.50	27.58	27.65	27.78	27.81
L3B	73.63	130.33	109.55	88.70	74.56
L4	18.05	17.23	8.86	5.90	8.01
L5	68.08	84.76	73.04	65.53	55.04
L6	14.77	15.12	9.32	7.71	11.50
L7	134.46	149.23	144.03	134.45	101.25
L8	50.06	50.41	50.70	51.17	51.64
L11	5.21	5.82	6.40	7.19	7.90

Total Employment

	1973	1974	1975	1976	1977
RE1	22.25	28.69	29.50	27.69	28.37
RE2	24.31	33.37	37.94	42.87	40.06
RE3A	36.62	40.19	42.19	47.19	43.62
RE3B	85.87	148.69	129.25	107.56	92.94
RE4	36.62	43.56	32.56	32.19	31.62
RE5	79.31	100.31	88.62	81.56	69.00
RE6	26.81	34.06	29.75	28.19	28.37
RE7	143.69	160.63	154.44	144.87	112.25
RE8	63.56	73.62	79.87	89.81	94.00
RE11	19.69	24.75	25.06	25.75	23.37

TABLE 6.3

IMPORT MULTIPLIERS

Imports by Sector

	1973	1974	1975	1976	1977
RM1	0.056	0.047	0.049	0.060	0.049
RM2	0.287	0.225	0.228	0.228	0.212
RM3A	0.600	0.601	0.602	0.605	0.606
RM3B	0.360	0.338	0.341	0.346	0.349
RM4	0.255	0.260	0.261	0.263	0.264
RM5	0.302	0.294	0.297	0.299	0.303
RM6	0.137	0.123	0.149	0.155	0.136
RM7	0.205	0.194	0.195	0.201	0.221
RM8	0.353	0.308	0.324	0.344	0.351
RM11	0.048	0.019	0.065	0.095	0.133

Total Imports

	1973	1974	1975	1976	1977
RE1	0.166	0.217	0.259	0.300	0.309
RE2	0.427	0.395	0.518	0.578	0.602
RE3A	0.650	0.681	0.712	0.755	0.766
RE3B	0.430	0.468	0.501	0.516	0.503
RE4	0.375	0.450	0.471	0.503	0.514
RE5	0.372	0.404	0.427	0.439	0.443
RE6	0.217	0.263	0.329	0.345	0.326
RE7	0.285	0.304	0.325	0.351	0.381
RE8	0.423	0.458	0.544	0.664	0.781
RE11	0.148	0.169	0.235	0.295	0.333

TABLE 6.4

INCOME MULTIPLIERS

	1973	1974	1975	1976	1977
RE1	1.54	1.79	1.95	2.16	2.30
RE2	1.99	2.36	2.73	3.27	3.45
RE3A	0.69	0.86	1.06	1.58	1.41
RE3B	1.02	1.35	1.49	1.47	1.62
RE4	1.65	2.03	1.81	2.14	2.16
RE5	0.91	1.12	1.16	1.27	1.23
RE6	1.13	1.52	1.65	1.73	1.64
RE7	1.14	1.13	1.19	1.38	1.36
RE8	1.04	1.68	2.24	3.24	4.18
RE11	1.33	1.53	1.60	1.74	1.74

when most of the effect of an increase in an exogenous variable has worked its way through the system. However, for all practical purposes, the multipliers given for 1977 may be regarded as a close approximation to the long run multipliers.*

In the case of the income multipliers in Table 6.4, it will be noticed that all the impact multipliers (i.e., those

* Consider, for example, the income multipliers given in Table 6.4 . In five cases (i.e., RE3A, RE5, RE6, RE7 and RE11) the multipliers in 1977 either decline slightly or remain unchanged from those in 1976. In all the other cases, except RE3B, the rate of change of the multipliers declines between 1975-76 and 1976-77. These results suggest that by the fifth year, most of the effect of a sustained increase in an exogenous variable has already worked its way through the model.

for 1973) are smaller than the long-run multipliers. Similarly for total imports (Table 6.3), the impact multipliers are smaller than the long-run multipliers. In the case of total employment (Table 6.2) however, the impact multipliers for RE4, RE5 and RE7 are larger than the long-run multipliers. This result is somewhat unexpected since one would normally expect the long-run multipliers to be larger than the impact multipliers as the former capture the effect of the increase in the exogenous variable in the previous periods. Examining the upper half of Table 6.3 reveals that the same characteristic is present in the employment by sector multipliers. To examine this issue more closely, Table 6.5 gives the ratio of employment to real output for sectors 4, 5, 7 in the period 1973-77.

TABLE 6.5

RATIO OF EMPLOYMENT TO REAL OUTPUT*

	Sector 7	Sector 5	Sector 4
1973	0.830	0.697	0.952
1974	0.851	0.840	0.956
1975	0.624	0.729	0.667
1976	0.564	0.585	0.558
1977	0.438	0.467	0.511

* Real output is in thousands of constant Malta pounds while employment is in number of employees.

As may be seen from Table 6.5, one common characteristic of these three sectors is that the ratio of employment to real output declined during the period. This implies an increase in the productivity per worker and, furthermore, provides an explanation for the result that the long-run multipliers are smaller than the impact multipliers. That is, since productivity per worker increased from 1973 to 1977, one would expect that an increase in output, by say 1 unit, would have a larger effect on employment in 1973 than in 1977, precisely the result given in Table 6.2 for these three sectors.

Two points are worth noting about these findings. First, as noted by Evans (1968, p. 559), one criticism of multiplier analysis is that the multipliers reflect more the properties of the model than the actual conditions in the real world. These results, however, strongly suggest otherwise. Indeed, it appears that the model gives quite a faithful representation of reality. Second, the benefits of the nonlinear specification of the input demand functions used are clearly indicated in this case. Had the traditional I-O model been used, it would have completely missed the decline in the multipliers since it would assume that the multipliers are constant throughout the period.

One final point to note about the employment multipliers given in Table 6.2 is that in several cases they imply a considerable spillover effect from one sector to the rest of the economy. For example, consider the effect of a £M100,000 increase in the exports of sector 2 (i.e., the Food, Beverages and Tobacco sector). The results of Table 6.2 indicate that while the total increase (both direct and indirect) in employment of sector 2 would be 4.52 in 1977, the increase in total employment would be 40.06 or almost nine times as much. This result is important because it has often been argued that because the I-O table of the Maltese economy has several blank cells, and because the Maltese economy is very open, importing a large quantity of its inputs, the interconnections in the economy are somewhat weak. However, the results in Table 6.2 indicate otherwise and suggest that an analysis of the various interconnections is, indeed, fruitful.

Before proceeding to an analysis of some of the policy implications of the multipliers derived in this study, two qualifications are necessary. First, it will be recalled from the previous chapter that the model assumes that the various sectors have some reserve capacity available. This is an important assumption which must be borne in mind in considering the policy implications of the multipliers. For example, in the preceding case of an increase in exports of sector 2 by £M100,000, the resulting increase in employment depends on the presence of reserve capacity. Whether in fact the required reserve capacity is available is a question which this model cannot answer due to lack of capital data.* Thus any application of this model

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* It should be noted however, that had the I-O model been used, the same problem would arise.

must be supplemented by an analysis of the capital utilization of the sectors. This would identify which sectors require further investment and thus allow policy makers to avoid creating bottlenecks.*

Second, implicit in the derivation of the multipliers is the assumption that the foreign exchange rate remains fixed at its historical level. That is, the model assumes there is no link between, for example, an increase in tourism representing a net inflow of foreign currency and the exchange rate.** This assumption is bound to be unrealistic in any application of the model, so that this model should be complemented by a study on the determination of the exchange rate as well as the effect that a change in the exchange rate has on the economy. In particular, not only will the price of imports be affected due to changes in the exchange rate, but also the price of exports. This suggests that a further extension of the model would be required, namely the setting up of export demand functions with the relative price of exports to the world price as one of the arguments.

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* In the case where further investment is required, the multipliers derived in this chapter are likely to be underestimates of the actual multipliers.

** It should be noted that the Central Bank of Malta started operations only in 1968, while up to 1971, the Malta pound was pegged to sterling. Thus, up to 1971, the assumption that the exchange rate is determined exogenously appears to be a reasonable assumption. After 1971, it would appear that Malta has had mainly a fixed exchange rate regime, as evidenced by the consistent surplus in the Balance of Payments (see below p. 144). Though this factor suggests that the assumption of the exogeneity of the exchange rate may also be reasonable after 1971, such

cont./

Policy Implications

Import Multipliers

One of the most significant results of this study from a policy standpoint, concerns the import multipliers presented in the previous section. Metwally (1977, p. 141) in his study estimates the import multiplier with respect to exports as 1.714 and the import multiplier with respect to tourism as 1.053 . Metwally's derivation of the multipliers for exports and tourism has already been criticised in chapter II. However, abstracting from these criticisms for the present, the important point to note is that both these multipliers are greater than one. This implies that an increase in either exports or tourism by say £M100 will result in an increase in imports by more than a £M100. Such a situation is highly disturbing. It suggests that the Maltese economy is unstable, with any increase in exports or tourism resulting eventually in the depletion of foreign reserves.

Fortunately, however, this study finds no support of such instability. The total import multipliers in Table 6.3 indicate that all of the total import multipliers with respect to exports are less than one.* Thus an increase in the exports

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a line of argument would ignore the fact that the government does react to changes in both internal and external conditions in setting the exchange rate.

* It should be noted that the model used to derive the multipliers in Table 6.3 assumes that the imports of capital goods are exogenous. Since this might lead to a possible underestimation of the import multipliers, the imports of capital goods were cont./

of any sector will not result in the kind of dilemma that Metwally's study suggests. Indeed, there will always be some net gain to the Balance of Payments, both in the short-run and in the long-run, whenever exports are increased.

Conflicting Goals

The multipliers presented in Tables 6.2, 6.3 and 6.4 provide an important aid to policy analysis and formulation. For example, an important role of government in Malta is the negotiation of various trade agreements with the E.E.C., Malta's main trading partner. This implies that the government can influence considerably the expansion of various sectors and hence requires knowledge of the effects that such changes have on the economy.

In order to examine more closely the policy implications of the multipliers, Table 6.6 reproduces the long-run multi-

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regressed on the gross output of all sectors, and the model re-simulated. A selective checking of the resulting total import multipliers indicated that most of the multipliers increased by less than 0.1 . The only exception found was in the case of RE8 which did approach one. However, this sector is the miscellaneous sector and hence relatively small. Hence, even if the imports of capital goods are endogenised, the import multipliers are still less than one. Furthermore, it should be noted that these alternative estimates are probably overestimates of the total import multipliers since the government is the largest contributor to gross fixed capital formation. (For example in 1976. gross capital formation by government stood at 57% of total gross capital formation.) Thus a considerable portion of imports of capital goods is probably exogenously determined and hence not related to increases in exports ofthe various sectors.

TABLE 6.6

SELECTED LONG-RUN MULTIPLIERS

Sectors	RXi	REi	Y	RMi	TOM	TOL
1	10,753	897	2.30	0.049	0.309	28.37
2	17,725	3,834	3.45	0.212	0.602	40.06
3A	19,091	17,848	1.45	0.606	0.766	43.62
3B	1,688	1,158	1.62	0.349	0.503	92.96
4	11,451	7,257	2.16	0.264	0.514	31.62
5	2,365	154	1.23	0.303	0.443	69.00
6	11,946	5,639	1.64	0.136	0.326	28.37
7	7,990	201	1.36	0.221	0.381	112.25
8	1,245	788	4.18	0.351	0.781	94.00
11	99,803	51,593	1.74	0.133	0.333	23.37

pliers of income (Y), import by sector (RMi), total imports (TOM) and total employment (TOL). Also given in Table 6.6 are the real level of output (RXi) and real exports (REi) by sector in 1977. The purpose of the RXi column is to indicate the relative size of the sectors. In particular note that sectors 3B, 5 and 8 are much smaller than the other sectors. The purpose of the REi column is to identify the relative importance of the domestic and export markets for each sector.

It should be noted that due to the structure of the model, the multipliers with respect to exports are the same as those with respect to government expenditure, so that these multipliers also provide an indication of the effect of changes in government expenditure on goods and services. In some cases, however, the link between these export multipliers and the government policy instruments may be indirect. An example might help to clarify this point, as well as indicate how this model should be complemented by other studies in actual policy analysis.

Consider the case where the government decides to stimulate tourism. This may be done by increasing advertising expenditure abroad so as to attract more tourists to Malta. Thus in this kind of policy change, the results in this study must first be complemented by a study on how advertising expenditure by government affects the "export" of tourism (part of E11). Second, once an estimate of this value is obtained, the effect on the rest of the economy may be obtained through the various multipliers derived in this chapter. However, as noted above, the model assumes the presence of reserve capacity by the various sectors so that the government would have to supplement further this study by an analysis of capital utilization, as for example, the occupancy rate of hotels, holiday apartments, etc. Should a shortage in these variables be envisaged, then the government would have to complement an increased advertising expenditure by a policy of encouraging the building of hotels and holiday apartments. Such an increase in investment would imply some further changes in employment, income and imports so that the model would have to be re-simulated, allowing for this increase in investment as well as the estimated increase in E11. One further point to note is that the model estimated in this study also assumes that relative prices, as well as the exchange rate, are determined exogenously. However, this is bound to be only an empirical approximation so that the effect on these variables due to changes in policy or exogenous variables should also be examined. If, for example, the postulated expansion of tourism requires a considerable increase in hotel construction, then it is likely that the price of the construction sector (PIx7) may be affected upwards, so that this change would also have to be incorporated in the model.

Two salient features of Table 6.6 are worth noting. First, a higher income multiplier does not necessarily imply a higher employment multiplier. For example, comparing sector 3A (Textiles and Wearing Apparel) with sector 11 (Services, i.e., Tourism, Shiprepairing, etc.) shows that while the income multiplier of the latter is larger, the employment multiplier of sector 3A is almost twice the size of that of sector 11. This finding is important since in more aggregate models a higher income multiplier is often implicitly assumed synonymous with higher employment multipliers. Thus, taking decisions on the basis of income multipliers could prove misleading if the primary concern of government is employment.

Second, Metwally (1977) recommends that tourism (part of sector 11) should be encouraged relative to exports of goods because the former has a lower import multiplier than the latter. Two points are worth noting about this view. First, lumping together all exports could provide a misleading picture since there are sectors which have a lower import multiplier (sector 6) than sector 11. Second, and more importantly, Table 6.6 reveals that the import and employment multipliers tend to be positively correlated. That is, sectors with low import multipliers tend to have low employment multipliers, while sectors with high employment multipliers tend to have high import multipliers.* For example, sector 3A has an import multiplier twice as large as that of sector 11. However, the employment multiplier of sector 3A is also twice as large. Thus, policy makers are faced with a trade-off. That is, encouraging the expansion of those sectors with a low import multiplier but which also have a low employment multiplier against encouraging sectors with high import and employment multipliers.

It should be noted that the import multipliers with respect to exports derived in this study indicate that there will always be some net gain to foreign reserves. Thus the question of whether to encourage sectors with low or high import multipliers with respect to exports, concerns the rate of increase of foreign reserves.

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* A notable exception is sector 7 which has the highest employment multiplier and an import multiplier of 0.381. However, sector 7 is the construction sector so that the export market is of minor importance.

In order to examine this issue more closely, Table 6.7 gives Malta's external reserves as well as the change and percentage change of these reserves for the period 1973 to 1977. As may be seen from Table 6.7, the yearly increase of the foreign reserves has been quite considerable, averaging 19.33% over the period. Though this rate of increase is impressive, yet it gives an incomplete picture. Appendix D provides a comparison of Malta's reserves with those of 43 other countries. As shown in Appendix D, Malta's reserves in 1978 amounted to U.S.$942 million. For a country of Malta's size, this figure represents a massive level of reserves. For example, relative to Iceland, a country of similar size, Malta's reserves were 7 times higher in 1978. An even better comparison of Malta's reserves with those of other countries is provided by the ratio of reserves to imports or alternatively by the number of weeks supply of imports that the reserves can maintain. Appendix D

TABLE 6.7

FOREIGN RESERVES

	1973	1974	1975	1976	1977
Total External Reserves[1]	160.21	178.01	228.71	286.60	318.35
Change[1]	27.46	17.80	50.70	57.84	31.75
% Change	20.69	11.11	28.48	25.31	11.08

[1] In millions of Malta pounds.

shows that Malta had the equivalent of 85 weeks supply of imports, the highest of the 43 countries considered. Even the oil exporting countries hold a much smaller ratio, the equivalent of 30 weeks supply of imports.

It is not clear why Malta should depart so drastically from other countries in its ratio of reserves to imports. One incentive for holding a high level of reserves is that the interest payments on these foreign reserves constitute an important source of revenue for the government. However, in 1978 the rate of return averaged only 4.25% . Since this figure is below the rate of inflation of the major currencies in 1978, a net loss in the real value of the reserves occured in that year.

Two points are worth noting about the performance of Malta's external reserves during the period 1973-77. First, the fact that these reserves have been increasing at an average rate of 19.9% lends support to one major result of this study, namely that the import multipliers with respect to exports are less than one. If Metwally's results are correct, namely that the import multipliers with respect to exports and tourism are greater than one, then one would not expect such a rate of increase in the foreign reserves, especially since in this period there was a considerable expansion in exports of goods and tourism.*

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*For example; real exports of sector 3A, which has an import multiplier of 0.76, almost doubled between 1973 and 1977.

Second, the choice between sectors with low import multipliers and those with high import multipliers is not as crucial as is conventionally assumed. Since all the import multipliers with respect to exports are less than one, the choice between these two types of sectors involves different rates of addition to reserves. However, an examination of the rate of increase in reserves and the stock of reserves already amassed, suggests that the implication of different rates of addition to reserves is not, at present, a crucial issue.

Turning now to the employment question, Table 6.8 gives the percentage rate of officially unemployed as well as employment in the Emergency Labour Corps. The latter was introduced in 1972 as an emergency measure, in order to provide temporary employment. The kind of work done by the Labour Corps involves mainly public works, such as the resurfacing of roads, extension

TABLE 6.8

UNEMPLOYMENT RATES[1]

	1973	1974	1975	1976	1977
Labour Corps	4.01	3.35	6.93	6.04	5.43
Officially Unemployed	4.45	6.10	4.34	4.29	4.30
Total	8.46	9.45	11.27	10.33	9.73

[1] All figures are in percentage rates of the total labour force.

of a runway at the airport, etc. The Labour Corps was envisaged as a temporary solution to the unemployment problem, with the object of eventually weaning them out as more productive jobs become available. For example, in the Supplement to the Development Plan for Malta 1973-1980, the plan projection was to reduce their number to 2,090 by 1976. However, the actual employment by the Labour Corps in 1976 was 7,876, indicating that the economy had not provided the required productive jobs by that time. Thus, in order to get a more accurate measure of the excess supply of labour one must also include the Labour Corps to the officially unemployed, though in actual fact the former were employed.

Table 6.8 shows that over the period 1973 to 1977, the average of the total of unemployed and Labour Corps was 9.85%. In other words, if the Labour Corps had not been introduced the average rate of unemployment would have been at least 9.85%.* By most standards, this rate of unemployment represents a grave problem, usually identified with periods of recession in industrialized countries.

Consequently, in answer to the question of whether to encourage sectors with relatively low import and employment multipliers or sectors with relatively high import and employment

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* If the rate of unemployment benefits was lower than the wage rate of the Labour Corps, then the average rate of unemployment would have been higher as aggregate income would have been lower.

multipliers (with respect to exports), the implication from the previous considerations is clear. Employment is the more important factor to take into consideration in encouraging the development of the various sectors of the economy. This policy recommendation contrasts quite sharply with that of Metwally (1977) who suggests that sectors with a low import multiplier should be encouraged.

Fiscal Policy.

The discussion so far has centred on one role of government,namely that of influencing the expansion of various sectors through trade agreements. However, the government can affect the economy in other more direct ways,as for example through its fiscal policy. In view of the unemployment problem in Malta it is relevant to examine some of the implications on fiscal policy of the multipliers derived.

An important tool of the government is, of course, its budgetary policy. An examination of government revenue and expenditure over the five years under consideration reveals that the budget was,on average, in surplus by £M3.5 million.* This finding is somewhat surprising since one would not expect that the budget was in surplus by such an amount during a period when the government had to create temporary jobs.

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* Source, Central Bank of Malta Quarterly Review, June 1979, p. 47.

Since the average surplus of the budget was £M3.5 million, it is interesting to enquire what would have been the effect of an increase in government expenditure by £ M3.5 million per year for the period 1973-77. Table 6.9 gives the long-run effect (i.e., for 1977) assuming that the increase in government expenditure occured in the construction sector. First, note

TABLE 6.9

CHANGES IN VARIABLES

	TOL	TOM[1]	Y[1]	TAXY[1]	X7[1]
1977	2403	2397	4983	538	4402

[1] In thousands of Malta pounds at 1977 prices.

that employment (TOL) would have increased by 2403 in 1977. This represents a substantial gain in employment, equivalent to half of the officially unemployed for that year. Second, total imports (TOM) would have been increased by £ M2.4 million. This implies that the foreign reserves would have increased by £M29.35 million rather than the actual increase of £ M31.75 . Finally, note that due to the increase in income of £ M4.98 million, revenue from taxation would also have been higher by £ M0.538 million, so that the budget at the end of the period would still have been in surplus, but by a much smaller margin.

A second important instrument of government is its taxation policy. The following income tax function was estimated for Malta, using 2SLS.

$$TAXY = -1103.69 + 0.04778YP + 0.05971(D_2)(YP) \quad (6.2)$$
$$(-1.20) \quad (3.57) \quad (6.63)$$

$\bar{R}^2 = 0.98$, $F = 460$, $DW = 1.83$, $SSR = 11690000$

where TAXY = Personal income tax plus National Insurance contributions in thousands of pounds

YP = Personal income in thousands of pounds

D_2 = 0 for 1962-72

1 for 1973-77

The tax system in Malta was overhauled in 1973, mainly through the introduction of a pay-as-you-earn system. Consequently, a dummy variable was introduced to capture any resulting change in the marginal tax rate.

Two points are worth noting about the estimated tax function. First, the marginal tax rate for the period 1962 to 1972 (i.e., 0.04778) is the same as that estimated by Waldorf (1969) for the period 1954 to 1966. Second, for the period 1973 to 1977, the effect of the overhaul in the tax system is seen to have more than doubled the marginal tax rate. Thus, the marginal tax rate for this period was approximately 11 percent.

Table 6.10 gives the changes in total employment (TOL), real income (RY), real total imports (TÒM) and tax revenue (TAXY) due to changes in tax parameters. The upper half of Table 6.10 gives the changes due to decreasing by half the increase in the

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* Equation (6.2) was also estimated including a dummy variable

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TABLE 6.10

CHANGES IN SELECTED VARIABLES

Decrease in the Marginal Tax Rate[1]

	1973	1974	1975	1976	1977
TOL	433.37	661.56	710.19	853.69	844.81
RY	9.57	17.16	22.37	31.38	39.20
TOM	4.24	6.72	8.86	11.89	14.77
TAXY	-3192.20	-4.026.49	-4169.80	-5159.19	-6189.63

Shift in Tax Function[2]

	1973	1974	1975	1976	1977
TOL	520.87	645.81	661.00	682.75	602.00
RY	11.50	17.62	21.79	27.44	29.55
TOM	4.30	6.81	8.43	9.94	10.93
TAXY	-3839.77	-3726.88	-3646.36	-3543.63	-3456.53

1 The increase in the marginal tax rate for the period 1973-77 was halved to 0.02985.

2 The intercept of the tax function was decreased by £M4 million.

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to allow for an intercept shift during the period 1973-77. However, the t-value of this variable was insignificant so that the overhaul of the tax system does not appear to have affected the intercept of the tax function.

marginal tax rate during the period 1973-77. Since the government budget was in surplus during this period, the average deficit from this policy would have been £M1.05 million, while employment would have increased by 845 .

The second example given in Table 6.10 is for a downward shift in the tax function by £M4 million. This policy would have resulted in an average decline of £M3.6 million in tax revenue, thereby wiping out the surplus on the government budget. It is interesting to note that the increase in employment by 1977 (i.e., 602) is substantially less than what would have been the increase in employment due to an increase in expenditure in construction by £M3.5 million (i.e., 2403 in Table 6.9). This indicates that the employment multiplier for an increase in government expenditure in construction is much larger than that for a decrease in taxes. This result agrees with theoretical expectations that the balanced budget multiplier is greater than zero, and suggests that there is considerable scope for fiscal policy in Malta.

Conclusion

The main purpose of this chapter was to examine some of the properties and policy implications of the generalized Leontief I-O macro model.

The first section presented historical simulation results for the complete model. In general, these results indicate that the model does give a satisfactory performance over the period 1963-77.

The second section presented employment income and import multipliers with respect to exports by sector for the period 1973-77. In the case of import and income multipliers, it was found that all the long-run multipliers are larger than the impact multipliers. However, in the case of employment multipliers, three sectors were found to have an impact multiplier larger than the long-run multiplier. Further examination of these three sectors revealed that the ratio of employment to real output declined during the period 1973-77. This was seen to imply larger employment multipliers for 1973 than for 1977, thereby providing an explanation for the smaller long-run multiplier relative to the impact multiplier (i.e., for 1973). Two implications were drawn from this result. First, the fact that the model captures this negative trend in employment was interpreted as an indication that the model does give a faithful representation of the real world. Second, these results clearly indicate the superiority of the non-linear specification used relative to the I-O model. The latter would have completely missed the decline in the employment multipliers since it would have assumed that the multipliers remain constant throughout the period.

Finally, it was noted in this section that in several cases, the employment multipliers imply a considerable spill-over affect from one sector to the rest of the economy. This suggests that an analysis of the various interconnections of the Maltese economy is, indeed, fruitful.

The third section dealt with some policy implications of the multipliers. These may be summarised as follows. First, all the import multipliers with respect to exports were found to be less than one. This result contrasts quite sharply with that of Metwally who found that the import multipliers with respect to exports and tourism were greater than one. Second, it was observed that if a sector has a higher income multiplier relative to another sector, it does not necessarily imply that the employment multiplier is also higher. This result is important since if employment is of primary interest to government, taking decisions on the basis of income multipliers could prove misleading. Third, while Metwally recommends that sectors with a lower import multiplier should be encouraged, this study found that import and employment multipliers tend to be positively correlated. This suggests that policy makers are faced with a conflict of goals; that is, encouraging sectors with low import multipliers but which also have low employment multipliers against encouraging sectors with high employment and import multipliers.

In order to examine this issue more closely, an assessment of Malta's foreign reserves and unemployment rates over the period 1973-77, was presented. While Malta's reserves increased at an average rate of 19.33%, reaching by 1978 the highest ratio of reserves to imports relative to 43 other countries, the average excess supply of labour over the period was 9.85% . These findings suggest that employment is the more important factor to take into consideration in encouraging the development of the various sectors. Differences in the net gain of reserves does not appear to be a crucial problem. Indeed, as was noted, a net loss in the real value of the foreign reserves resulted in 1978, raising serious questions on the management of the huge level of reserves already amassed.

Finally, the multipliers were used to analyse the effect of some changes in fiscal policy. It was noted that during the period 1973-77, the government's budget was, on average, in surplus by £M3.5 million. Thus, the first policy experiment conducted was to examine the effect of a sustained increase in government expenditure in the construction sector by £M3.5 million. The results indicated that by 1977, employment would have increased by 2402, which is equivalent to more than half the officially unemployed for that year, while the budget would still have been in surplus by £M0.54 million. The effect of changes in tax parameters were also analysed, the most important result being that, as theory suggests, the effect of an increase in government expenditure is larger than that of a cut in taxes.

This chapter has considered only some of the policy implications of the generalized I-O macro model. As will be indicated in the concluding chapter, the model may be extended and used to analyse many other important issues. However, the policy implications drawn in this chapter are judged to be of sufficient importance to indicate the usefulness of the model in assessing policy implications.

CHAPTER VII

CONCLUSION

The main object of this study was to construct a macro model of the Maltese economy, integrating both I-O and Keynesian final demand models. One special characteristic of the Maltese case is the availability of 17 annual I-O tables (1961-77). This feature has made possible a study which is of interest not only as a case study of Malta, but also from a wider perspective. The main results of the various chapters may be summarised as follows.

Chapter II provided a critical assessment of Metwally's (1977) study of the Maltese economy. Various specification problems with Metwally's model were identified, the most significant being his derivation of multipliers for exports and tourism. It was pointed out that his derivation of different multipliers for these two variables is inconsistent with the specification of his model, unless one assumes that the E variable in the investment function refers only to the export of goods. That this assumption is in fact made by Metwally, was confirmed by re-estimating his investment function. However, though this provides an explanation of Metwally's results, the justification of this assumption, as was noted, is highly dubious. Thus, Metwally's main policy recommendation that Malta should concentrate on the tourism sector rather than the export sector is seriously in question.

Another significant problem with Metwally's results was seen to be his finding that the import multipliers with respect to exports and tourism are greater than one. This suggests an element of instability which, if it correctly portrays the actual structure of the Maltese economy, has considerable policy implications. These types of problems in Metwally's model clearly indicate the need of an alternative model of the Maltese economy, capable of addressing such questions.

The third chapter considered mainly Tilanus' (1966) study on a time series of I-O tables for the Netherlands. Tilanus comes to the rather surprising conclusion that a time series of I-O tables is of little use. Since this conclusion runs counter to the main theme of this study, and since Tilanus' results appear to have been quite influential in discouraging attempts to collect I-O tables annually, his study was examined at some length.

It was found that Tilanus' study suffers from various estimation problems which may have contributed to his negative results. However, the main criticism of Tilanus' study is that he adhered too rigidly to the traditional assumptions of the I-O model. The only use he makes of the time series of I-O tables is to estimate linear trends for the technical coefficients.

As was pointed out, however, the availability of a time-series of I-O tables allows the relaxation of some of the traditional assumptions, as for example, the assumption that inputs are demanded in fixed proportions to output. Consequently, Tilanus underutilised the information contained in a time-series of I-O tables, so that the issue of the usefulness of a time-series of I-O tables is still an open question.

The issue of relaxing some of the traditional assumptions in the I-O model was examined more closely in Chapter IV. The Leontief production function was substituted by the generalized Leontief cost function, and cost-minimizing input demand functions derived. These derived input demand functions were seen to allow for factor substitution, and in addition reduce to the Leontief specification for the case of no factor substitution. Thus, this extension of the I-O model provides a generalization of the traditional I-O model, and furthermore, represents the supply side of the economy. The demand side of the economy was captured by setting up sectoral consumption functions. Finally, this chapter also provided a comparison between the approach suggested in this study and the conventional approach of linking I-O with final demand models.

Chapter V presented the regression results from estimating the complete model identified as the generalized I-O macro model. In all, the model has 122 equations and was estimated for the period 1962-77. The estimation technique used is 2SLS with principal components in the first stage and correcting for autocorrelation. The finding that 56% of the input demand functions have a relative price (times output) variable which is positive and significant clearly indicates the importance of relative prices. Thus, in general, the Leontief specification is rejected in favour of the generalized Leontief form used in this study. Moreover, all the estimated cost functions satisfy the monotonicity condition while 10 out of the 12 cost functions satisfy the concavity condition. As pointed out, these results compare favourably with other similar empirical studies.

In order to test Tilanus' results, ex-post forecasts were made for the year 1977 using the traditional I-O model and the generalized Leontief specification. The absolute percentage error of the forecasts of I-O was found to be 9.82 while that of the 2SLS forecasts was 5.44. In other words, the error of I-O was found to be almost twice as large as that of the generalized I-O macro model (using 2SLS). This marked improvement in forecasting ability clearly indicates that the specification used is worthwhile, and contrasts quite sharply with Tilanus' results. Finally, this chapter also provided forecasts using OLS as an estimation technique. It was found that though OLS provided superior forecasts than I-O, they were considerably inferior to 2SLS. These results are of interest not only because they provide a small sample comparison between OLS and 2SLS, but also because several other relevant studies use OLS as an estimating technique.

Chapter VI examined some policy implications of the generalized I-O macro model. One major result in this chapter is that the import multipliers of all sectors with respect to exports were found to be less than one. Thus, in contrast to Metwally's results, this study found no supporting evidence of instability. A second important result is the finding that import and employment multipliers by sector, with respect to exports, tend to be positively correlated. Thus, while Metwally (1977) recommends that sectors with a lower import multiplier should be encouraged, this study found that policy makers are faced with a conflict of goals; that is, encouraging sectors with low import multipliers but which also have low employment multipliers against encouraging sectors with high employment and import multipliers.

In order to examine this issue more closely, an assessment of Malta's foreign reserves and unemployment rates over the period 1973-77 was presented. While Malta's reserves increased at an average rate of 19.33%, reaching by 1978 the highest ratio of reserves to imports relative to 43 other countries, the average excess supply of labour over the period was 9.85%. These findings suggest that employment is the more important factor to take into consideration in encouraging the development of the various sectors. The question of differences in the net gain of reserves does not appear to be a crucial problem.

Finally, the multipliers derived were used to analyse the effect of some changes in fiscal policy. It was noted that the government's budget was, on average, in surplus by £M3.5 million during the period 1973-77. Thus, the first policy experiment conducted was to examine the effect of a sustained increase in government expenditure in the construction sector by £M3.5 million. The results indicated that by 1977, employment would have increased by 2402, which is equivalent to more than half the officially unemployed for that year. The effect of changes in tax parameters were also analysed, the most important result being that, as theory suggests, the effect of an increase in government expenditure is larger than that of a cut in taxes.

The model constructed in this study is relatively large by conventional standards. Yet, it remains a simple model, based on four basic relationships, namely, (a) input demand functions (b) sectoral consumption functions (c) an investment function for construction and (d) an income tax function. Clearly, the generalized I-O macro model may be extended in many directions. A few examples of such extensions are the following. First, a monetary sector needs to be added. This is particularly important in order to be able to assess better the implications on the balance of payments. Second, some relative prices may be endogenised so that with the addition of the monetary sector, questions relating to the inflationary impact of various policies may be assessed. Third, a more accurate measure of government revenue would be obtained if a corporate income tax function, and taxes on expenditure by sectoral category (including imports), are added. Fourth, investment functions for categories other than construction may be added. Fifth, the capital input needs to be taken into consideration more explicitly than in this study.

Most of these suggested extensions require the development of data in classifications not currently published. However, in several cases, it should not be too difficult for the Central Office of Statistics to derive series on, for example, capital utilization by sector from the annual Census of Production. Furthermore, if the model is to be updated to the current year, then such series as, for example, exports which are published quarterly, need to be made available by sectors consistent with the classification used in the I-O table.

Given such data, the generalized I-O macro model may be extended to analyse many other important issues. However, the policy implications drawn in this study are judged to be of sufficient importance to indicate the usefulness of the model in assessing policy implications.

APPENDIX A

PRICE INDICES

Sector 1

Sector 1 includes both agriculture and fisheries. However, in the calculation of a price index for this sector, fisheries was excluded both because of its small size relative to agriculture, and because of the large variety of fishes that would have to be considered.* On the agricultural side, the flowers and seeds category, making up only 2% of the total value of this sector in 1977, was excluded because no quantity data are available.

From the production account for agriculture, which gives both quantity and value data, price indices were derived for each item in the following categories:**

(i) 9 types of livestock

(ii) 3 types of milk

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* In 1977, the retail value of the locally caught fish was only 4.7% of the total value of output of sector 1, while 52 species are listed in the Annual Abstract of Statistics (1977, pp. 160-162).

** See for example the Production Account for Agriculture in A.A.S. for 1977, Section A, p. 153.

(iii) Eggs

(iv) Hides, skins, wool and tallow

(v) Cereals, legumes and other crops.

In the case of fruits and vegetables, however, the price index was derived from the published quantity index and the current value of output series.* For these two cases this alternative information is preferable than that given in the Production Accounts as the latter lumps together all types of vegetables and all types of fruits.

Once the above price indices were derived, they were weighted by the base year value of each category to the total value of all categories, and aggregated to give a price index for sector 1 .

Sectors 2 to 8, 10

The price indices for these sectors were derived from the Index of Industrial Production (I.I.P.).** For a particular sector producing n products, the I.I.P. is defined as follows:

$$IIP = \sum w_i \; Q_{1i}/Q_{0i} \tag{A1}$$

where

$$w_i = P_{0i}Q_{0i}/\sum P_{0i}Q_{0i} \tag{A2}$$

---

* The same method was used as that described below for deriving a price index from the Index of Industrial Production. The current value of output used is that given in Table II, A.A.S. (1961 to 1977).

** The I.I.P. is published in the A.A.S. (1964-1977).

P_{0i} , Q_{0i} = base year price and quantity of good i .

P_{i1} , Q_{1i} = current year price and quantity of good i .

Substituting (A2) into (A1) gives,

$$IIP = \Sigma P_{0i}Q_{1i}/\Sigma P_{0i}Q_{0i} \qquad (A3)$$

Multiplying the IIP (i.e.,(A3)) by the total base year value yields,

$$(IIP)(\Sigma P_{0i}Q_{0i}) = \Sigma P_{0i}Q_{1i} \qquad (A4)$$

Thus, (A4) is the base year value of current output. Substracting and dividing (A4) by the current value of current output gives,

$$\Sigma P_{1i}Q_{1i} - \Sigma P_{0i}Q_{1i}/\Sigma P_{0i}Q_{1i} = \Sigma P_{1i}Q_{1i}/\Sigma P_{0i}Q_{1i} - 1$$

$$= \text{Paasche Price Index} - 1$$

Hence, given the I.I.P. and the value of output for each sector, a price index can be derived.* The only problem encountered was that the I.I.P. goes back only until 1964 while I-O tables are available since 1961. To overcome this difficulty, the derived price indices were regressed against the index of retail prices and backcasts made for the period 1961-63.

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* The values of output used to derive the price indices for sectors 2 to 8 are those published in the A.A.S., Section VII, Table (2), except for food (part of sector 2) for which the value given in the I-O tables was used, as this value includes the output of milk while that in A.A.S. does not. For sector 10, the value of output used is also that given in the I-O table because the A.A.S. does not give this figure.

Sectors 9 and 11

For sector 9 (public administration) and sector 11 (services), the index of retail prices was used as a proxy variable. In the former case, the all items price index, while in the latter case the services price index were used.

The price indices of the various sectors derived in this study are given in Table A1 where PIXi indicates the price index of sector i .

TABLE A1

Year	PIX1	PIX2	PIX3A	PIX3B
1961	99.149	97.508	78.550	96.225
1962	97.271	97.806	79.145	101.254
1963	95.393	100.635	84.791	102.763
1964	100.000	100.000	100.000	100.000
1965	104.741	101.425	97.312	94.155
1966	106.487	107.556	104.522	98.620
1967	106.638	110.577	102.284	104.958
1968	106.789	117.221	109.632	118.924
1969	116.527	116.729	115.031	117.196
1970	120.201	122.800	120.735	113.313
1971	120.830	130.125	124.795	132.389
1972	136.808	137.114	145.458	156.875
1973	159.385	140.439	171.268	161.758
1974	176.950	163.427	221.664	207.905
1975	184.940	186.519	250.666	221.352
1976	192.009	214.310	313.084	212.089
1977	213.549	241.934	306.262	247.328

Year	PIX4	PIX5	PIX6	PIX7
1961	74.818	89.943	95.009	95.265
1962	75.614	90.303	95.340	92.374
1963	83.172	93.720	98.486	92.070
1964	100.000	100.000	100.000	100.000
1965	97.483	99.664	108.254	97.922
1966	100.359	100.554	101.121	98.484
1967	99.668	101.458	104.904	102.112
1968	115.362	110.689	108.660	107.304

cont./

TABLE A1--Continued

Year	PIX4	PIX5	PIX6	PIX7
1969	124.751	118.190	118.484	115.821
1970	135.165	119.577	123.904	122.263
1971	155.853	128.158	134.551	124.444
1972	174.794	186.371	125.201	121.241
1973	203.839	141.743	132.314	151.037
1974	250.085	176.138	171.739	152.967
1975	215.756	178.876	183.695	157.774
1976	241.590	186.371	178.533	174.309
1977	254.596	192.179	167.396	186.529

Year	PIX8	PIX9	PIX10	PIX11
1961	81.491	95.841	101.782	98.577
1962	82.104	96.026	101.782	99.431
1963	87.927	97.782	101.106	99.620
1964	100.000	100.000	100.000	100.000
1965	105.278	101.571	108.450	102.656
1966	104.813	102.126	90.258	103.700
1967	106.206	102.773	89.387	103.985
1968	115.778	104.898	99.317	104.934
1969	117.048	107.375	104.730	107.979
1970	129.088	111.368	108.401	118.596
1971	137.945	113.946	114.174	123.159
1972	145.144	117.782	87.864	131.338
1973	163.809	126.858	101.577	137.030
1974	236.988	136.091	137.790	146.366
1975	300.105	144.427	142.847	151.518
1976	405.544	148.900	147.570	155.651
1977	544.667	163.850	151.735	164.037

TABLE A2

I-O TABLE OF THE MALTESE ECONOMY FOR 1977

	1	2	3A	3B	4	5	6	7	8
1	-	3551		26					
2	6939	-							
3A			-						
3B				-					
4	53	314	51	22	-	95	153	637	11
5		15		5		-	45	1410	
6		268	232	50	402		-	3	14
7		43	23	1	15	14	11	-	3
8	5		415						-
9									
10		419	353	23	426	50	200	35	50
11	772	9135	6011	702	4154	678	2689	2561	1028
M	2385	17768	26444	1738	9407	1443	6417	3144	2117
W	1215	4223	10730	866	6665	1220	4584	3340	1250
P	11582	6950	13330	727	6955	937	5683	3258	1936
T	12	198	881	16	1129	109	216	515	371
X	22963	42884	58470	4176	29153	4546	19998	14903	6780

TABLE A2--Continued

9	10	11	C	G	I	S	E	X
		25	15022	1951		477	1911	22963
			25754	447		469	9275	42884
			2562	31		1216	54661	58470
			1049	10		252	2865	4176
	9	384	3739		4234	975	18476	29153
	20	453	131		2135	35	297	4546
		57	8772	213	498	50	9439	19998
	5				14153	261	374	14903
			1856	19		195	4290	6780
	480		22949	30173			220	53822
		2127	4390	260			149	8482
	3793		31480	5694	10386		84631	163714
	980	87244	44451	936	24532	1668	14658	241996
41277	2024	30067					5593	113054
12545	1569	41373						106845
	398	1984	10265		4056		527	19881
53822	8482	163714	172420	39734	59994	2262	207366	

APPENDIX B

TABLE B1

THE GENERALIZED LEONTIEF I-O MACRO MODEL

	Constant	Output	Relative Prices, Output	Time	Dummy
Rx2.1		-0.5201	0.4988	1.4380	4.9759
		(-3.06)	(2.69)	(7.88)	(2.71)
Rx11.1	1.4886	0.1007	-0.0208	-0.2653	
	(1.01)	(2.69)	(-0.89)	(-3.97)	
RM1	22.4062	-0.05016	0.3225	-1.0403	
	(11.45)	(-0.71)	(1.69)	(-7.83)	
L1	205.2080	-7.6289	15.7233	13.2709	
	(0.79)	(-1.83)	(4.35)	(0.86)	
Rx1.2	16.7858	-0.2125	0.1878	0.4163	
	(12.58)	(-2.90)	(2.64)	(3.87)	
Rx4.2	5.9052	-0.1168	0.0620	0.3367	
	(8.18)	(-3.41)	(1.99)	(2.84)	
Rx5.2	0.1236	-0.0012	0.0005	0.0028	
	(8.55)	(-1.37)	(0.80)	(2.56)	
Rx6.2	2.8644	-0.0605	0.0185	0.3181	
	(4.03)	(-2.20)	(1.03)	(4.52)	
Rx7.2	0.6380	-0.0125	0.0057	0.0372	
	(6.39)	(-2.78)	(1.89)	(4.14)	
Rx10.2		0.0007	0.0045	0.0985	
		(0.16)	(0.92)	(3.09)	
Rx11.2	21.7796	-1.3908	1.4385		
	(5.69)	(-10.76)	(14.17)		
RM2	33.4570	0.4512	-1.2749	3.6735	
	(3.31)	(2.07)	(-2.22)	(3.30)	
L2	2559.8300	4.5534		24.3810	
	(32.21)	(2.80)		(1.89)	
Rx6.4	0.0991	-0.0414	0.0431		-0.5534
	(1.41)	(-5.26)	(6.65)		(-4.51)

cont./

TABLE B1--Continued

	DW	$\bar{R}^2$	F-Ratio	SSR	RHO
Rx2.1	1.76*	(0.994)	(131.10)	26.940	
Rx11.1	1.80	0.440	4.91	4.250	-0.3594
RM1	1.59	0.940	79.55	34.310	-0.6563
L1	2.01*	0.595	8.33	72325.300	0.5078
Rx1.2	1.84*	0.750	15.99	4.859	-0.1484
Rx4.2	1.58	0.696	12.45	2.812	0.3281
Rx5.2	2.06*	0.643	10.02	5.516E-04	-0.2266
Rx6.2	2.04*	0.463	5.30	1.517	
Rx7.2	2.13*	0.587	7.64	0.020	
Rx10.2	1.76*	(0.993)	(37.61)	0.360	
Rx11.2	2.03*	0.991	862.51	43.640	-0.1605
RM2	2.06*	0.791	19.98	125.317	0.5000
L2	1.83*	0.942	123.50	88071.800	-0.2000
Rx6.4	2.49	0.913	53.34	0.377	-1.0000

cont./

TABLE B1--Continued

	Constant	Output	Relative Prices, Output	Time	Dummy
Rx7.4	-0.0260	-0.0002	-0.0016	0.0226	
	(-1.27)	(-0.08)	(-1.13)	(5.53)	
Rx10.4		-0.0877	0.0532	0.2327	
		(-4.22)	(4.86)	(4.72)	
Rx11.4		-0.0861	0.2396		
		(-2.14)	(6.67)		
RM4	-2.9045	0.2459		0.6335	-4.9063
	(-4.69)	(8.41)		(3.92)	(-5.90)
L4		-65.5075	171.6490	362.2300	-1184.7200
		(-2.00)	(2.24)	(3.95)	(-3.19)
Rx4.5	0.0995	0.0231		-0.0133	
	(1.47)	(2.81)		(-1.47)	
Rx7.5	0.0203	-0.0053	0.0066	-0.0014	
	(1.63)	(-1.39)	(2.00)	(-0.84)	
Rx10.5	-0.0184	-0.0022	-0.0058	0.0360	
	(-0.37)	(-0.18)	(-0.59)	(5.84)	
Rx11.5		0.0754	0.0648	0.5465	
		(1.58)	(1.35)		(2.45)
RM5	0.2372	0.2381	0.0871	-0.1191	
	(0.31)	(0.83)	(0.36)	(-0.81)	
L5	587.2170	-52.5111	264.3780	-41.9572	
	(6.47)	(-4.79)	(6.55)	(-4.76)	
Rx4.6		-0.0005	0.0032	0.0228	-0.1354
		(-0.12)	(0.75)	(5.10)	(-4.09)
Rx10.6		-0.0054	0.0095	0.0212	0.1611
		(-1.41)	(3.48)	(4.04)	(3.60)
Rx11.6	4.1094	-0.6303	0.5944	0.8834	
	(6.74)	(-8.42)	(10.26)	(6.53)	
RM6	2.7688	-0.1856	0.5697	0.3472	-2.2935
	(6.21)	(-2.19)	(3.81)	(3.82)	(-2.61)

cont./

TABLE B1--Continued

	DW	$\bar{R}^2$	F-Ratio	SSR	RHO
Rx7.4	1.85*	0.778	18.51	4.950E-3	0.2500
Rx10.4	1.70	(0.970)	(63.01)	0.764	0.2000
Rx11.4	1.67*	(0.988)	(230.53)	14.375	0.2000
RM4	1.95*	0.987	391.24	11.671	-0.1146
L4	1.18	(0.939)	(13.10)	1.256E-06	0.8000
Rx4.5	2.03*	0.497	8.40	6.105E-02	
Rx7.5	2.05*	0.560	6.93	1.812E-03	-0.2345
Rx10.5	1.91*	0.914	54.47	2.376E-02	-0.3137
Rx11.5	1.99*	(0.989)	(314.13)	0.560	0.3556
RM5	1.33	0.773	18.04	1.659	0.6016
L5	1.52	0.858	31.17	36671.900	-0.2578
Rx4.6	1.47	(0.981)	(50.17)	1.128E-02	0.4774
Rx10.6	1.91*	(0.997)	(400.92)	4.035E-02	-0.6000
Rx11.6	2.24*	0.986	352.74	2.813	0.1641
RM6	2.13	0.980	189.67	7.861	-0.4832

cont./

TABLE B1--Continued

	Constant	Output	Relative Prices, Output	Time	Dummy
L6	577.3320 (4.28)	-37.2928 (-2.37)	88.7437 (3.10)	174.0570 (8.43)	-470.0080 (-2.98)
Rx4.7	-0.6644 (-1.47)	0.0695 (3.28)	-0.0287 (-1.34)	0.0411 (0.87)	
Rx5.7	2.0398 (2.74)	0.0640 (5.11)			
Rx6.7	0.2278 (4.46)	0.0013 (0.98)		-0.0177 (-3.38)	
Rx10.7	0.05676 (1.59)	-0.0024 (-1.92)	0.0017 (1.87)	0.0079 (1.77)	
Rx11.7	-2.4169 (-2.10)	0.1716 (4.46)	0.1070 (2.52)	-0.4151 (-2.71)	
RM7		0.1112 (2.89)	0.0862 (1.80)	-0.2865 (-3.44)	
L7	1675.5800 (2.36)	-40.7054 (-1.09)	376.6660 (6.48)	-298.7270 (-3.31)	
Rx4.8	0.0106 (0.60)	0.0182 (1.75)	-0.0091 (-0.82)	-0.0049 (-2.71)	
Rx7.8	-0.0093 (-0.89)	0.0211 (3.53)	-0.0178 (-2.94)	0.0012 (1.14)	
Rx10.8		-0.0289 (-1.15)	0.0447 (2.06)		
Rx11.8	-0.3586 (-1.31)	-0.8446 (-7.81)	1.3210 (9.97)	-0.0659 (-2.09)	
RM8	0.5039 (0.36)	0.1376 (0.12)	0.4907 (0.24)	0.1233 (0.44)	
L8		49.6428 (2.33)		41.6972 (1.92)	364.1020 (2.43)
L9	10475.2000 (11.76)	37.6443 (1.85)		209.3710 (0.58)	

cont./

TABLE B1--Continued

	DW	$\bar{R}^2$	F-Ratio	SSR	RHO
L6	1.84	0.963	99.93	2.602E+05	0.1075
Rx4.7	1.85*	0.738	15.06	3.391	0.0156
Rx5.7	1.86*	0.684	33.42	6.325	0.3469
Rx6.7	1.58*	0.437	6.82	2.669E-02	0.3349
Rx10.7	1.77*	0.619	9.10	8.758E-03	0.4512
Rx11.7	1.90*	0.910	51.44	25.440	-0.1484
RM7	1.90*	(0.987)	(44.00)	8.722	0.2000
L7	1.84*	0.933	71.13	7.226E+06	-0.0078
Rx4.8	1.79*	0.407	4.45	3.293E-03	0.2000
Rx7.8	1.78*	0.530	6.62	1.079E-03	0.0781
Rx10.8	1.73*	(0.822)	(13.64)	2.420E-02	0.6481
Rx11.8	2.35	0.952	100.37	1.871	-0.5469
RM8	1.27	0.704	12.90	3.420	0.9063
L8	1.68	(0.977)	(32.95)	1.527E+05	0.4000
L9	1.56*	0.934	107.38	1.227E+07	0.1563

cont./

TABLE B1--Continued

	Constant	Output	Relative Prices, Output	Time	Dummy
Rx5.10		-0.0035	0.00684	-0.0111	
		(-2.04)	(4.01)	(-2.48)	
Rx11.10		-1.2764	1.9762	-1.1950	-14.8307
		(-3.34)	(4.90)	(-1.65)	(-2.94)
Rx5.11		-0.0081	0.0091	1.3975	
		(-5.16)	(5.59)		(6.24)
Rx10.11	3.8156	-0.0626	0.0371	1.3478	
	(2.09)	(-2.92)	(2.79)	(6.34)	
RM11		-0.1658	0.4671	12.3743	
		(-0.60)	(1.06)	(2.96)	
L11	15594.3000	4.5797		584.0330	
	(23.04)	(1.63)		(4.18)	
Rx4.3A		-0.0102	0.0069	0.0309	0.2330
		(-3.50)	(3.31)	(4.46)	(7.49)
Rx6.3A		-0.0110	0.0160		
		(-3.26)	(5.51)		
Rx7.3A	0.0383	-0.0047	0.0038	0.0050	
	(1.73)	(-2.06)	(2.53)	(0.93)	
Rx8.3A		-0.0066	0.0073		1.0471
		(-6.74)	(7.56)		(29.66)
Rx10.3A		0.0065	-0.0110	0.1841	0.9477
		(0.23)	(-0.69)	(2.28)	(3.06)
Rx11.3A		0.2834		-1.0161	
		(7.71)		(-2.92)	
RM3A		0.5963		-1.1667	
		(20.12)		(-4.59)	
L3A		27.3851		251.2380	
		(2.72)		(2.48)	
Rx6.3B	0.0736	-0.1072	0.0888	0.0057	
	(1.49)	(-3.84)	(4.20)	(1.32)	

cont./

TABLE B1--Continued

	DW	$\bar{R}^2$	F-Ratio	SSR	RHO
Rx5.10	1.56	(0.782)	(7.42)	3.730E-03	
Rx11.10	1.94*	(0.926)	(23.04)	111.406	-0.2457
Rx5.11	2.67	(0.982)	(159.42)	1.829	-1.0000
Rx10.11	1.85*	0.894	43.09	13.200	0.3341
RM11	1.84*	(0.973)	(12.77)	8041.000	0.1619
L11	1.74*	0.914	81.04	9.325E+06	0.3356
Rx4.3A	2.23	(0.983)	(62.81)	1.035E-02	-0.4000
Rx6.3A	1.95*	(0.987)	(160.52)	0.376	-0.8000
Rx7.3A	1.80*	0.768	15.32	4.283E-03	
Rx8.3A	1.38	(0.999)	(4985.09)	9.249E-03	-0.9558
Rx10.3A	1.95*	(0.982)	(32.66)	0.817	
Rx11.3A	1.76*	(0.971)	(103.43)	32.581	0.6000
RM3A	2.37*	(0.999)	(1402.71)	95.934	-0.6000
L3A	2.17*	(0.960)	(77.85)	1.824E+06	0.7650
Rx6.3B	1.64	0.812	16.80	5.975E-03	0.4000

cont./

TABLE B1--Continued

	Constant	Output	Relative Prices, Output	Time	Dummy
Rx10.3B		-0.0101 (-2.21)	0.0117 (3.70)	0.0012 (1.70)	0.0277 (4.96)
Rx11.3B		-0.0657 (-1.20)	0.2594 (4.70)		
RM3B		0.23864 (4.52)	0.22808 (2.21)		
L3B	43.2907 (1.84)	-165.2210 (-8.39)	400.2080 (11.87)	23.4389 (5.49)	
Rx4.10	0.0492 (1.94)	0.0051 (1.31)	-0.0026 (-0.84)	-0.0088 (-1.02)	
RM10	6.7326 (1.89)	-0.7727 (-1.11)	0.5069 (1.17)	1.602 (1.02)	
L10	1915.4100 (10.18)	12.7760 (0.69)	-16.8817 (-0.63)	-29.9966 (-0.46)	
Rx6.11	-0.4251 (-0.13)	0.0327 (0.74)	-0.0304 (-1.16)	0.4007 (0.62)	
Rx7.6	0.0711 (1.45)	-0.0001 (-0.01)	0.0000 (0.02)	0.0005 (0.09)	

cont./

TABLE B1--Continued

	DW	$\bar{R}^2$	F-Ratio	SSR	RHO
Rx10.3B	2.16*	(0.990)	(79.60)	9.592E-04	-0.4270
Rx11.3B	2.00*	(0.991)	(348.88)	0.626	-0.6456
RM3B	2.13*	(0.998)	(898.61)	0.316	-0.2000
L3B	1.94	0.039	473.20	40120.400	-0.4922
Rx4.10	1.44	0.989	1.20	0.008	0.0547
RM10	2.10	0.025	1.13	105.490	0.4844
L10	1.23	0.008	0.96	211200.0	0.4609
Rx6.11	2.55	0.151	1.89	68.570	0.3984
Rx7.6	1.92	0.009	0.003	0.020	0.1719

cont./

TABLE B1--Continued

Consumption Functions

	Constant	Income	Relative Prices	Lagged Consumption	Dummy
RC1	22.7728 (1.22)	0.0462 (3.34)	-6.7655 (-0.31)	0.1257 (0.58)	
RC2	43.7728 (1.56)	-0.0035 (-0.09)	-52.4260 (-1.44)	1.2665 (4.40)	
RC3A	-4.9476 (-3.60)	0.0070 (2.30)	5.2356 (2.80)	0.4893 (4.15)	-8.2328 (-7.09)
RC3B	1.8410 (1.41)	-0.00003 (-0.03)	3.3147 (2.73)	-0.9714 (-2.67)	3.3591 (4.01)
RC4	-1.9648 (-0.69)	0.0220 (4.66)	-6.9453 (-2.23)	0.3892 (1.22)	-3.9259 (-1.77)
RC5	0.0904 (0.83)	0.0006 (6.19)	-0.2624 (-1.80)	-0.1993 (-3.16)	0.3970 (16.66)
RC6	18.3033 (2.91)	0.0317 (3.91)	-27.9421 (-4.74)	0.6342 (3.35)	
RC8	-1.1770 (-1.86)	0.0093 (4.58)	-0.3702 (-0.50)	0.1922 (1.73)	-5.0894 (-7.97)
RC9	-184.0240 (-1.65)	0.0527 (2.83)	163.4760 (1.46)	0.8831 (5.76)	
RC10	13.3391 (3.91)	0.0155 (4.46)	-15.6070 (-4.54)	0.4341 (3.22)	
RC11	626.8900 (3.57)	0.3202 (2.46)	-657.8750 (-3.59)	1.1595 (4.35)	-69.5225 (-4.92)
RMC	88.9218 (3.06)	0.0853 (2.72)	-46.3952 (-2.44)	0.3750 (1.78)	

cont./

TABLE B1--Continued

	DW	$\bar{R}^2$	F-Ratio
RC1	1.80	0.847	28.62
RC2	2.08	0.923	65.41
RC3A	1.86	0.914	40.91
RC3B	2.51	0.886	30.14
RC4	1.59	0.735	11.41
RC5	2.05	0.991	396.79
RC6	2.53	0.978	222.90
RC8	1.56	0.911	39.49
RC9	2.31	0.975	193.66
RC10	1.77	0.978	225.38
RC11	2.24	0.836	17.61
RMC	1.66	0.756	16.48

APPENDIX C

HISTORICAL SIMULATION RESULTS (1963-1977)*

Sector 1	RMS	WRMS
Rx2.1	15.10	0.775
Rx11.1	12.71	2.424
RM1	10.43	7.018
W1	9.62	0.819
		11.036

Sector 2	RMS	WRMS
Rx1.2	3.45	0.734
Rx4.2	28.20	1.235
Rx5.2	6.81	0.008
Rx6.2	24.21	0.254
Rx7.2	19.21	0.069
Rx10.2	9.46	0.113
Rx11.2	11.02	1.625
RM2	8.38	3.457
W2	2.30	0.359
		7.743

Sector 3A	RMS	WRMS
Rx4.3A	28.32	0.025
Rx6.3A	35.02	0.081
Rx7.3A	36.63	0.018
Rx8.3A	26.80	0.051
Rx10.3A	16.37	0.398
Rx11.3A	19.44	4.986
RM3A	10.69	5.969
W3A	9.03	1.401
		12.930

Sector 3B	RMS	WRMS
Rx10.3B	21.82	0.092
Rx11.3B	20.31	3.769
RM3B	9.70	4.706
W3B	6.23	1.971
		10.538

Sector 4	RMS	WRMS
Rx6.4	58.82	0.582
Rx7.4	15.85	0.039
Rx10.4	25.62	0.569
Rx11.4	14.59	2.487
RM4	6.16	2.379
W4	8.56	3.498
		9.555

Sector 5	RMS	WRMS
Rx4.5	17.96	0.686
Rx7.5	36.40	0.167
Rx10.5	35.60	0.270
Rx11.5	10.01	1.497
RM5	8.29	2.595
W5	4.87	2.372
		7.588

Sector 6	RMS	WRMS
Rx4.6	23.70	0.298
Rx10.6	12.67	0.153
Rx11.6	11.97	2.193
RM6	6.57	2.879
W6	4.81	1.702
		7.225

Sector 7	RMS	WRMS
Rx4.7	24.60	0.671
Rx5.7	12.87	1.656
Rx6.7	29.92	0.317
Rx10.7	22.14	0.068
Rx11.7	12.16	2.175
RM7	10.65	2.014
W7	13.05	6.033
		12.936

Sector 8	RMS	WRMS
Rx4.8	35.35	0.194
Rx7.8	40.63	0.109
Rx10.8	24.78	0.743
Rx11.8	28.85	5.124
RM8	30.13	15.725
W8	14.56	3.779
		25.675

Sector 9	RMS	WRMS
W9	5.19	5.190

Sector 10	RMS	WRMS
Rx5.10	116.70	0.349
Rx11.10	7.29	7.268
		7.617

Sector 11	RMS	WRMS
Rx5.11	26.28	0.111
Rx10.11	17.48	0.236
RM11	19.55	9.123
W11	3.29	1.696
		11.167

Consumption	RMS	WRMS
RC1	7.49	0.8074
RC2	5.77	0.8746
RC3A	9.39	0.1339
RC3B	10.36	0.0778
RC4	27.92	0.1649
RC5	22.66	0.0055
RC6	10.56	0.2818
RC8	20.22	0.1888
RC9	12.81	0.9295
RC10	8.79	0.6378
RC11	27.17	4.5453
RMC	5.17	1.7997
		10.0874

P	11.74
W	1.91
YD	5.50
YP	5.03
RI7	12.47

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* RMS refers to root mean square percent errors while WRMS refers to weighted RMS. The weighting scheme used is the value of the variable to the total value of the inputs of each sector in the base year (1964).

APPENDIX D

INTERNATIONAL COMPARISON OF RESERVES

	Reserves*	Imports*	R/Imp	Weeks
Industrial Countries	209064	836990	0.2498	13
United States	19582	183137	0.1069	6
Canada	4569	46388	0.0985	5
Japan	33500	79899	0.4193	22
Austria	6007	16019	0.3750	20
Belgium	5908	48497	0.1218	6
Denmark	3219	14807	0.2174	11
France	13929	81795	0.1703	9
Germany	53884	121754	0.4426	23
Italy	14899	56459	0.2639	14
Netherlands	7586	53822	0.1409	7
Norway	2913	11440	0.2546	13
Sweden	4397	20585	0.2136	11
Switzerland	21560	23804	0.9057	47
United Kingdom	17067	78586	0.2172	11
Other Europe	22322	69721	0.3201	17
Other Europe (excluding Malta)	21380	69146	0.3092	16
Finland	1266	7866	0.1610	8
Greece	1171	7647	0.1532	8
Iceland	138	679	0.2034	11
Ireland	2689	7107	0.3784	20
MALTA	942	575	1.6381	85
Portugal	1881	5174	0.3636	19
Spain	10774	18713	0.5758	30
Turkey	999	4600	0.2172	11
Yugoslavia	2462	9988	0.2465	13

cont./

	Reserves	Imports	R/Imp	Weeks
Australia	2418	15749	0.1535	8
New Zealand	453	3491	0.1299	7
South Africa	870	7614	0.1143	6
Oil Exporting Countries	60215	103070	0.5842	30
Algeria	2233	8530	0.2618	14
Indonesia	2637	6690	0.3942	21
Iran	12151	16020	0.7585	39
Kuwait	2616	4613	0.5671	29
Libya	4217	4603	0.9162	48
Nigeria	1916	12731	0.1505	8
Saudi Arabia	19408	22852	0.8493	44
United Arab Emirates	838	4892	0.1712	9
Venezuela	6554	11745	0.5580	29
Mexico	1928	7555	0.2552	13
Jamaica	59	895	0.0655	3
Cyprus (1977)	366	623	0.5876	31
Egypt	604	6727	0.0898	5
Israel	2679	7403	0.3618	19
Morocco	650	2970	0.2189	11
Tunisia	451	2119	0.2127	11
Korea	2776	14972	0.1854	10
Singapore	5302	13094	0.4049	21

* Millions of U.S. Dollars

Source: IMF Financial Statistics 1979.

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