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An Econometric study of the Indian economy

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AN ECONOMETRIC STUDY OF THE INDIAN ECONOMY

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By

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ABSTRACT

AN ECONOMETRIC STUDY OF THE INDIAN ECONOMY

by Brinda S. Mahalingam

The objective of this research is to analyze the Indian economy using econometric techniques. The data used are from 1965 to 1983. A simple Keynesian model is used to estimate the multiplier as well as the marginal propensities to consume and import. A modified version of the ISLM model treats consumption, disposable income, the interest rate, taxes, investment and money demand as endogenous. The accelerator model examines the effect of the rate of growth of the economy on investment purchases. International trade is modeled by including exports and imports as functions of exchange rate. The two stage least squares method is used to estimate the structural parameters.

The results from the simplest model reveal that the marginal propensity to consume out of GNP is 0.510. The Keynesian multiplier is 1.835. The marginal propensity to consume out of disposable income is 0.554. The accelerator model shows the existence of a business cycle of about seven years.

ACKNOWLEDGMENTS

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SYMBOLS USED:

B = Balance of Payments

C = Consumption

DI = Disposable income

E = Exchange rate

F = Net Foreign Financial Investment

G = Government Expenditure

I = Investment

M = Imports

MD = Money Demand

MS = Money Supply

NI = Nominal rate of Interest

NT = Net taxes

NTF = Net Transfers to Foreigners

R = Rate of Interest

RI = Real rate of Interest

S = Savings

X = Exports

Y = National Income

CHAPTER 1

INTRODUCTION TO THE INDIAN ECONOMY

India is an expanding economy with the gross national product (GNP), investment, savings and population increasing. The factors that influence these variables and the dynamics of the process can be examined with some macroeconomic analysis. The effect that various exogenous variables have on the GNP can be determined by econometric techniques.

The main contribution to GNP comes from agriculture although industrial participation has been increasing in recent years. Agriculturalists, who are deep rooted traditionalists, differ greatly from the modernized urban industrialists, and India can be justifiably classified as having a dual economy. But modern technology is slowly taking its place in agriculture.

The government plays a major role in the economy and its growth. There is a large public sector alongside a growing private sector. The public sector monopolizes areas of national interest, such as defense, postal services and railways. Fourteen major banks were nationalised in 1969, and branches were opened in the rural areas to serve the farmers.

Following the Soviet example in planning, India started systematic and regular economic development programs in a series of five-year plans, beginning in 1951. The main objective was to raise the productivity of various sectors and thereby increase national output and raise standards of living. India, however is still predominantly a market type economy.

The data for this research were obtained primarily from the sources published by the International Monetary Fund such as the International Financial

Statistics Yearbook, the Government Finance Statistics Yearbook and the Balance of Payments Yearbook. Data for the period from 1965 to 1983 were used in this study. Nominal data is divided by the wholesale price index (1980 prices) to convert the data into real terms.

Chapter 2 is a brief review of the two stage least squares (2SLS) method used in this study to estimate the coefficients of the models. Chapter 3 uses a simple linear model with consumption, imports and GNP being endogenous, and investment, government expenditure and exports as exogenous. Chapter 4 adds interest rates, investment and taxes as additional endogeneous variables. The effects of money supply and price levels are also considered. Chapter 5 includes the effect of foriegn trade on the economy. The effect of the rate of growth of GNP and business cycles, as explained by the acceleration model, is discussed in Chapter 6. Chapter 7 gives the structural and reduced form of the complete model, discussing the identification problem.

CHAPTER 2

ECONOMETRIC METHOD USED

An exogenous variable is one that is determined outside a model. An endogenous variable is determined within the model. The effects of changes in the exogenous variables on the endogenous variables are determined by multiple regression analysis. Regression analysis is thus used to estimate and predict the expected value of the dependent variable in terms of the independent or explanatory variables. In general the latter includes exogenous as well as lagged endogenous variables. The exogenous, or predetermined variables are treated as nonstochastic.

The linear regression model for the statistical population is represented by:

$$\mathcal{Y}_i = b_0 + \sum_j b_{ji}\mathcal{X}_{ji} + u_i \tag{2.1}$$

where $\mathcal{Y}_i$ is the i-th value of the endogenous variable, $\mathcal{X}_{ji}$ is the i-th value of the j-th predetermined variable and u_i represents the distance of the i-th observation from its expected value. Since data for the whole population are in most cases at least difficult and costly to obtain if not impossible, sample data are used for the regression analysis to predict the population. The sample regression function is then:

$$\mathcal{Y}_i = \hat{b}_0 + \sum_j \hat{b}_{ji}\mathcal{X}_{ji} + e_i \tag{2.2}$$

where e_i is the distance of the i-th observation from the expected value. The variable e_i is also known as the error or disturbance term. It is logical to expect that the larger the sample, the greater the accuracy of the regression estimates.

Models which have more than one equation, generally contain more than one mutually dependent, endogenous variable. The equations representing the model are known as structural equations and the associated parameters are called structural coefficients. The structural form is generally written in matrix notation as:

$$Bx_t + Cz_t = \eta_t \tag{2.3}$$

where, x_t denotes the vector of n endogenous variables, z_t denotes the vector of m exogenous variables, B and C are matrices of size $n \times n$ and $n \times m$ respectively, and η_t the vector of n errors.

The aim is to determine how changes in exogenous variables and random errors, that is z_t and η_t, can determine the values of endogenous variables x_t. The values should be unique for every set of z_t and η_t.

To solve for x_t, assume B to be a non singular matrix and η_t to be mutually independent and identically distributed with zero mean. A specific model imposes restrictions on the elements of matrices B and C. Thus if a particular variable (endogenous or exogenous) does not appear in an equation, the corresponding matrix (B or C) will have a zero in the appropriate column. In some instances, there may be restrictions that the coefficients of a particular variable be the same in the different equations in which it appears.

From the structural equations, one can solve for endogenous variables solely in terms of exogenous variables or lagged variables and thus derive the reduced form equations and the reduced form coefficients. Hence, a reduced form equation is one which expresses endogenous variables in terms of predetermined variables and stochastic disturbances. This can be expressed as:

$$x_t = \mathcal{A} z_t + \epsilon_t \tag{2.4}$$

Since $\mathcal{B}$ is non singular,

$$\mathcal{A} = -\mathcal{B}^{-1}\mathcal{C} \quad ; \quad \epsilon_t = \mathcal{B}^{-1}\eta_t \tag{2.5}$$

Like the structural form, the coefficients of the reduced form too, have restrictions. Because of limitations imposed on $\mathcal{B}$, $\mathcal{C}$ and η_t, $\mathcal{A}$ and the distribution of ϵ_t may be restricted. These restrictions cause models to be overidentified. In other word unique values are not obtained for x_t.

A system of equations is identified when the numerical estimates of the parameters of a structural equation can be obtained from the estimated reduced form coefficients. If this cannot be done the equation is said to be unidentified or underidentified. An equation is said to be exactly identified if unique values of the structural parameters can be obtained from the reduced form coefficients. If more than one numerical value can be obtained, the equation is said to be overidentified.

Two Stage Least Squares(2SLS) is one method used to solve the problem of getting unique estimates of the parameters of an overidentified simultaneous equation. Since the endogenous variable will be correlated with the stochastic terms in an equation, a proxy is used in its place in the regression analysis. This proxy is called the instrumental variable. In 2SLS the instrumental variable is generated from the data for the model. This rids the said endogenous variable of any correlation with stochastic disturbances.

In the first stage, the endogenous variable is estimated in terms of the exogenous variable, that is, from the reduced form equation. In the second stage, the estimated values of this variable are used to estimate the parameters of a structural equation. This is summarized for the following simultaneous equation model, involving the exogenous variables $\mathcal{X}_1$ and $\mathcal{X}_2$ and two endogenous variables $\mathcal{Y}_1$ and $\mathcal{Y}_2$

$$\mathcal{Y}_1 = \alpha_0 + \alpha_1 \mathcal{Y}_2 + \alpha_2 \mathcal{X}_1 + \alpha_3 \mathcal{X}_2 + u_1 \tag{2.6}$$

$$\mathcal{Y}_2 = \beta_0 + \beta_1 \mathcal{Y}_1 + u_2 \tag{2.7}$$

Stage 1:

Estimate the endogenous variable $\hat{\mathcal{Y}}_1$ using the exogenous variables $\mathcal{X}_1$ and $\mathcal{X}_2$, that is,

$$\hat{\mathcal{Y}}_1 = \tilde{\alpha}_0 + \tilde{\alpha}_1 \mathcal{X}_1 + \tilde{\alpha}_2 \mathcal{X}_2 \tag{2.8}$$

using the reduced form regression coefficients $\tilde{\alpha}_0$, $\tilde{\alpha}_1$ $\tilde{\alpha}_2$.

Stage 2:

Use the estimated endogenous variable in regressions for the other endogenous variables; e.g.

$$\mathcal{Y}_2 = \tilde{\beta}_0 + \tilde{\beta}_1 \hat{\mathcal{Y}}_1 \tag{2.9}$$

Using 2SLS takes into account that $\mathcal{Y}_i$ is dependent on the random disturbance term u_i. The estimates obtained by this method are consistent, that is to say, they converge to their true values as sample size increases.

The 2SLS method has many desirable features:

1. It can be applied to an individual equation in the system independently.
2. It provides unique estimates for the parameters of structural equations in an overidentified model.
3. It can be used for exactly identified equations as well.
4. A good R^2 in the first stage indicates a well estimated instrumental variable.
5. Standard errors for estimated coefficients can be computed, because the structural coeffecients are directly estimated from second stage regression.

The 2SLS method is used in this study, in most cases unless otherwise specified. Its use is necessary because the models involve overidentified, simultaneous equation systems.

CHAPTER 3

THE SIMPLE KEYNESIAN MODEL

Aggregate demand is the total amount of goods and services demanded in the economy. Consumption, investment, government purchases and net exports are its major components. At equilibrium Gross National Product and Gross national Income is equal to aggregate demand. The simple model used here involves aggregate supply being equal to aggregate demand, that is:

$$Y = C + I + G + X - M \tag{3.1}$$

Keynes, in his book, writes that "the principal variable, upon which the consumption constituent of the aggregate demand will depend, is the aggregate income."[1] The basic Keynesian model may be used to estimate the multiplier for the Indian economy and study the dependence of consumption and imports on real GNP. National income, imports and consumption are endogenous. Investment, government expenditure and exports are exogenous.

The Model

The structural form of the model is:

$$Y = C + I + G + X - M$$
$$C = c_0 + c_1 Y$$
$$M = m_0 + m_1 Y$$

[1] J. M. Keynes, The General Theory of Employment Interest and Money

In matrix form:

$$\begin{pmatrix} 1 & -1 & 1 \\ -c_1 & 1 & 0 \\ -m_1 & 0 & 1 \end{pmatrix} \begin{bmatrix} Y \\ C \\ M \end{bmatrix} + \begin{pmatrix} 0 & -1 & -1 & -1 \\ c_0 & 0 & 0 & 0 \\ m_0 & 0 & 0 & 0 \end{pmatrix} \begin{bmatrix} 1 \\ I \\ G \\ X \end{bmatrix} = \begin{bmatrix} 0 \\ u \\ v \end{bmatrix} \tag{3.2}$$

where u and v are the error terms for the consumption and import function.

Since the consumption function and the import function are assumed linear, there is a linear relationship between Y and $(I + G + X)$. This relationship is a reduced form equation. It is derived from the relationships between C and Y and M and Y.

The reduced form of the model is:

$$Y = Ka + K(I + G + X) + K(u - v) \tag{3.3}$$

$$C = c_0 + c_1 Ka + c_1 K(I + G + X) + c_1 K(u - v) + u \tag{3.4}$$

$$M = m_0 + m_1 Ka + m_1 K(I + G + X) + m_1 K(u - v) + v \tag{3.5}$$

where:

$$K = \frac{1}{1 - (c_1 - m_1)} \tag{3.6}$$

$$a = c_0 - m_0 \tag{3.7}$$

In matrix form,

$$\begin{bmatrix} Y \\ C \\ M \end{bmatrix} = \begin{pmatrix} Ka & K \\ c_0 + c_1Ka & c_1K \\ m_0 + m_1Ka & m_1K \end{pmatrix} \begin{bmatrix} 1 \\ I + G + X \end{bmatrix} +$$

$$\begin{bmatrix} K & -K \\ 1 + c_1K & -c_1K \\ 1 + m_1K & -m - 1K \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix} \tag{3.8}$$

The reduced form equation for income, the first equation of the above matrix is:

$$Y = y_0 + y_1 (I + G + X) \tag{3.9}$$

where $y_0 = Ka = K(c_0 - m_o)$and $y_1 = K$. Here K is what is known as the Keynesian multiplier. It is the rate of increase in GNP due to an increase in autonomous aggregate demand. To compute the multiplier for the model, income is regressed on the exogenous variables.

Results

The results obtained for the Indian data are:

$$Y_i = 4.176 \quad + \quad 1.835\ (I_i + G_i + X_i)$$

$$(21.530)$$

$$R^2 = 0.96462 \qquad \overline{R^2} = 0.96254 \tag{3.10}$$

The t-statistic for the coefficient is given in paretheses. The subscript i refers to the i-th year of the data. The multiplier for the Indian economy is thus 1.835, implying that an increase of one billion rupees in autonomous purchases would increase GNP by Rs 1.835 billion. The results are statistically significant at the 99% level of confidence and the coefficients of determination R^2 shows a good fit to the data.

Using Equation (3.10), the estimate of K is 1.835. Using the definition for K in Equation (3.9), $(c_1 - m_1) = 0.4550$ and $(c_0 - m_0) = 2.275$. But is is not possible to establish unique values of c_0, m_0, c_1, c_0 from the reduced form coefficients. Hence the model is overidentified.

The 2SLS gives definite estimates for these parameters using structural equations. The structural form of the consumption function is:

$$C = c_0 + c_1 Y \tag{3.11}$$

Applying the 2SLS method to the Indian data results in:

$$\begin{aligned} C_i = 2.389 \quad + \quad & 0.510\hat{Y}_i \\ & (20.695) \\ & R^2 = 0.96397 \quad \overline{R^2} = 0.96185 \end{aligned} \tag{3.12}$$

The t-statistic is given in parentheses.. The autonomous consumption is Rs. 2.389 billion and an increase of one billion rupees in national income would lead to a 0.510 billion rupees increase in consumption. Thus the marginal propensity to consume is 0.51. Figure 3.1 graphically depicts the results of this function.

Imports also are assumed to be positively dependent on GNP. The structural relationship between the two is expressed as:

$$M = m_0 + m_1 Y \tag{3.13}$$

A similar two-stage regression for the Indian data yields:

$$\begin{aligned} M_i = -0.934 \quad + \quad & 0.157 Y_i \\ & (8.072) \\ & R^2 = 0.78595 \quad \overline{R^2} = 0.77336 \end{aligned} \tag{3.14}$$

The t-statistic is significant and the R^2 shows a good fit to the data. The marginal propensity to import is 0.157; that is to say, an increase of one billion rupees in income would increase imports by 0.157 billion rupees. The result is graphed in Figure 3.2.

Given the 2SLS estimates of the structural parameters the reduced form coefficients should have been:

$$K = \frac{1}{1 - (0.510 - 0.157)} = 1.546 \tag{3.15}$$

This is statistically different than the value of $K = 1.835$ obtained previously.

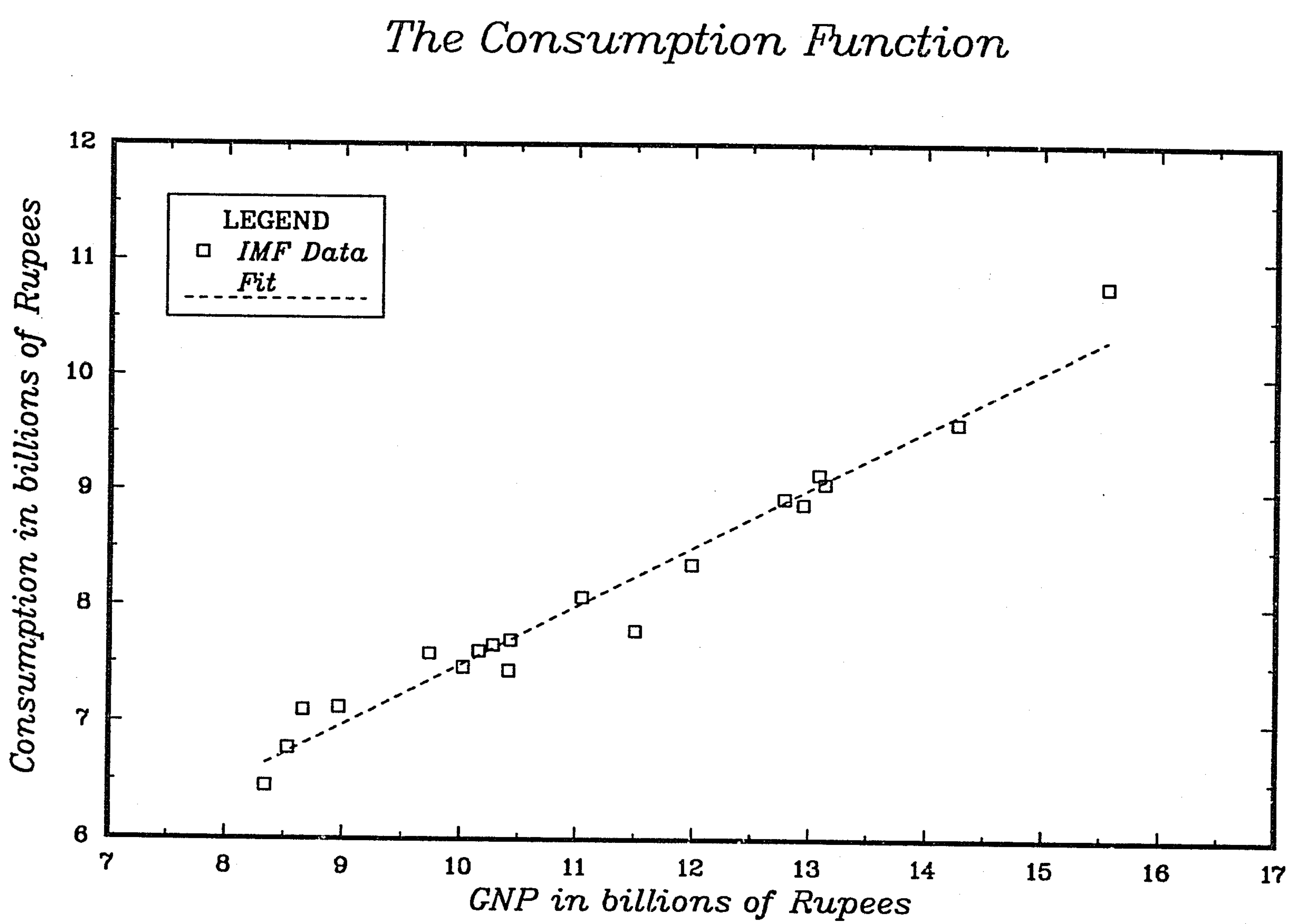
The Consumption Function
LEGEND
IMF Data
Fit
Consumption in billions of Rupees
GNP in billions of Rupees
6
7
8
9
10
11
12
13
14
15
16
17

Figure 3.1

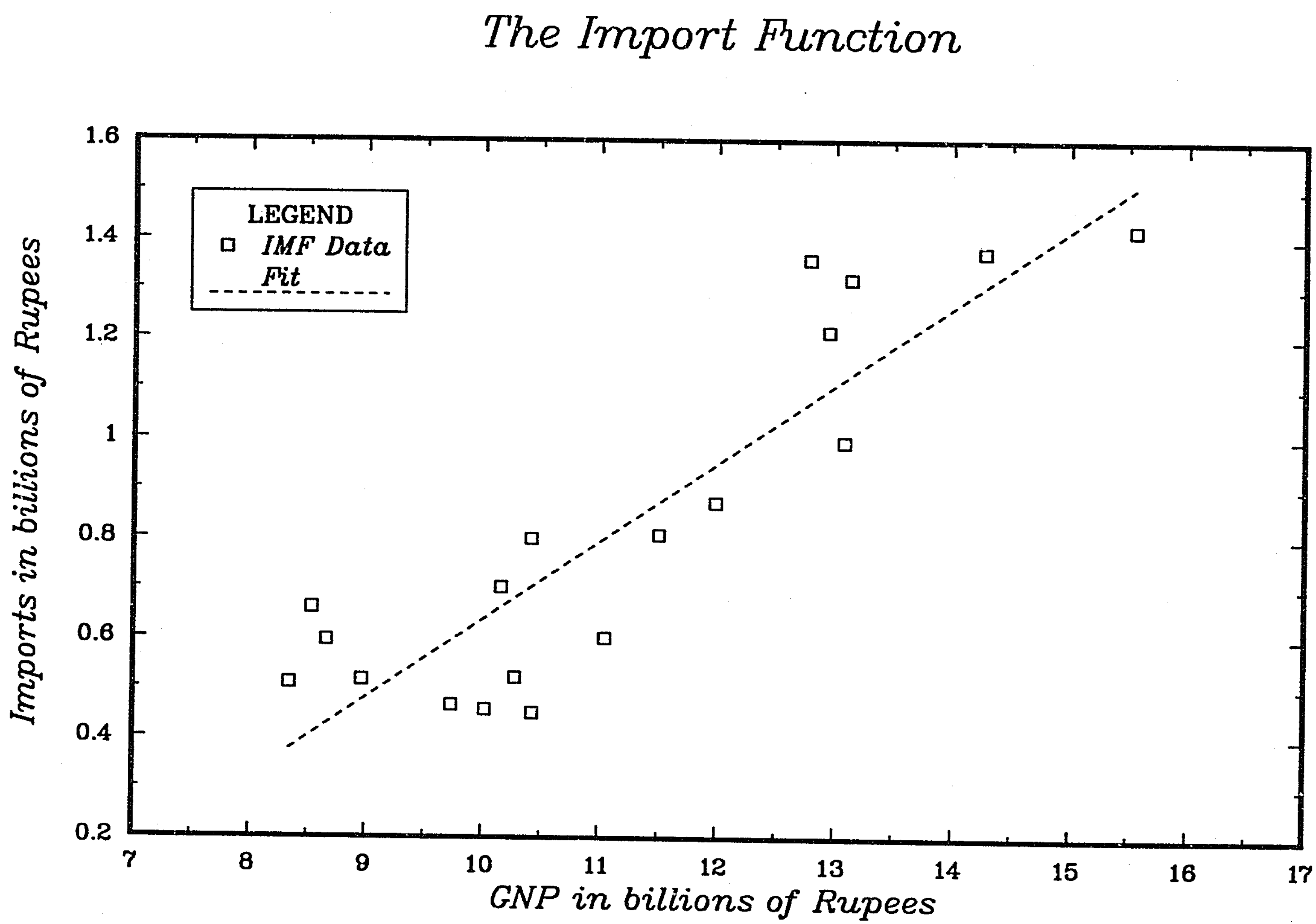
The Import Function
LEGEND
IMF Data
Fit
Imports in billions of Rupees
GNP in billions of Rupees
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
7
8
9
10
11
12
13
14
15
16
17

Figure 3.2

CHAPTER 4

THE ISLM MODEL

The Keynesian model was modified by Alvin Hansen and others to include the effects of interest rates on investment and money demand and supply in determining interest rates. In the model there are two sectors: the commodity-expenditure sector and the monetary sector. Equilibrium in the commodity sector is depicted by the equality of Investment-Saving (in the simplest version) at different interest rates and income. The graph of these equilibrium combinations of GNP and the interest rate is denoted as IS. In the more general version, $(I + G + X)$ must equal $(S + NT + M)$. Equilibrium in the monetary-sector is depicted by the equality of money demand and supply for different levels of interest rates and income. These points of monetary equilibrium are denoted as LM. The equilibrium of these two sectors reveal the equilibrium income and interest rates. This equilibrium is where the IS curve intersects the LM curve. The ISLM model thus extends the Keynesian income equilibrium to include the equilibrium interest rate as well.

The Model

The structural form of the model can be expressed as:

$$Y = C + I + G + X - M$$

$$C = c_0 + c_1 DI$$

$$DI = Y - NT$$

$$NT = t_0 + t_1 Y$$

$$M = m_0 + m_1 Y$$

$$I = i_0 + i_1 Y - i_2 R$$
$$MS = l_0 + l_1 Y - l_2 NI$$

where Y, C, I, G, X, and M are as in Chapter 3. Net taxes is calculated as taxes less transfer payments. The exogenous variables are G, X and MS. The reduced form of the model is overidentified and the structural form of the model is estimated using 2SLS.

Results

Consumption is assumed positively related to disposable income. The linear relationship can be expressed as:

$$C = c_0 + c_1 DI \tag{4.1}$$

The two stage least squares estimate coefficients of the above relationship for Indian economy are:

$$C_i = 2.452 \quad + \quad \underset{(20.531)}{0.554 DI_i}$$
$$R^2 = 0.96342 \quad \overline{R^2} = 0.961276 \tag{4.2}$$

The marginal propensity to consume from disposable income is 0.554 and hence the marginal propensity to save would be 0.446.

Assuming that net taxes is a function of real income, the linear relationship can be expressed as:

$$NT = t_0 + t_1 Y \tag{4.3}$$

where t_1 is the marginal net tax rate. The 2SLS regression on the data yields:

$$NT_i = 0.108 \quad + \quad 0.079Y_i$$

$$(100.048)$$

$$R^2 = 0.99835 \quad \overline{R^2} = 0.99825 \tag{4.4}$$

The significant t-statistic and the 'good fit' confirm the hypothesis. An increase in GNP of Rs 1 billion will increase net tax revenue by about 0.079 billion rupees. The tax function is shown in Figure 4.1.

Imports are positively related to income. The 2SLS estimation of the import function is:

$$M_i = -0.932 \quad + \quad 0.157Y_i$$

$$(8.064)$$

$$R^2 = 0.78601 \quad \overline{R^2} = 0.77342 \tag{4.5}$$

The estimated coefficients are significant at the 99% level.

Interest rates are nominal or real. The nominal interest rate is the rate of return earned on any asset. The real interest rate is the rate of return in terms of its purchasing power of goods. It is adjusted for inflation. Investment is assumed to be positively related to real GNP and negatively to nominal interest rates.

The 2SLS estimates of the linear relationship:

$$I = i_0 - i_1 Y + i_2 NI \tag{4.6}$$

are given by:

$$\begin{array}{llll} I_i = -2.286 & + \quad 0.0398Y_i & + \quad 0.635NI_i & \\ & \quad\;\; (0.076) & \quad\;\; (0.475) & \\ & R^2 = 0.89189 & \overline{R^2} = 0.87837 & \end{array} \tag{4.7}$$

The coefficient for NI does not have the expected sign. The t-statistics are also not significant at the 95 % level of confidence even though the above model explains 89 % of the variation in the data for investment.

A more precise specification of the investment function makes it dependent upon real interest rate. The real interest rate is the nominal interest rate corrected for inflation. The formula used for RI:

$$RI = \frac{(NI - rate\ of\ inflation)}{(1 + rate\ of\ inflation)} \tag{4.8}$$

The $2SLS$ regression of the investment function yields:

$$I_i = -1.120 \quad - \quad 0.283Y_i \quad + \quad 0.005RI_i$$
$$(20.763) \qquad (1.297)$$
$$R^2 = 0.96433 \quad \overline{R^2} = 0.95987 \tag{4.9}$$

The coefficient for the interest rate does not have the expected sign but t-statistic show it is not significant at the 95% level of confidence. The t-statistic for Y is highly significant. The negative value for i_1 probably reflects the replacement of private by public investment. There is a small increase in the R^2, showing a better fit of the result to the data.

The monetary sector consists of the demand and supply of money. The demand for money displays an inverse relationship with nominal interest rates but shows a positive relationship with nominal income. The linear version of this can be mathematically expressed as:

$$MD = l_0 - l_1Y + l_2NI \tag{4.10}$$

Equilibrium in the money market requires that:

$$MD = MS \tag{4.11}$$

Regressing nominal money supply (which is currency) with nominal interest rate and nominal GNP using 2SLS gives the estimate of the demand function.

$$MS_i = -1348.019 \quad - \quad 0.3099Y_i \quad + \quad 283.039NI_i$$

$$(0.4417) \qquad (-0.2926)$$

$$R^2 = 0.42789 \quad \overline{R^2} = 0.35638 \tag{4.12}$$

Not only are the t-statistics insignificant and the R^2 low, but the signs of the coefficients are not as expected.

The problem is that the official definition for money changed during the year 1978. This reflected in the results when the data was split into different samples. The first two sets had negative coefficients for interest rates but the final set of 8 years showed a positive coefficient. Demand deposits (checking accounts) were included in the new definition. Therefore a new set of data for money supply, defined as $M1$ was used. MS and demand deposits were added to obtain $M1$. The 2SLS results are:

$$M1_i = 1618.203 \quad + \quad 1.0542Y_i \quad - \quad 356.4474NI_i$$

$$(-0.4375) \qquad (0.7830)$$

$$R^2 = 0.89276 \quad \overline{R^2} = 0.87935 \tag{4.13}$$

Here again the t-statistics are insignificant but the R^2 shows a good fit. The term involving Y_i is interpreted as the transactions demand for money, while the constant plus the term involving NI_i is the speculative demand for money. The money demand equation implies that:

$$NI_i = 4.54 - 0.0028MS_i + 0.00296Y_i \tag{4.14}$$

The reduced form multiplier for the ISLM model is:

$$K = \frac{1}{1 - c_1(1 - t_1) + m_1 + i_1\frac{l_2}{l_1} - i_2} \tag{4.15}$$

Given the 2SLS estimates of the structural coefficients, $K = 1.0755$.

The Net Tax Function

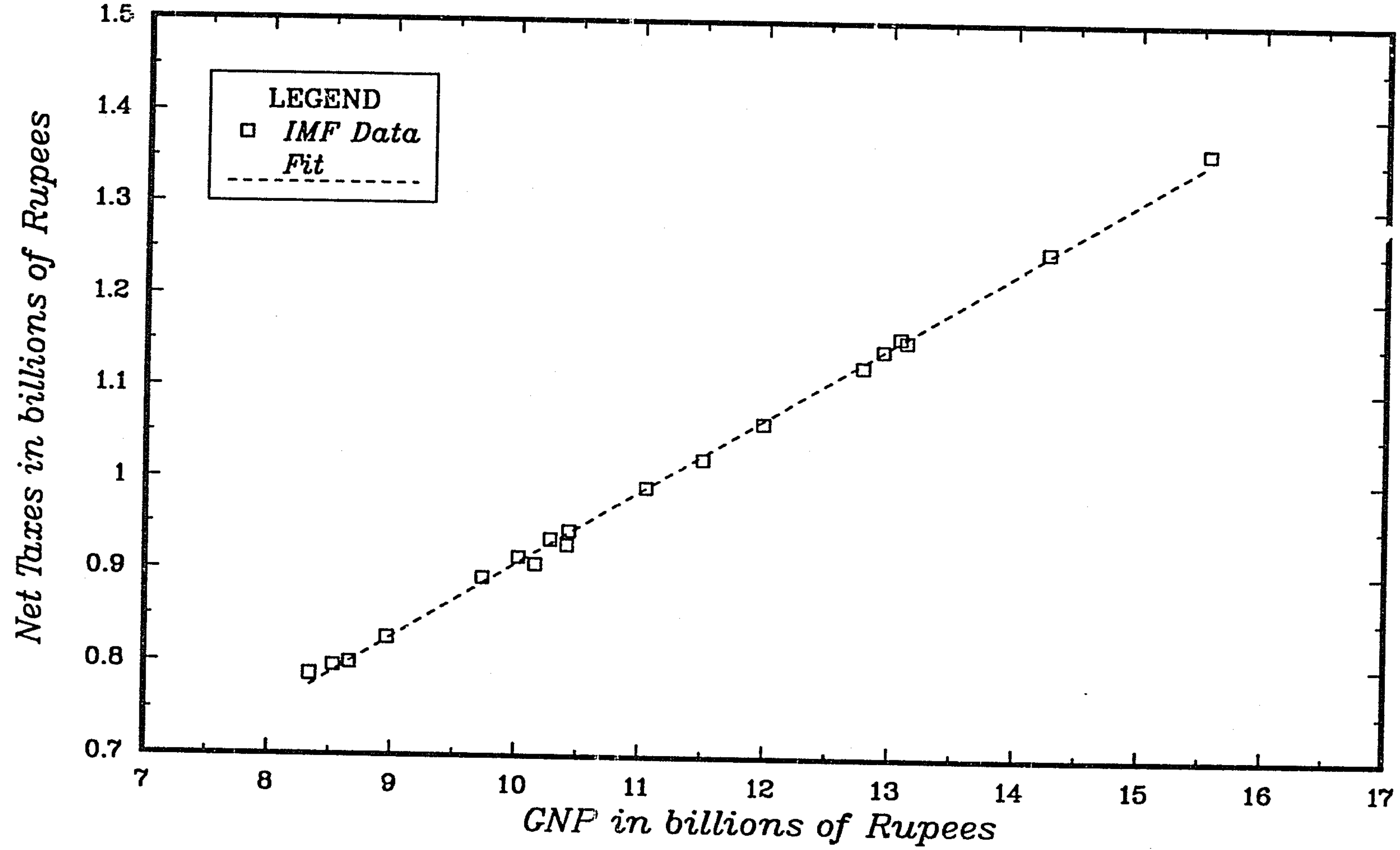

Figure 4.1

CHAPTER 5

INTERNATIONAL TRADE

Economies of the world are to a great extent interdependent. With imports and exports arise the matter of exchange rates, the price at which one country's currency is bought and sold in terms of other countries' currencies. When a country exports its product to another country, the cost of the product is perceived as expensive if the exchange rate is high and cheap if the exchange rate is low. Hence the level of exports is negatively related to the exchange rate. A linear version of this proposition is:

$$X = x_0 - x_1 E \tag{5.1}$$

On the other hand, foreign goods are perceived expensive if the exchange rate is low; that is to say more of the country's currency is required to buy the product. Imports are assumed to be positively related to income as well as to the exchange rate. Mathematically, this can be expressed as:

$$M = m_0 + m_1 Y + m_2 E \tag{5.2}$$

The exchange rate is determined by the balance of payments equilibrium. The balance of payments consists of the trade account and the capital account; i.e.,

$$B = (X - M) + (F - NTF) \tag{5.3}$$

where B is the Balance of Payments, F the Net Foreign Financial Investment in the country and NTF is the Net Transfers to Foreigners. When the balance of payments is in equilibrium; that is, $B = 0$,

$$X - M = NTF - F \tag{5.4}$$

In other words net exports are determined by F and NTF. Net foreign financial investment in the country is assumed to be positively related to the real rate of interest in the country.

$$F = f_0 + f_1 RI \tag{5.5}$$

Therefore Equation (5.4) can be written as:

$$X - M = NTF - f_0 - f_1 RI \tag{5.6}$$

where $(X - M)$ is the trade balance and varies negatively with RI.

This makes it possible to include balance of payments schedule (if the assumption of $B = 0$ is made) within that of ISLM model. Both exports and imports are endogenous to the model now. When the real interest rate goes up, net exports fall and reduce aggregate demand.

The Model

The structural form of the new macroeconomic model can be summarized as:

$$Y = C + I + G + X - M$$

$$C = c_0 + c_1 DI$$

$$DI = Y - NT$$

$$NT = t_0 + t_1 Y$$

$$M = m_0 + m_1 Y + m_2 E$$

$$X = x_0 + x_1 E$$

$$I = i_0 + i_1 Y - i_2 R$$

$$F = f_0 + f_1 RI$$

$$X - M = NTF - f_0 - f_1 RI$$

$$MS = l_0 + l_1 Y - l_2 NI$$

The exogenous variables are G, MS and NTF. Here net exports may be considered as one variable rather than treating exports and imports as separate quantities. The reduced form of this model is overidentified and 2SLS is used to estimate the structural form coefficients.

Results

The coefficients of the structural model for the Indian data are estimated using 2SLS. The estimated coefficients are similar to those in the ISLM model. The estimated consumption function is:

$$C_i = 2.410 \quad + \quad \underset{(20.641)}{0.558 DI_i}$$

$$R^2 = 0.96360 \quad \overline{R^2} = 0.961246 \tag{5.7}$$

The estimated net tax function is:

$$NT_i = 0.106 \quad + \quad 0.080Y_i$$

$$(99.673)$$

$$R^2 = 0.99834 \quad \overline{R^2} = 0.99824 \tag{5.8}$$

The investment function estimate is:

$$I_i = -1.110 \quad - \quad 0.282Y_i \quad + \quad 0.0053RI_i$$

$$(20.661) \qquad (1.260)$$

$$R^2 = 0.96446 \quad \overline{R^2} = 0.96002 \tag{5.9}$$

The estimates of the money demand function are:

$$M1_i = 1618.203 \quad + \quad 1.0542Y_i \quad - \quad 356.4474NI_i$$

$$(-0.4375) \qquad (0.7830)$$

$$R^2 = 0.89276 \quad \overline{R^2} = 0.87935 \tag{5.10}$$

The linear estimation of the export function, that is Equation (5.1):

$$X_i = 0.728 \quad - \quad 0.173E_i$$
$$(-1.22)$$
$$(5.11)$$

The t-statistics is not significant. A negative coefficient of determination is possible in 2SLS regression. This however, does not indicate that the model is inadequate. Henceforth a negative coefficient of determination will not be reported. The import function estimate, Equation (5.2):

$$M_i = -1.416 \quad + \quad 0.196Y_i \quad + \quad 0.711E_i$$
$$(7.031) \qquad (0.891)$$
$$R^2 = 0.82253 \quad \overline{R^2} = 0.79026 \qquad (5.12)$$

the estimated cofficient for income is significant at the 99% level but for exchange rates, it is not significant. The R^2 shows a good fit of the model to the data. The estimated coefficients of the net financial investment in the country, Equation (5.5):

$$F_i = 51.675 \quad + \quad 116.041RI_i$$
$$(1.11)$$
$$R^2 = 0.119019 \quad \overline{R^2} = 0.021132 \qquad (5.13)$$

Insufficient data may have caused the poor statistical results. Neither t-statistics nor R^2 show significant results. There may be other factors like trade restrictions, cultural and socio-economic factors which affect the results.

CHAPTER 6

THE ACCELERATOR MODEL

Investment may depend upon the interest rate but the dependence is weak. There are probably other variables which are more important determinants of investment. The accelerator model states that investment is sensitive to growth in production. A small change in production can lead to larger investment.

$$I = I(\Delta Y) \tag{6.1}$$

where, $\Delta Y = Y_t - Y_{t-1}$. More precisely, investment depends on the rate of change of production. A simple linear version of the model can be written as:

$$I_i = a_i + b_i (Y_t - Y_{t-1}) \tag{6.2}$$

This investment function is incorporated into the ISLM model.

The Model

The structural form of the model can be expressed as:

$$Y = C + I + G + X - M$$

$$C = c_0 + c_1 DI$$

$$DI = Y - NT$$

$$NT = t_0 + t_1 Y$$

$$I = i_0 + i_1 (Y_t - Y_{t-1}) - i_2 RI$$

$$MS = l_0 + l_1 Y - l_2 NI$$

The consumption and net tax functions remain the same as in the ISLM model. Government expenditure, exports and money supply are exogenous to the model. The reduced form of the model is overidentified.

Results

Hence the structural form of the model is estimated using 2SLS. The estimates of the consumption function are:

$$C_i = 2.452 \quad + \quad 0.554 DI_i$$

$$(20.531)$$

$$R^2 = 0.96342 \quad \overline{R^2} = 0.961276 \tag{6.3}$$

The estimates of the net tax function are:

$$NT_i = 0.108 \quad + \quad 0.079 Y_i$$

$$(100.048)$$

$$R^2 = 0.99835 \quad \overline{R^2} = 0.99825 \tag{6.4}$$

The 2SLS estimates of the investment coefficients are:

$$I_i = 1.038 \quad + \quad \underset{(2.247)}{2.217(Y_i - Y_{i-1})} \quad - \quad \underset{(-1.583)}{0.905RI_i} \tag{6.5}$$

The amount of investment that is autonomous is Rs 1.038 billion. The accelerator coefficient is 2.217, implying that a Rs 1 billion increase in production would cause a Rs 2.217 billion increase in investment. The t-statistic for the accelerator is slightly below the significant level.

The accelerator reveals the volatile relationship between investment and growth, which economists view as a key to explanations of business cycles. A small increase in aggregate demand is accelerated into a business boom, while a small slackening of aggregate demand brings about a depression. The accelerator and the multiplier act together. Depending on their values, an initial increase in an exogenous variable, working through the the multiplier, causes an increase in income and this leads to an increase in investment, through the accelerator.

Paul Samuelson studied the interaction of the multiplier and the accelerator[1] and derived a model in which the two forces interact over time. The model used below follows Samuelson's and is different from the previous model in that the accelerator effect is driven by changes in consumption instead of changes in

[1]Paul Samuelson, "Interactions between the Multiplier Analysis and the Principle of Acceleration," *Review of Economic Statistics* May, 1939.

aggregate demand:

$$Y_t = C_t + I_t + G_t + X_t - M_t \tag{6.6}$$

$$C_t = \alpha Y_{t-1} \tag{6.7}$$

$$I_t = \beta \left(C_t - C_{t-1} \right) \tag{6.8}$$

where t is a subscript indicating time. It is assumed that $0 < \alpha < 1$ and $\beta > 0$. In this model G, X, M are exogenous variables.

When the appropriate substitutions are made a second order difference equation is obtained; i.e.,

$$Y_t - \alpha \left(1 + \beta \right) Y_{t-1} + \alpha\beta Y_{t-2} = \left(G_t + X_t - M_t \right) \tag{6.9}$$

Solving the above, reveals the time path and growth pattern of the economy.

The parameter estimates for the model are:

$$\begin{aligned} C_t = 1.85 \quad + \quad & 0.591 Y_{t-1} \\ & (10.041) \\ & R^2 = 0.869032 \quad \overline{R^2} = 0.86030 \end{aligned} \tag{6.10}$$

$$I_t = 1.50 \quad + \quad 2.513\,(C_t - C_{t-1})$$

$$(2.317)$$

$$(6.11)$$

The t-statistics are significant. The homogeneous solution for Equation (6.9) is obtained by making the substitution, $Y_t = Ab^t$. This results in the quadratic equation:

$$b^2 - \alpha\,(1+\beta)\,b + \alpha\beta = 0 \tag{6.12}$$

whose roots are given by:

$$b_{1,2} = \frac{\alpha\,(1+\beta) \pm \sqrt{(\alpha\,(1+\beta))^2 - 4\alpha\beta}}{2} \tag{6.13}$$

Substituting the parameters from (6.7) and (6.8) shows that the system has complex roots, indicating existence of business cycles:

$$b_{1,2} = 1.03809 \pm i0.638 \equiv \lambda \exp\left[\pm i\theta\right] \tag{6.14}$$

where $i = \sqrt{-1}$. The value of λ, the term which reveals the path taken:

$$\lambda = \sqrt{1.03809^2 + 0.638^2} = 1.2186 \tag{6.15}$$

Since $\lambda > 1$, it implies the oscillations are growing Solving for θ:

$$\theta = \tan^{-1} \frac{0.638}{1.03809} = 0.5513 \tag{6.16}$$

The time for one business cycle T, is given by

$$T = \frac{2\pi}{\theta} = 11.395 \tag{6.17}$$

This estimate of a business cycle should not be taken seriously as the period covered by the data is only eighteen years. The strength of the cycle is indicated by the growth factor from cycle to cycle of $1.218^{11.395}$ indicating that if a small fluctuation develops in output the size of this fluctuation will increase by a factor of 1.2 in one year.

CHAPTER 7

THE COMPLETE MODEL

The accelerator and the international trade models are incorporated into the modified ISLM model to form a generalized model.

The structural form of this model can be expressed as:

$$Y = C + I + G + X - M$$

$$C = c_0 + c_1 DI$$

$$DI = Y - NT$$

$$NT = t_0 + t_1 Y$$

$$I = i_0 + i_1(Y_{t-1} - Y_{t-2}) - i_2 RI$$

$$MS = l_0 + l_1 Y - l_2 NI$$

$$NI = RI + P$$

$$M = m_0 + m_1 Y + m_2 E$$

$$X = x_0 - x_1 E$$

$$X - M = NTF - F$$

$$F = f_0 + f_1 RI$$

The exogenous variables, determined outside the model are G, MS, P, NTF and $B \equiv Y_{t-1} - Y_{t-2}$. The coefficients of the reduced form equations for this model are given below:

endogenous variables	*exogenous* B	*variables* P	G	MS	NTF
Y	Ki_1	Ke_2	K	Ke_4	K
NT	Ki_1t_1	Ke_2t_1	Kt_1	Ke_4t_1	Kt_1
C	Ki_1b	Ke_2b	Kb	Ke_4b	Kb
DI	Ki_1d	Ke_2d	Kd	Ke_4d	Kd
RI	r_1	r_2	r_3	r_4	r_5
F	f_1r_1	f_2r_2	f_3r_3	f_4r_4	f_5r_5
I	$i_1 - i_2r_1$	$-i_2r_2$	$-i_2r_3$	$-i_2r_4$	$-i_2r_5$
E	h_1	h_2	h_3	h_4	h_5
X	$-x_1h_1$	$-x_1h_2$	$-x_1h_3$	$-x_1h_4$	$-x_1h_5$
M	g_1	g_2	g_3	g_4	g_5

where,

$$K \equiv \left[1 - c_1(1 - t_1) + i_2\frac{l_1}{l_2} + f_1\frac{l_1}{l_2}\right]^{-1}$$

$$e_2 \equiv f_1 + l_2 \quad ; \quad e_4 \equiv \frac{f_1}{l_2}$$

$$r_1 \equiv \frac{l_1}{l_2}Ki_1 \quad ; \quad r_2 \equiv= \frac{l_1}{l_2}Ke_2 - 1$$

$$r_3 \equiv \frac{l_1}{l_2}K \quad ; \quad r_4 \equiv \frac{l_1}{l_2}Ke_4 - \frac{1}{l_2} \quad ; \quad r_5 \equiv \frac{l_1}{l_2}K \quad ; \quad Note\ r_3 = r_5$$

Defining $p \equiv \frac{f_1 l_1}{l_2} - m_1$ and $q \equiv \frac{1}{z_1+m_2}$,

$$h_1 \equiv pqKi_1 \quad ; \quad h_2 \equiv (pKe_2 - f_1)q \quad ; \quad h_3 \equiv pqK$$

$$h_4 \equiv pqKe_4 - \frac{f_1 q}{f_2} \quad ; \quad h_5 \equiv (pK-1)q$$

$$g_1 = m_1Ki_1 + m_2h_1 \quad ; \quad g_2 = m_1Ke_2 + m_2h_2 \quad ; \quad g_3 = m_1K + m_2h_3$$

$$g_4 = m_1Ke_4 + m_2h_4 \quad ; \quad g_5 = m_1K + m_2h_5$$

In principle, estimates of structural form coefficients may be derived using the reduced form coefficients. However, it is not possible to obtain unique estimates of all the structural coefficients. For example, the reduced form consumption and income equations give five estimates of b and the reduced form income equation gives two estimates of K. Since more than one estimate can be obtained for some of the parameters, the model is overidentified. As discussed in Chapter 2, 2SLS is used to obtain unique estimates of the structural coefficients.

The effect of a change in any predetermined variable on various endogenous variables can be studied using the reduced form coefficients.

CHAPTER 8

CONCLUSIONS

The Indian data yielded useful estimates for parameters for macroeconomic analysis. The simple Keynesian model revealed the marginal propensity to consume and import for the Indian economy. The MPC was 0.51, indicating that an increase in income by one billion, would lead to a 0.51 billion increase in consumption. Similarly the marginal propensity to import was 0.15. The multiplier for the Indian economy, was 1.835 indicating an increase of Rs.1.8 billion in real GNP when autonomous expenditure increases by a billion.

The ISLM model is an expansion of the Keynesian model and incorporates the effect of interest rates and monetary sector. The consumption function is refined to measure the MPC of disposable income and is 0.55. The tax function gives the marginal net taxe rate of 0.079. Investment, however shows a stronger dependence on income than on real interest rates. The signs of the coefficients are not as expected. The monetary sector covers the money demand and supply functions. The transactions demand for money depends on income and the slope of the curve is 1.05, while the speculative and precautionary demand depends on interest rate. The results indicate that when the interest increases by one percent this demand decreases by Rs 356.45 billion. Though the t statistics in both cases were not significant, the model explains 89% of the variation in the data.

The international trade model examines the relationship of exports and inports to exchange rate expressed in terms of rupees to dollars. Imports are affected by nominal GNP as well. As expected, exports are negatively related to to exchange rate to the extent of 0.173 billion with a change of the exchange by one rupee per dollar. Imports are positively related to exchange rate and real GNP. The marginal propensity to import is 0.196. An increase in imports of Rs 0.711 billion can be expected from one unit change in the exchange rate. As net financial investment of foreigners is positively related to the real rate of interest, it can be shown that the balance of payment is a function of income and interest rates. This makes it possible to incorporate the international trade sector into the ISLM model. The regression yielded poor results and factors such as inadequate data and socio-economic conditions may be the reason for this negative result.

The accelerator model used was a simple one, with investment depending on changes in aggregate demand. Investment is sensitive to changes in capital stock which in turn is dependent on income. The coefficient of the investment function to changes in income, known as the desired capital to output ratio, is 2.22. Paul Samuelson's accelerator model has lagged income affecting consumption and investment being linked to changes in consumption. This model applied to Indian data yeilds figures of 0.59 and 2.51, respectively. Working through the results of the second order difference equation suggests a business cycle with a complete oscillation taking about 7 years.

The complete model was analyzed through the structural and reduced form. The exogenous variables are MS, P, G and NTF. The coefficients of the reduced form are estimated. The reduced form estimates are overidentified, giving several estimates for every structural coefficient. The coefficients of the structural form obtained through 2SLS are unique and better estimates.

The Indian data showed a good fit to the various models used here. The Indian economy reveals a trend of growth in the past two decades. The results obtained could be used for forecasting future trends and in various policy making decisions.

TABLE 1

Data used in obtaining the regression results

(in billions of rupees)

Year	GNP	Consumption	Investment	Govt. Expenses
1965	239.5	185.3	41.3	23.0
1966	274.3	217.7	46.0	25.0
1967	320.4	262.6	50.8	27.9
1968	330.2	262.4	53.8	30.5
1969	365.8	285.1	59.0	34.2
1970	399.8	298.0	63.1	38.0
1971	430.7	321.0	70.7	44.6
1972	475.6	351.3	80.7	47.5
1973	586.2	428.7	90.3	51.0
1974	693.0	519.1	109.3	61.4
1975	738.3	527.5	132.5	73.5
1976	799.7	541.1	153.0	82.1
1977	896.2	625.3	172.2	86.7
1978	975.9	682.4	188.8	96.2
1979	1076.0	738.6	213.1	110.3
1980	1278.1	893.2	252.2	130.3
1981	1473.9	1017.1	296.2	152.8
1982	1640.6	1102.6	347.8	180.2
1983	1928.7	1337.1	401.8	208.6
1984	2122.1	-	449.5	245.0

TABLE 2

Data used in obtaining the regression results

(in billions of rupees)

Year	Money supply	Interest rate	Prices	Net taxes
1965	59.07	5.32	28.71	-
1966	65.69	5.54	32.14	-
1967	71.84	5.52	36.98	-
1968	78.68	5.07	36.82	-
1969	89.32	5.00	37.59	-
1970	100.05	5.00	39.89	-
1971	117.14	5.64	41.90	-
1972	135.17	5.65	45.61	-
1073	161.52	5.65	53.07	-
1974	181.27	6.04	68.24	57.10
1975	206.74	6.35	70.90	67.28
1976	257.35	6.29	69.53	72.35
1977	306.67	6.32	74.77	76.03
1978	371.54	6.37	74.61	88.09
1979	437.35	6.45	83.12	100.82
1980	506.88	6.71	100.00	110.21
1981	595.33	7.15	112.24	131.56
1982	697.75	7.59	114.97	143.97
1983	815.58	7.99	124.03	166.71
1984	930.65	-	134.63	-

TABLE 3

Data used in obtaining the regression results

Year	Imports	Exports	Current acc.	Changed Resv.	Exch.Rate
1965	14.6	9.3	-	-	-
1966	21.2	13.3	-	-	-
1967	22.0	15.1	-	-	-
1968	19.0	16.0	-	-	-
1969	17.5	16.3	-	-	-
1970	18.2	17.7	-	-	-
1971	21.8	17.9	-	-	-
1972	20.5	22.3	-	-	-
1073	31.8	28.3	-449.0	140	0.13
1974	47.8	38.4	998.0	62	0.123
1975	56.6	48.1	-107	-252	0.12
1976	56.1	61.4	1362	-1889	0.112
1977	65.2	66.4	1808	-2019	0.114
1978	74.2	71.2	535	-1496	0.122
1979	100.9	83.4	40	-690	0.123
1980	136.0	90.3	-1374	499	0.127
1981	148.2	102.6	-2286	1762	0.116
1982	158.1	116.7	-2288	1532	0.106
1983	176.3	132.4	-1799	626	0.099
1984	-	-	2302	-990	0.088

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