CHAPTER 4
CGE METHODOLOGY AND THE PRESENT MODEL

4.0. INTRODUCTION

A computable general equilibrium (CGE) model, which is also known as applied general equilibrium model, tries to relate the basic notions of economic theory with policy issues of current concern. Unlike the traditional macro-econometric models, most of the CGE models do not estimate but numerically calculate the parameters of the model (Gary Macmohan 1989). In this framework, a researcher assumes that the structure of the model is correct at a given point in time, describes an equilibrium and then algebraically calculates the parameters of the model.

The fundamental notion of general equilibrium goes back to Walras and the empirical estimation starts with the Johansen's path breaking model of the Norwegian economy. Computable general equilibrium models which analyze a wide variety of policy issues have now became one of the standard tools in some policy areas.

Depending on their focus the existing CGE models fall into four broad categories, viz (1) models that focus on issues of international trade, growth, structure and income distribution, (2) models that focus on the theory of public finance, (3) multi-country international trade models that explore issues
concerning the volume, and direction of trade and its impact on particular regions and (4) country-specific and multi-country models focusing on energy.

The CGE models are also price endogenous. Issues relating to imperfect competitive behavior, quantity and price adjustment lags and wide-spread government intervention are compatible with the CGE framework. This essentially is an applied general equilibrium analysis adopted for mixed market economies.

Two sector models provide a good starting point for such an analysis. These CGE models capture the essential mechanism by which external shocks and economic policies ripple through the economy. They are used in the developing countries to analyze the effect of economic policy changes on the relative prices and so on. Consider for example, the appropriateness of a major devaluation in a country facing a foreign exchange shortage and deficits in external accounts. This can be studied with the help of a model that captures the shocks and policies relating to the external sector of the economy. Questions like the following could be analysed:

(a) Would devaluation be effective with low export demand elasticities and or low substitution elasticities between domestic and imported goods (terms of trade effect)?
(b) Are supply elasticities thought to be very low? If so, in which sectors and for what reasons?
(c) Is the problem more of macro-economic in nature i.e., does a nominal devaluation turn into a real devaluation? and
(d) Does devaluation adversely affect the income distribution patterns?

Theory and intuition can provide only limited help in settling such questions. What is needed is an economy-wide framework that permits an explicit specification of an economy's working where each of these views can be evaluated. The first task in the CGE modeling is to compile a consistent data set. Once the data are collected, an appropriate model can be constructed. The structure of the model will usually depend on the availability of the data.

The application of CGE models in the field of international trade includes studies pertaining to country-specific issues (case studies), multi-country studies that focus on trade relations among nations, studies relating to BOP, devaluation and its effects, exchange rate models dealing with terms-of-trade effects, trade strategies and so on.

Another issue in trade policy modelling concerns the role of exchange rates and the related issue of international capital flows. In traditional pure theory of international trade, exchange rate changes produce no real effects. If a monetized extension of a classical general equilibrium model were to be used to analyze trade policy changes, money demand function
appears along with specified levels of national money stocks, neutrality would prevail in the sense that once the real and financial behaviour of the economy were known, specifying national money stocks would simply serve to determine domestic price levels and exchange rates. Alternatively, should a fixed exchange rate regime be analyzed, one can calculate the national money stocks that are necessary to support the equilibrium and achieve the desired exchange rates. In either case there are no real effects emanating from the monetary sector.

4.1. PAST STUDIES ON CGE MODELS OF TRADE

Numerical general equilibrium trade policy analysis started with the works of Scarf (1973) and subsequently these models were used to study the policy issues in the areas of public finance, trade and development. The major objective in the general equilibrium models is to make an attempt to blend theory and policy so as to improve both analytical foundations of policy evaluation work and to bring the theoretical work that already exists in the literature more fully into the policy debate.

Global trade policy issues are analyzed in multi-country models, while single country models investigate as to how developments abroad affect individual economies. Some are oriented exclusively to trade policy questions. The major features of the models are summarized in the work of Srinivasan
and Whalley (1989) and cover a wide range of applications.

A multi-sector CGE model for the Yugoslav economy is used (Robinson et al 1985) to analyse some of the internal and external causes of the foreign exchange crises of the 1976-80 period. Empirical results suggest that internal policy errors were the main factors behind Yugoslavia's growing foreign exchange crisis.

Gupta and Togan (1984) employed separate multi-sectoral general equilibrium models for Turkey, Kenya and India to study the adjustment problems confronting these countries. The effects of liberal and interventionist policies on GDP and on class-specific incomes were analysed. Their results have shown that liberal policies minimised the GDP losses and both capitalists and farmers are relatively better-off under these policies, while industrial workers experienced reduced welfare.

In Chile, a comprehensive package of reforms, liberalised international trade were introduced in 1977. The restrictive labour legislation was abolished. These reforms resulted in significant changes in relative prices and structure of production and demand. The economy witnessed an unprecedented growth with declining inflation. But, by the year 1982, Chile was seen to develop large macro-economic imbalances and a sudden and severe recession. Timothy Condon et al (1985) have tried to
analyse the causes for this sudden change of events in the Chilean economy during 1977-81 using a CGE model. In their model, the authors used real exchange rate as an exogenous policy variable and compared the model generated growth path with that of the actual growth path of the economy. It was suggested that the macro-economic imbalances that led to the crisis in 1982 were exacerbated by large capital inflows and appreciation of real exchange rate that resulted from the use of the real exchange rate as a stabilisation device.

Canvary (1986) examined the persistent trade deficits phenomenon that occurred in the developing countries in general and for the Turkish economy, in particular after the oil price hike of the 1970s. His results highlighted the primary role played by government tariff and exchange rate policies in the creation of trade deficits. The Turkish economy provided an example of contractionary devaluation. It also highlighted the importance of devaluation-cum-liberalisation for deficit reduction and economic growth.

Sweder (1986) identified the channels through which devaluation affects the supply side of the economy. A comparison is made between contractionary effects of devaluation through supply and demand sides. He found that effects through supply side are more damaging than that of Krugman and Taylor (1978) effects via demand side to counter inflation.
The modelling efforts of Chakravarthy (1973) for India's fifth five year plan was the starting point and, since then, most of the Indian models are in that spirit. De Janvry and Subba Rao (1986) tried to quantify the links between government's agricultural pricing policies and income distribution. Taylor, Sarkar and Rettso (1984) have incorporated both price and quantity adjustments in their model of the Indian economy. Sarkar and Kadekodi (1988) have analysed the energy pricing policies in India. Two other CGE models for India, which are close to the neo-classical tradition, are those of Mohammed and Whalley (1983) and Blomoquist and Mohammed (1986).

The mainstream CGE modelling has been to develop frameworks based on neo-classical micro-economic theory, and for the most part, neglected structural factors. The main contribution of Indian models has been to bring these important structural aspects back into the spotlight. The major challenge of the future is to merge these two approaches into models which allow some flexibility while realistically addressing the economic structure of the country in question.

4.2. THE PRESENT MODEL

This study considers an aggregate model of the Indian economy. It focuses on identifying the determinants of India's
trade balance and inflation, it aims at examining the linkage between trade and monetary sectors. Traditional export and import functions do not include monetary sector variables in the analysis. Here, an attempt is made to incorporate a monetary disequilibrium variable into the trade equations and test its impact. The effectiveness of devaluation and credit policy on trade balance and balance of payments is analysed with the estimated model and policy simulations are undertaken.

A computable general equilibrium trade model was specified and estimated. Some of the institutional features like import restrictions, tariffs and export subsidies, etc. were taken into account. The model provides a proper synthesis of both elasticities and monetary approaches to BOP. The role of monetary factors (money demand and supply) on trade variables was examined by integrating monetary and trade sectors.

The effects of devaluation on macro variables like trade balance, domestic prices, money supply, imports, exports in the Indian economy are analysed. The monetary disequilibrium variable is derived from the estimated money demand equation and is used in the export supplies and import demand equations to capture the effect of monetary changes on trade. The trade block of the model explains the export demand, export supplies and imports. Two specifications namely, with and without the monetary disequilibrium variable are estimated and compared.
Thus, the trade equations, the money demand function, and various definitional identities together make-up the complete model, representing the markets for three goods namely exportables, importables and non-traded goods as well as one asset viz., money. The complete model, thus determines price level, balance of payments and money supply under the assumption that output is exogenously given. The model emphasises the endogeneity of money supply owing to the link between prices and balance of payments. Changes in these variables are regarded as primary channels through which equilibrium be brought about in the money market, keeping the level of output as exogenous.

Output is assumed to be exogenous in the model in order to analyse the complex and dynamic interactions between devaluation and inflation. The present study draws heavily from the model of Sunderarajan (1986). The modifications in this theoretical model include (i) replacing $R_{t-1}$ with $(\frac{R}{PM_{s}})_{t-1}$ in imports equation i.e., imports depend on lagged purchasing power (foreign exchange) rather than simply lagged foreign exchange assets, (ii) incorporating another important variable in the equation viz essential imports mainly consisting of Petroleum, Oil and Lubricants (POL), (iii) including a dummy variable representing change in exchange rate regime from fixed to flexible type since 1973 in three equations- unit value of exports, demand for exports and import demand and (iv) more importantly, the EM variable (excess flow demand for real cash balances) is made
independent of v parameter obtainable from money demand function i.e., it is assumed that adjustment of real cash balances to desired level is instantaneous (v=1) for purpose of measuring EM. This modification is important particularly because of volatality (excessive sensitivity) of v to changes in sample period which is transmitted to EM if it depends on v through partial adjustment. However, in policy simulations, EM is computed by using estimated value of v. As we shall notice, this modification made EM variable more significant. The exchange rate regime dummy also turned out to be significant thereby improving the goodness of fit as well. The modified theoretical model may be summarised as below:

4.3. MODEL SPECIFICATION
Money demand and price determination:

In the empirical specification of money demand function, three broad issues are discussed and debated. The first one relates to the appropriate definition of money which is identifiable, controllable and linked stably with the national income or price level. The second issue relates to the conditions under which the demand for money is consistent with aggregation theory. Third one concerns whether demand for money is a stable function or not, so that the effects of monetary policy action on the economic system can be reasonably and accurately predicted and explained. A survey of the main stream money demand models
can be found in Subramanyam (1990). The inflation rate has a
direct and significant effect on demand for money. The issue of
money substitutes, adjustment costs and opportunity cost of
holding real money balances necessitates the inclusion of
inflation rate into the empirical models.

Goldfeld (1971) has analysed the issues concerning
specification and estimation of money demand function
incorporating the expected rate of inflation in the money demand
function. He used a distributed lag of current and past rates of
inflation in a stock adjustment version and polynomial
distributed lags on income and interest rates. Inflation rate was
found to have a significantly negative effect.

The traditional models of money demand function assumed that
nominal interest rate on short term bonds is sufficient to
explain the opportunity cost of holding money. However, the
inclusion of inflation rates as a direct determinant of money
demand function was employed by Baba, Hendry and Sterr (1988),
Hetzel and Mehra (1989). The theoretical justification was
provided in the work of Emery (1991). There were also some
attempts to include rate of inflation in the money demand
function for India ((Kamaiah (1985), Sunderarajan (1986), Thomas
Paul(1994)).

The demand for money is specified as a function of a scale
variable (income or wealth) and an opportunity cost variable (interest rate or expected rate of inflation). In situations of excessive price rise, the opportunity cost of money is better proxied by the rate of return on real assets. In literature, the expected rate of inflation is used to capture this.

Following Sunderarajan (1986), the demand for real cash balances is specified\(^1\) in a log-linear (infact semi-log) form\(^2\) as:

\[
\ln \left( \frac{M}{P} \right)^d - a_0 + a_1 \ln (YM) - a_2 \pi^e \quad (4.1)
\]

where \(M\) = stock of nominal money balances, \(P\) = price level, \(YM\) = marketed output or real income, \(r^e\) = expected rate of inflation. The expected rate of inflation is assumed as a distributed lag function of current and past rates of inflation upto \(n\) periods. The value of \(n\) is determined empirically.

\[
\pi^e = \sigma_0 \pi + \sum_{i=1}^{\infty} \sigma_i \pi_{-i} \quad (4.2)
\]

The actual stock of real money balances is assumed to adjust partially to the gap between the demand for real money balances and the actual stock in the previous period:

\[
\ln \left( \frac{M}{P} \right) - \ln \left( \frac{M}{P} \right)_{-1} = \nu \left( \ln \left( \frac{M}{P} \right)^d - \ln \left( \frac{M}{P} \right)_{-1} \right) \quad (4.3)
\]

\(^1\)In each of the equations specified below, the expected sign of the coefficient is incorporated into the specification itself in order to facilitate interpretation/understanding of the likely effect. For example, in money demand function, output and expected rate of inflation are expected to have positive and negative coefficients respectively.

\(^2\)In empirical analysis, both linear and semi-log forms are estimated.

\(^3\)We use the value of \(n\) as 5, obtained by Sunderarajan (1986).
Substituting equations (4.1) and (4.2) into equation (4.3) and solving for real money balances we get:

\[
\ln \left( \frac{M}{P} \right) = a_0 + a_1 \ln (YM) - a_2 \sigma \pi - a_3 \xi \pi_{-1} + (1-\nu) \ln \left( \frac{M}{P} \right)_{-1}
\]  

(4.4)

A model of price determination can be stated by re-writing equation (4.4) to bring price level to the left hand side and by spelling out the definition of the rate of inflation.

\[
\ln (P) = \ln (M) - \nu a - (1-\nu) \ln (YM) + (1-\nu) \ln (\frac{M}{P})
\]  

(4.5)

\[
\pi = \ln (P) - \ln (P-1)
\]  

(4.6)

Equations (4.5) and (4.6) together determine the price level and the rate of inflation corresponding to any given level of nominal money stock, real output and past history of output and inflation.

From the parameter estimates of the money demand function, we can compute the unobservable variable viz., desired level of real balances as:

\[
\ln \left( \frac{M}{P} \right)_d = a_0 + a_1 \ln (YM) - a_2 \sigma \pi - a_3 \xi \pi_{-1}
\]  

(4.7)

Using (4.7) in conjunction with the adjustment mechanism given in (4.3), a new unobservable variable called "flow excess demand for real balances" (EM) can now be defined as,

\[
EM = (M/P)_d - \left( \frac{M}{P} \right)_{-1} - \Delta (D.K/P)
\]  

(4.8)

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where $A$ is the first difference operator. In the R.H.S of (4.8), $(M/P)^d - (M/P)_t$ measures the gap between desired real balances and the existing opening stock of real balances, which can be interpreted as the flow demand for real balances. Some part of this flow demand is met from domestic credit creation. The expression $(D.k/P)$ measures the stock of real balances supplied domestically, either through fiscal deficits or through RBI lending to the commercial banks. The second part of (4.8) can thus be viewed as flow supply of real balances and EM therefore is excess flow demand for real cash balances. This way of measuring excess flow demand which is a measure of extent of disequilibrium in the market for real cash balances is one of the several ways (see White (1978) and Lumsden (1979) for other alternative measures).

Money Supply:

The supply of money is related to the stock of high power money through money multiplier which is assumed to be exogenous,

$$M = k(R+D)$$

(4.9)

where $k = $money multiplier, $R = $net foreign assets of RBI, $D = $net domestic assets of RBI.

Supply of and Demand For Exports:

The empirical literature on trade modelling has been appearing in the trade surveys at least once in every five years.
since 1959. The early estimates of income and price elasticities during 1936-57 were surveyed by Cheng (1959) and Prais (1962). World trade models are discussed in Taplin (1973), Deardorff and Stern (1977) and Fair (1979). Another comprehensive trade survey of Learner and Stern (1970) gives the discussion of the time series estimation of import and export demand relationships. Magee's (1975) trade survey is the broadest one available, and deals with the methodological questions, empirical evidence, pure trade and monetary theory. The specification and the theoretical justification of export and import equations was given in the survey of income and price effects in foreign trade in Goldstein and Khan (1985). Export and import equations for developing countries was estimated (Khan, 1974)

The export supply is specified as a function of subsidy inclusive relative price, real national income and lagged exports. The monetary disequilibrium variable is also used to estimate the export supply function in one variant.

\[
\ln(X^e) = b_0 + b_1 \left( \ln PX^e (E+s)/P \right) + b_2 \ln(Y) + b_3 EM + b_4 \ln (X_{-1})
\] (4.10)

where \( X^e \) = export supply at constant prices, \( PX^e \) = unit export value, \( E \) = exchange rate of Indian Rupee, \( s \) = unit export subsidies, \( Y \) = real national income.

Since EM takes both positive and negative values, it enters the export supply equation (4.10) only linearly. The export
supply equation is otherwise log-linear. The lagged volume of exports on the R.H.S. of (4.10) represents a partial adjustment mechanism of exports to desired level of exports. This adjustment may arise both from domestic demand and supply of exportables given the exogenous output. The subsidy inclusive relative price of exports can be viewed as relative profitability or attractiveness of supplying to export market rather than domestic market. Higher the profitability, more the exports. In computing this relative price, unit subsidy is added to exchange rate because it reflects the unit rate received by the exporters. Export subsidy used to be an important element of export promotion measures until recently (prior to liberalisation). The inclusion of excess flow demand for real balances (EM) in export supply function is meant to measure the domestic demand component of tradable and non-tradables. An increase in EM is expected to reduce real expenditures on both tradables and non-tradables and therefore will have a positive effect on export supply since domestic demand component will be reduced. This may be called the expenditure effect of changes in EM. Further, EM will have a relative price effect through the prices of non-tradables and export substitute goods.

The demand for exports is specified as a function of real GNP of major trading partners and unit value of Indian exports relative to prices in India's trading partners and competitor countries.
\[ \ln(X^d) - c_0 - c_1 \ln(PX^g/PW) + c_2 \ln(YW) + c_3 \ln(X_1) \] (4.11)

where \( X^d \) = demand for exports, \( PW \) = price level in trading partner and competitor countries in US Dollars, \( YW \) = real GNP of trading partner countries.

Assuming equilibrium in export market i.e., equating exports supply with exports demand and solving for \( PX^g \), in other words, the reduced form equation for the unit value of exports can be obtained as:

\[ \ln(PX^g) = \frac{1}{b^1+c_1} \left( (c_0-b_0) + b_1 \left( \ln \left( \frac{P}{(E+s)} \right) \right) - c_1 \ln(PW) - b_2 \ln(Y) + c_2 \ln(YW) - b_3 EM + (b_4-c_3) \ln(X_1) \right) \] (4.12)

Equation (4.12) should be used in combination with either (4.10) or (4.11), but not both, since only one data series on exports volume are available to describe exports market. Equation (4.12) reflects the price taking nature of India in export market. The numerical values of coefficients for the relative price variables in demand and supply equations would tell us whether India is a price taker or price setter in the export market.

Import Demand and Foreign Exchange Rationing:

The import demand is specified as a function of tariff inclusive relative price, real national income, the excess flow demand for real balances and essential imports. While specifying the function, the importance of essential imports and the nature
of foreign exchange rationing was taken into account. The import restrictions that were prevailing in the country during early 1960's played an important role in the allocation of foreign exchange receipts. The need for incorporating such behaviour into the import functions was well documented in the work of Heller (1976). Considering the importance of all the above institutional factors, the import demand function for India was specified as:

\[ I_d = d_0 - d_1 \left( PM^s \frac{(E+t)}{P} \right) + d_2 Y + d_3 I_F - d_4 EM \] (4.13)

where \( I_d \) = import demand in volume terms, \( PM^s \) = unit value of imports, \( t \) = unit import duties, \( I_F \) = proxy for essential imports.

The actual volume of imports is governed by the import licensing system. The authorities are expected to permit the optimal level of imports in order to minimise the cost of deviations from the desired import level, as well as the cost of deviations of actual reserves from the desired reserve level. Since these two objectives conflict with each other, a compromise linear allocation procedure is adopted as given below:

\[ I^p = (1-\beta)I_d + \beta(F-(R^*-R_{1})) \] (4.14)

where \( I^p \) = permitted level of imports, \( F \) = foreign exchange receipts, \( R^* \) = desired reserve level, \( R_{1} \) = reserve level at the beginning of the period.
In equation (4.14), the foreign exchange receipts are the sum total of current value of exports and capital inflows. This variable as well as the desired level of reserves are expressed in real terms by deflating with import price index. The deflated foreign exchange receipts represents the importing capacity of the country which is linearly allocated between current imports and desired reserve changes as in (4.14). The unobservable desired reserves variable (R*) is specified as a linear function of long-run exchange receipts as perceived by the licensing authorities:

\[ R^* = \alpha_0 + \alpha_1 F^* \]  

(4.15)

where \( F^* \) = long-run exchange receipts.

Further, it is assumed that

\[ I - I_{-1} = \lambda (I^p - I_{-1}) \quad 0 < \lambda < 1 \]  

(4.16)

i.e., the change in import flow is some positive fraction (A) of the discrepancy between the permitted level of imports and the previous period's imports. Rewriting (4.16) suitably we get

\[ I = \lambda I^p + (1-\lambda)I_{-1} \]  

(4.16')

Equation (4.16') implies that the actual level of imports is assumed to be a distributed lag function of the permitted level of imports with geometrically declining lag coefficients
Assuming that the long-run exchange receipts can be approximated by current exchange receipts \((F^* = F)\), and substituting equations (4.13), (4.14) and (4.15) into equation (4.16'), we get the estimable import demand function:

\[
I = D_0 + D_1 \left( PM^s (E + t)/P \right) + D_2 Y + D_3 I_F + D_4 EM
+ D_5 \left( (X.PX^s + KI^S)/PM^s \right) + D_6 \left( R/PM \right)^{a-1} + D_7 I_{-1} \quad (4.17)
\]

The BOP identity can be written as:

\[
R = R + X.PX^S - I.PM^S + KI^S \quad (4.18)
\]

where \(R\) = reserves.

The four equations (4.4) or (4.5), (4.10) or (4.11), (4.12), and (4.17), together with four identities viz., (4.6), (4.7), (4.9) and (4.18) constitute the complete CGE trade model of balance of payments and inflation. Thus, the complete model may be written as:

1. Money demand function and price equation:

\[
\ln \left( \frac{M}{P} \right) = \nu a_0 + n_a_1 \ln(YM) - \nu a_2 \sigma \pi - \nu a_3 \sigma \pi_1
+ (1-v) \ln \left( \frac{M}{P} \right)_{-1}
\]

A log-linear version of (4.17) can be obtained by suitably modifying equations (4.13) to (4.16') into log-linear form. Care should be taken to specify variables like EM in linear form only.
\[ \ln(P) = \ln(M) - \nu a_0 - \nu a_1 \ln(YM) + \nu a_2 \sigma \pi + \nu a_3 \pi_{-1} - (1-\nu) \ln(M/P) \]

2. Rate of inflation definition:
   \[ \pi = \ln(P) - \ln(P)_{-1} \]

3. Desired real balances identity:
   \[ \ln(M/P)^d = a + a_0 \ln(YM) - a_2 \sigma \pi - a_1 \pi_{-1} \]

4. Money supply identity:
   \[ M = k (R+D) \]

5. Export supply and unit value of exports equations:
   \[ \ln(X^{es}) = b_0 + b_1 (\ln PX^s (E+s)/P) + b_2 \ln(Y) + b_3 \text{EM} + b_4 \ln(X_{-1}) \]

6. Export demand equation:
   \[ \ln(X^{d}) = c_0 - c_1 \ln(PX^s / PW) + c_2 \ln(YW) + c_3 \ln(X_{-1}) \]

7. Import demand equation:
   \[ I = D_0 + D_1 (PM^s(E+t)/P) + D_2 Y + D_3 I_F + D_4 \text{EM} + D_5 ((X.PX^s + KI^s)/PM^s) + D_6 (R/PM^s)_{-1} + D_7 I_{-1} \]

8. Balance of payments identity:
   \[ R = R + X.PX^s - I.PM^s + KI^s \]
where

**Endogenous variables;**  
$P =$ Price level, $r =$ Rate of inflation, $M =$ Nominal money supply, $(M/P)^d =$ Desired real balances, $PX^s =$ Unit value of exports, $X =$ Export volume, $I =$ Import volume, $R =$ Net foreign assets in rupees.

**Exogenous variables;**  
$YM =$ Marketed output, $Y =$ Real national income, $YW =$ Real GNP of trading partners, $E =$ Exchange rate (Rs per US $1)$, $s =$ Unit export subsidies, $t =$ Unit import duties, $PW =$ World price level, $PM^s =$ Import unit value, $KI^s =$ net capital inflows, $I =$ Essential imports, $D =$ Net domestic assets of the RBI and $k =$ Money multiplier.