Macro Economic Models in Developing Countries

*Kamal Raj Dhungel**

Abstract

In seeking solutions for various planning and policy issues of economic development, quantitative tools have been used widely. Macro-models influenced by Keynesian income expenditure theory are often used to redress short-term stabilization problems, however, no consensus among policy makers in developing countries exists due to widespread differentiations remained in the socio-economic conditions and banking practices. On the basis of prevailing macro-economic conditions of the country, various models such as investment function, government investment expenditure, trade-imports and exports, industrial and agricultural sectors, services sector and models governing monetary aspects and revenue have been introduced. Most of the models include lag endogenous variable as an explanatory variable to capture the partial adjustments.

Introduction

Models are quantitative tools generally used by national planners to find solution for wide variety of economic planning and policy issues. In an economy where planned development exists, the input-output model is an essential tool for the determination of input to be used and output to be produced. The data required for input-output analysis is extremely a difficult task for a developing country like Nepal. Thus, the data base for input-output analysis can be generated through macro-econometric modelling. Macro-models are influenced by Keynesian income expenditure theory and therefore are applied to address short term stabilization problems. There is no unanimous concensus for the models to be used in developing countries. The overall models are often conflicting because of wide range of crucial aspects of developing economies such as the nature of financial markets, the degree of capital mobility, the firm and function of the exchange rate regime,

* Lecturer, Central Department of Economics, Tribhuvan University, Kirtipur, Kathmandu

the degree of wage price flexibility, expectations of forward looking and so on. (Haque: 1990)

The objectives of macro models for the short run and long run stabilization problems is to find the optimum size of investment, a tolerable rate of inflation, an acceptable ratio of deficit, a stipulated rate of growth of per capita consumption in order to increase the consumption level of poor people, a realistic level of foreign investments and to determine the optimum level of employment generation. This paper attempts to analyse the macro-models for various sector on an economy on the basis of aggregate demand and supply.

Specification of the Model

To achieve the goal of macro-models in developing countries, like Nepal, there is an urgent need to specify the models. Most of the developing countries are characterized by the absence of data base where the proper specification of macro-models requires the availability of data. Therefore, the models should also be specified according to the nature and pattern of economies of the particular country. For this reason, there are substantial disagreements over the general specification of such models as well as the orders and magnitude of certain key macro economic parameters.

Aggregate Demand Model

Verbally, aggregate demand is the sum of consumption, investment, government expenditure and trade balance. Mathematically,

$$Y_t = C_t + I_t + G_t + X_t - \frac{e^t P_t^* Z_t}{P_t} + \text{error.}$$

where, t = the time period,

Y_t = the real gross domestic product,
C_t = the real private consumption expenditure,
I_t = the real gross domestic investment expenditure,
G_t = real gross government expenditure on domestic goods,
X_t = the real export,
e^t = nominal exchange rate (price of foreign currency in domestic currency terms),
Z_t = real imports measured in terms of the foreign goods,
P_t^* = foreign currency price of imports,

P_t = domestic currency price of domestic output,

$\frac{e^t P_t^*}{P_t}$ = real exchange rate.

This aggregate demand model consists five exogenous variables of which one is the predetermined variable i.e. government expenditure G_t. The specification of other exogenous variables including government expenditure is as follows:

Consumption Function

The consumption function is devided into two major parts. Turning to the private consumption function, thus,

$$Pc_t = b0 + b1\, r_t + b2\, y_t^d + b3\, Pc_{t-1} + b4\, Y_{t-1}^d + \text{error}$$

where,

b_i = coefficient to be determined and (i = 0.1 ..... n),
r_t = domestic rate of interest,
Y_t^d = real disposable income.

This private consumption expenditure model includes the real rate of interest (r_t). This will provide the semi-elasticity of consumption measured by the parameter b_1. The other one period lag endogenous explanatory variable such as private consumption expenditure (Pc_{t-1}) provides Ratchet effect of lifecycle hypothesis, permanent income hypothesis and partial adjustment assumption. Similarly, the inclusion of one period lag disposable income as an endogenous explanatory variable provides a Blanchard hypothesis of finite horizons for private agents (see, Haque: 1988). The consumer disposable income, the key explanatory variable in the private consumption is identified to be GDP plus the earnings on net assets held abroad minus interest paid on domestic debt and taxes.

The second macro-econometric model for consumption function is the government expenditure which may be considered as the policy variables. But the developing countrie's government has no discretionary power to change the government consumption expenditure in the short run. Therefore, the endogenous variable GC (government consumption) is assumed to be affected by government revenue, foreign assistance and the inclusion of lagged endogenous variable here reflects Ratchet effect.

The equation of real government consumption be

$$GCt = \alpha_0 + \alpha_1\, GR_t + \alpha z\, GC_{t-1} + \alpha_3\, FA_t + e_I$$

where,

GC_t = real government consumption,

GR_t = real government revenue,

and FA_t = foreign assistance.

Investment Function

Before specifying the model for investment function, it is necessary to define what is capital stock. From the early period there are different types of interpretations for the stock of capital among economists. For some economists having interest in economic growth, capital is generally taken to mean the stock of produced means of production available to a firm or an economy at any point in time i.e., stock off fixed capital equipment – Apart from the above argument economists recently have increasingly developed special concept of capital and investment in rather different contexts. Social overhead capital refers to the road, bridges, port etc. which although not contributing directly to the production of output, but it provides the essential framework in which conventional economic activity can take place and facilitate investment. In this context, modelling in investment is rather difficult because the decision to invest in capital assets depends on expectations for the future. Haque suggested that the developing countries are characterized by the absence of data of capital stock. So, the adoption of linear formulation to avoid the absence of capital stock data by first differentiating the equation, thus,

$$I_t = K_0 + K_1\, r_t + K_2\, Y_t + K_3\, I_t - 1 + \text{error}.$$

where, I_t = investment,

r_t = real interest rate,

Y_t = real output.

Now, with first differences it becomes,

$$I_t = K_1\, (r_t - r_{t-1}) + K_2\, (Y_t - Y_{t-1}) + K_3\, I_{t-1}.$$

This transformation eliminates the capital stock available for which no developing countries data are available. The private investment expenditure model would assumed to be

$$P.I_t = \beta_o + \beta_1 GDP_{t-1} + \beta_2 r_t + \beta_3 BCR_t + error.$$

where,

PI_t = private investment expenditure,
GDP_t = real gross domestic product,
r_t = real interest rate,
BCR_t = bank credit to the private sector.

The inclusion of one period lagged of real gross domestic product captured the acceleration principle. Some of various empirical studies include the GDP as an explanatory variable.

Government Investment Expenditure

Economists refer to the government investment expenditure as the policy variable. In developing countries like Nepal, the development process has been accelerated through government investment. Unlike the government consumption expenditure, the government investment expenditure is much more under government discretionary control. The government investment expenditure is assumed to effect by the government revenue and foreign assistance. Thus the one of the possible equation for public investment is

$$GI_t = l_o + l_1 GR_t + l_2 FA_t + l_3 GDP_t - l_4 GI_{t-1} + error.$$

where,

GI_t = government ment expenditure,
GR_t = governmen ue,
FA_t = foreign assistance.

The inclusion of GDP and previous years public investment indicates that it captures acceleration principle and the influence of on-going projects for which commitments have already been made respectively.

The fourth and fifth components of aggregate demand function is the foreign sector. Turning to the export sector, exports are assumed to be a function of the real exchange rate and the level of real output and foreign income. Thus, the export function may be expressed in the form:

$$X_t = a_0 + a_1 \frac{e^t P_t^*}{P_t} + a2\, Y_t^* + a_3\, GDP_t + a_4\, X_{t-1} + \text{error}$$

Here, Y_t^* = foreign income.

The lagged dependent variable incorporates the practical adjustement and $a_1 > 0$, $a_2 > 0$.

Imports

Real imports are related negatively to the real exchange rate and positively to real domestic product. The imports are generally dependent on the level of economic activity and development projects, foreign aid and grants and the level of purchasing power. Again to capture the practical adjustment behaviour a lag import term is included in the estimated equation. Similarly, restricted foreign exchange availability frequently leads to the imposition of import control and foreign exchange rationing, which act as a constraint on imports in developing countries like Nepal. Therefore, the reserve import ratio is also often included in the regression.

Thus, the import equation can therefore be written as:

$$Z_t = \delta_0 + \delta_1 \frac{e^t P_t^*}{P_t} + \delta_2\, GDP_t + \delta_3 \frac{R_{t-1}}{P_{t-1}^* Z_{t-1}} + \delta_4\, Z_{t-1} + \text{error.}$$

where, R_t = foreign exchange value of international reserves.

Aggregate Supply Model

Let us consider the Cobb-Douglas production function relating labour and capital to output.

$$Y_t = \alpha_0\, K^{\alpha 1}\, L^{\alpha 2}$$

where, K and L are the measures of the aggregate capital stock and labour respectively and α_1 and α_2 are coefficients to be estimated. In under developed countries like Nepal, the estimation of the supply side of the model is hampered by the shortage of data on aggregate capital stock. Therefore, Haque adopted the following procedure.

Now taking the difference equation

$$K_t = (1 - \delta)\, K_{t-1} + I_t$$

where δ is the rate of depreciation

Taking log in both sides we get,

$$\text{Log } Kt = \log\left[\sum_{i=0}^{t-1} (1 - \delta)^i\, I_{t-1} + (1 - \delta)^t\, K_o\right]$$

where K_o is the initial capital stock.

Adopting the log approximation, we obtain,

$$\text{Log } K_t = \log_2 + \frac{1}{2}\left[\log \sum_{i=0}^{t-1} (1 - \delta)^i\, I_{t-1} + \log\,(1 - \delta)^t\, K_o\right]$$

$$= \log_2 + \frac{1}{2}\log \sum_{i=0}^{t-1} (1 - \delta)^i\, I_{t-1} + \frac{t}{2}\log\,(1 - \delta) + \frac{1}{2}\log K_o$$

Thus, $\log Y_t = \log \alpha_0 + \qquad K_t + \alpha_2 \log L_t$

$$\log Y_t = \log \alpha_0 + \text{[illegible]}\, 2 + \frac{1}{2}\log \sum_{i=0}^{t-1} (1 - \delta) i\, I_{t-i} + \frac{t}{2}\log\,(1 - \delta)$$

$$+ \log Ko] + \alpha_2 \log L$$

The equation can be estimated for different values of δ over the internal (0, 1). By assuming constant returns to scale, the above equation can be written with the assumption of complete wage price flexibility where the price wage flexibility in developing countries is an unsettled question. So, under this circumstances, the following empirical production function with lagged adjustment and technical progress over time as additional explanatory variables in per capita terms represents the economy's supply function.

$$\log\,[Y/L] = \log \alpha_0 + \alpha_1\left[\log 2 + \frac{1}{2}\log \sum_{i=0}^{t-1} (1 - \delta) i\, I_{t-1} + \frac{t}{2}\ \log\,(1 - \delta) + \frac{1}{2}\log K_o\right]$$

$$+ \log L_t + gt + \alpha_3 \log\,(Y/L)_{t-1} + \text{error}$$

The Nepalese Perspective

Agricultural Sector

Using the Cobb-Douglas type production function the model for agricultural sector is assumed to take real value added in this sector. Thus, the model be expressed as

$$\text{Log } VAA_t = a_0 + a_1 \log LAEA_t + a_2 \log GCL_t + a_3 \log PIL_t + \text{error.}$$

where,

VAA = value added in agriculture,
LAEA = Labour employed in agriculture,
GCL = Gross cultivated land, and
PIL = Proportion of irrigated land.

Industrial Sector

Nepalese economy is still behind in the development of industrial sector. There are some industries which contribute small proportion of total output and employment. Most industries, are agro-based. So, to analyse the effect on industrial sector, the agricultural production is added in order to reflect the dependence of agro-based industries on agricultural inputs. Thus, the model for industrial sector would assumed to be,

$$\text{Log } VAIST = b_0 + b_1 \text{ Log } LFIST + b_2 \log KSISt + b_3 \log AGDP_t + \text{error.}$$

where,

$VAIS_t$ = Value added in industrial sector,
$LFIS_t$ = Labour force in industrial sector,
$KSIS_t$ = Capital stock in industrial sector,
$AGDP_t$ = Agricultural gross domestic product.

Social Service Sector

In this sector, the Cobb-Douglas type production function is assumed to be

$$\text{Log } VAS_t = C_o + C_1 \log LS_t + C_2 \log KS_t + C_3 GDP_t + \text{error.}$$

where,

BAS_t = Value added in social services,

LS = Labour force in social services,
KS = Capital stock in social services.

In short, when modelling for Nepalese economy, the production block tentatively will have the eight major sectors. They can be modelled as.

$VA_X = f(x - i)$

where, VA_X = Value added in Xth sector,
x_i = Cumulative investment in Xth sector,
i = log period and,
X = Agricultural,
= construction,
= manufacturing and mining,
= Social services,
= Finance, real estates and dwelling,
= Transport and communication,
= Trade and restaurant,
= Electricity, gas and water.

Money Supply an Prices Block

The supply of money in the economy consists of reserves and domestic credit. The money supply function is dependent on the domestic credit, government fiscal deficit and foreign exchange reserves. In dealing with the money supply and prices block there are four major empirical model to be used for Nepalese economy.

1. $MS_t = a_0 + a_1 DC_t + a_2 GD_{t-1} + a_3 FER$ + error.
   where MSt = Money supply,
   DC_t = Domestic Credit,
   GD_t = Government fiscal deficit,
   FER = Foreign exchange reserves.

2. $AGDP_t = b_0 + b_1 MS_t + b_2 IMPI_{t-1}$ + error
   where, $AGDP_t$ = Agricultural GDP deflator,
   $IMPI_t$ = Import price index.

3. $NAGDPD_t = C_0 + C_1 MS_t + IMPI_{t-1}$ + error,
   where, NAGDPD = Non-agricultural GDP deflator.

4. $CPIT_t = d_0 + d_1$ $AGDPD_t + d_2$ $NAGDPD_t$ + error,
where, CPI = Consumer price index.

Now turning to the money demand function, the demand for money is taken to be related negatively to the nominal rate of interest and positively to the level of income. Thus,

$$\text{Log}\,(M_t/P_t) = \alpha_0 + \alpha_1\, i_t + \alpha_2 \log Y_t + \alpha_3 \log Y_{t-1} + \alpha_4 \log \frac{M_{t-1}}{P_{t-1}} + \text{error}$$

where $\frac{M_t}{P_t}$ = Demand for money,

i_t = Nominal interest rate.

The lagged term in Y allows for different speeds of adjustment of the demand for money to changes in interest rates and income.

The Government Revenue Block

The main sources of government revenue are the tax as well as non tax revenue. These sources are divided into six major headings. The models to be used in government revenue are as follows:

1. $IT_t = a_0 + a_1$ $VAM_t + a_2$ $GDP_t + a_3$ IT_{t-1} + error

   where, IT = Income tax revenue,
   VAM = Value added in manufacturing.

The inclusion of endogenous variable as an explanatory variable one period lag to capture the partial adjustment responses.

2. $EXD_t = b_0 + b_1$ $VAM_t + b_2$ GDP_t + error
where EXD_t = Excise duties.

3. $TAD_t = C_0 + C_1 + IMG_t + C_2$ TAD_{t-1} + error
where, TAD = Tariff duties,
IMG = Import of goods.

4. $SAT_t = d_0 + d_1$ $NAGDP_t + d_2$ SAT_{t-1} + error
where, SAT = Sales tax revenue.

5. $NTR = \alpha_0 + \alpha_1 \, NAGDP_t + error$
   where NTR = non-tax revenue.

6. $AGT_t = \beta_0 + \beta_1 \, TCA_t + error$
   where, AGT = Agricultural tax,
   TCA = Total cultivated land.

Labour Employment Block

There are tentatively nine sectors where the total labour force is engaged. The functional relationship between employment and these sector can be expressed.

$$LX = f\,(VAX)$$

where, LX = Employment in Xth sector
VAX = Value added in Xth sector
X = Agriculture,
= Manufacturing and mining,
= Construction,
= Tourism,
= Transportation and communications,
= Trade Hotel and restaurant,
= Electricity and gas,
= Finance, real estate and dwelling,
= Social services.

Validation of the Model

The estimates obtained from OLS are examined by the R^2, DW, F and t statistics which gives the statistical significance of the OLS estimates of the single equation model. But in the simultaneous equation system, it is necessary to evaluate the fitness of the multiequation model which is a precondition for examining the forecasting ability of the model. The application of OLS in the multi equation model provides the inconsistent, bias and inefficient estimates. So, it is necessary to apply ILS method for the exactly identified simultaneous equation and 2SLS and 3 SLS for the overidentified simultaneous equation. For the accuracy of the estimates which are estimated from the ILS, 2 SLS and 3 SLS the Cocrane-Orcutt iterative method and DW statistics are not the proper statistics to be used for the evaluation of accuracy of forecasts. Therefore, there are most common methods of perspective accuracy that have been used in the literature are Theil's Inequality Coefficient, Mean square Error MSE and Root Mean Square Error RMSE.

Theil's Index

A systematic measure of the accuracy of forecasts of the above econometric models has been suggested by Henry Theil. This measure is called the inequality coefficient and is defined by the expression

$$U^2 = \frac{\Sigma (P_i - A_i)/n}{\Sigma ai^2/n}$$

where, Pi = predicted change in the dependent variable

Ai = Actual change with dependent variable. The smaller the value of the inequality coefficient better will be the fit of the simulation. The value of U ranges from zero to infinity.

MSE and RMSE

The accuracy of the predictive performance where the purpose of the model is conditional prediction, the choice of technique has been based on the predictive performance of the estimates obtained from the various techniques. When attempting the ranking of the technique the most common measure of the forecasting performance has been the mean square error of the forecast or its square root. Thus,

$$MSE = \frac{\Sigma(F_i - A_i)^2}{n}$$

$$\text{and RMSE} = \sqrt{\frac{\Sigma (F_i - A_i)^2}{n}}$$

The accuracy of the aforesaid model can be evaluated by using above three indices.

Conclusion

This paper attempted to fill a void in empirical Nepalese macro-economics. Most of the models include lag endogenous variable as an explanatory variable in order to capture the partial adjustment. The application of OLS in such circumstances, will provide an inaccurate, inconsistent and bias estimates. So, the suitable method to estimate the parameters stated in the models in simultaneous equation method. By the application of this method the accuracy or forecasts can be judged by using Thiels inequality index and Root Mean Square error as defined in the text.

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