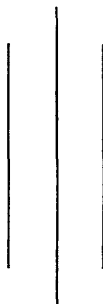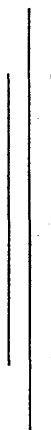# Application of Mathematical and Econometric Tools in Macro-Economic Analysis in Nepal

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A Resume

The analysis of economic policy has evolved through the interaction between economic theories and their application to specific country problems. In this process, there has been a shift from planning technique to models that simulate functioning of mixed or market economies in which policies are implemented largely through market mechanisms. The basic economic problem as we understand is of resources allocation - what to produce, how to produce and for whom to produce? Early formulation and analysis of this problem was through the input-output and linear programming planning models. However with economic liberalization taking place all over the globe, analysis of economic problem from the view point of a planner able to determine the optimal allocation of resources in a centrally planned economy has shifted to modelling the market mechanism where resources are allocated through price incentives. The computable general equilibrium (CGE) model is pioneering work in this direction. The CGE establishes a more structured framework for applied economic model of multi-sector analysis away from static input-output models with fixed prices to dynamic models with endogenous price determination and elaborate treatment of trade and income distribution. The CGE models are applicable to the analysis of policy issues of growth and structural change, foreign exchange regime and income distribution as well. The objective of this paper is to review these models in the context of solving basic economic problems and analyzing policy issues in the context of Nepal.

Econometric modelling has evolved as an alternative instrument of economic policy analysis. Rather than resource allocation and growth oriented mathematical models just the like discussed above, econometric models are stabilization oriented and give a framework for consistent policy making in the spectrum of growth, inflation, debt, balance of payment and exchange rate. We understand that there are trades-off between these macro objectives, and macro models can be helpful to make economic policies which provide the highest possible growth and employment without deteriorating the price, debt and external sector situation. This paper also attempts to discuss some of the issues related with macro econometric modeling and its application for economic policy analysis in Nepal.

Application of Mathematical and Econometric Tools in Macro-Economic Analysis in Nepal

1. Introduction

1.1 Nepal is a small, mountaineous, and landlocked country with an area of 147 thousand square kilometers and population of nearly 21 million. The country falls among the least developed nations of the world with per capita income of merely 200 U.S. dollars. Difficult terrain with high ranging Himalayas to a narrow strip of plain land, the geo-physical diversity has been both the virtue and vice for the country's development. Virtue in the sense that steep terrain with a number of large rivers originating from the Himalayas has provided immense hydro potential, and geo-physical diversity has been a centre of tourist attraction. Vice in the sense that limited land is available for cultivation and infrastructure development is highly expensive. The country rectangular in shape stretching from East to West is still not completely integrated horizontally. The mobility of people and resources is normally from North to South bordering India. Fragmented national economy with free access to India for the mobility of labour, capital and commodities has strongly linked Nepalese economy with India. As we shall be discussing later on, the geo-physical setting has a significant bearing on economic management and for that matter in economy-wide modelling as well.

1.2 About half of the Nepalese people are illiterate and illiteracy is more concentrated among women as only a quarter of the female population is literate. Among the literates also, those who have graduated high school level of education are only 10 percent of the total population. The country has limited number of universities for higher education. No university exists for specialization in science and technology. The department of mathematics is usually the smallest department in Tribhuvan University, the only university having any faculty for mathematics. The limited mathematical background of the university graduates in social science and commerce constrains the application of mathematical tools in empirical economic and business analysis.

1.3 Recently, econometrics has evolved as a popular tool to economic analysis and forecasting, although some of the mathematical tools like input-output analysis, linear programming and computable general equilibrium analysis are also applied in micro and macro analysis of the Nepalese economy. Such analyses are normally done with the initiatives of donor institutions like the World Bank and the Asian Development Bank along with other U.N. agencies like UNDP and ESCAP. Before discussing the mathematical and econometric tools applied in economic management in Nepal, the following section briefly introduces the structure of the Nepalese economy and the reform measures introduced so far.

2. The Economy

2.1 Nepalese economy is basically agrarian. Agriculture alone contributes nearly half of the country's gross domestic product, 80 percent of the employment, and means of livelihood to a vast majority of the households. The country's gross domestic product grew by 5 percent, on an average, during the last decade whereas population also grew by 2.1 percent during the same period resulting in a less than 3 percent growth in per capita income. Rain fed agriculture, nascent industrial sector, and slowly expanding service sector are all responsible for slower growth rate of the economy. Poor natural endowment, landlockedness resulting in high transportation cost and lack of capital and technology have hindered Nepal's scope for higher economic growth. The country's only potential resources are water and human resources which if harnessed would contribute to higher growth and development of the country.

2.2 Nepal started planned development effort since later 1950's and then onwards Japan took a lot of interest in Nepal's economic development. Today Japan stands as the largest donor to Nepal for development activities ranging from infrastructure development to economic and social services. As a result, 'Japan' has become a very popular and respected word to every Nepalese. This very strong bond of friendship has paved way for us to be together at this moment and share our experiences to each other. I take this forum as an opportunity to know each other more closely and strengthen our cordial relationship in the country level as well as at the institutional level.

2.3 Nepal initiated economic liberalization and structural reforms since mid 1980's. To start with, the financial system was liberalized by inviting private sector and foreign banks to establish commercial banks and finance companies. The interest rate was set free to market forces and financial institutions were made almost free for managing their portfolio. In the industrial and external trade sectors, massive reform measures were introduced since early 1990's with delicensing of industries and full convertibility of the Nepalese rupee on the current account. In the fiscal sector, government spending was reoriented to the social sector and more than a dozen public enterprises were privatized. A few enterprises were either liquidated or merged. The government intends to privatize another two dozen enterprises in a few years' time.

2.4 At the resources front, tax structure was streamlined by prunning down tax rates, reducing number of tax slab and simplying tax administration. Foreign investment was encouraged in the country by providing various tax incentives and foreign exchange facilities along with introducing 'one window' system for completing bureaucratic procedures for foreign investment projects. A Hydropower Development Act has been enacted providing various incentives for foreign investment in hydropower projects. As a response, quite a few large power companies have shown interest in harnessing the vast hydropower potential of the country. Initiatives have also been taken to develop Kathmandu as an international financial centre to facilitate capital flow.

3. Data Constraints for Mathematical and Econometric Model Building

3.1 The data base of the Nepalese economy is very narrow and time series very short. Gross Domestic Product (GDP) figures are available from 1965 onwards with nine sub-sectors as the sources and four sub-sectors as the uses of GDP. Frequent revision in GDP series and changing bases with no corresponding backward adjustments has led to broken GDP series itself with a degree of unreliability on it. The sources of GDP are at current prices only in the absence of GDP deflators for each of the sub-sectors or sources. In the uses side also, there are no investment, export and import price deflators. The consumption deflator is also proximated by urban consumer's price index, the only price index available for measuring inflation. Total consumption and investment can be broadly classified into public and

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private only. The consumption and investment demand of government enterprises come up into public sector demand and no separate information for this sector exists. The private sector demand is highly aggregative as it can not be decomposed into household and business sector demands. For that matter, the consumption and investment demand of these sectors is unknown.

3.2 The absence of flow of funds account is also due to unavailability of the segregated data for each sectors of the economy. Recent attempts to build flow of fund account are also in aggregative term; the flow of resources is chalked out among government, government enterprises, financial sector, rest of the world and private sector as a whole as a residual. The information on government enterprises is also incomplete and updated figures for their transactions are missing.

3.3 One important area where information is lacking is labour force participation and unemployment situation. There is census in each 10 years' time and information on these issues is obtained. But the situation remains unknown till next census. Income distribution and consumption patterns are also known in a long time gap, as surveys purported to collect information in these areas are very infrequent.

3.4 The financial sector information is normally available with no significant time lag. However, the information is available in a scattered form, as no consolidated financial sector balance sheet of the sort of Financial Survey is yet compiled. In the external sector, trade figures are available in value terms only, but not in volume. The capital account transaction is highly aggregative as it can be decomposed into official and private capital only. No separate information on foreign direct investment, short-term credit and portfolio investment is available from the current balance of payments statistics. As there are no export and import indices, the external terms of trade of the country is unknown.

3.5 More importantly, there is problem in the frequency of data. GDP figures are available on annual basis, no quarterly or monthly series are available. Since GDP figures are not available in monthly or quarterly basis, any mathematical or econometric analysis of the economic relationship that includes GDP as one of the variables has to confine with annual analysis. The availability of monetary, fiscal and external sector data in monthly form

has no meaningful use unless real sector data like income and employment are also available in the same frequency.

3.6 In essence, the application of mathematical and econometric tools for macroeconomic analysis of the Nepalese economy is highly constrained by paucity of information and data set. This is also why input-output, computable general equilibrium and linear programming models of economic analysis are very remotely applied in the management of the Nepalese economy.

4. Macro-econometric Model

4.1 There has been a tremendous development in the field of macro economic modelling and forecasting during the last decades. In particular, econometric modelling has been the basis for policy preparation and decision making for policy makers. The introduction of powerful computer technology and user-friendly softwares has paved the way for further application of this tool in economic decision making and forecasting. In an econometric model, the modeller tries to formalize the economic relations in a mathematical way. A model consists of a set of equations, a relatively large number of equations when it is a 'structural model' and only a few equations when it is a 'reduced-form model'. In either case, the standard rule for mathematical economic modelling is that the number of unknown variables should be less than or equal the number of equations.

4.2 Regarding the application of econometric models for macro economic analysis of the Nepalese economy, the economy can be broadly classified into real , monetary , fiscal and the external sectors. For real sector analysis, real gross domestic product can be estimated with a simple equation where lagged gross domestic product appears as the only explanatory variable. The Cobb-Doglas type of production function can not be applied for estimating aggregate production just because there is no any information on employment and capital stock. Investment can be specified as a function of interest rate, one period lagged income (working through the acceleration principle), and proposed government expenditure. The determinants of exports and imports of goods and non-factor services can be specified as a function of income, relative prices and exchange rate. Consumption can be estimated as a residual after the estimation of gross domestic product (or income), investment, and exports and imports of goods and non-factor services.

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4.3   In the monetary side, demand for real money can be estimated as a function of real income and interest rate. Demand for currency and demand deposits is specified as a function of income, interest rate, the share of agricultural GDP to aggregate GDP and some proximate indicator of financial deepening. Money supply can be derived as an identify by summing up estimated currency and demand deposits.

4.4   The price equation is specified in an open economy framework where domestic prices are affected by foreign prices and exchange rate along with domestic factors like money supply growth in excess of output growth and fiscal policy stance.

4.5   In the fiscal sector, the size of government expenditure is arrived at through independent estimation of the sources of expenditure. Tax revenue is supposed to be determined by non-agricultural income and average tax rates whereas non-tax revenue is taken as a function of one period lagged non-tax revenue. Foreign aid is estimated as trend determined. Bank borrowing of the government comes from the monetary sector model whereas non-bank borrowing of the government is affected by interest rate and gross domestic savings. The sum of all the sources of financing of government expenditure gives the estimated size of government expenditure which in turn affects the real sector through investment function.

4.6   The macro economic analysis and projections in Nepal have also been done with the help of Revised Minimum Standard Model (RMSM) of the Fund - Bank type. The RMSM model consists of three sectors namely national accounts, balance of payments, and public debt. The model is designed to attain the desired macroeconomic conditions like sustained moderate/high GDP growth, adequate investment/GDP ratio, sustainable current account deficit, low/moderate foreign debt service ratio, adequate foreign exchange reserves, low government budget deficit, low inflation, and stable/competitive exchange rate.

4.7   The limitation of such a model is that the estimation of GDP is based on historic growth trend and no production function is applied for its estimation. So is the case with exports (of goods and non-factor services). Imports are however estimated with the help of lagged imports and two parameters estimated outside the model - the growth rate of the GDP and the import elasticity of GDP. Investment is estimated as the product of

change in GDP and incremental capital output ratio (ICOR). Consumption is residually estimated in this model after deriving the sources and uses of GDP (except for consumption).

4.8 In the balance of payments front, current account balance is derived by estimating export and import functions as mentioned earlier and taking net transfer as exogenous item. In the capital account, official capital flow is derived by taking grants and loans as exogenous and private capital flows derived as residual from the information on current account balance, official capital and foreign exchange reserves situation (derived with exogenous information on required foreign exchange reserves ratio and imports of goods and non-factor services).

4.9 A modified version of the RMSM has recently been developed by the World Bank Office in Nepal. A broader macro model is in preparation with the initiative of the National Planning Commission. International organizations like Asian Development Bank and ESCAP have also developed macro-models of the Nepalese economy for their own purpose.

4.10 Besides, sectoral models have been developed by other institutions and economists for specific purposes. Nepal Rastra Bank, the central bank of Nepal, estimates financial sector behavioral equations for projecting monetary aggregates, credit flows, prices and the balance of payments situation. As the major task assigned to the central bank is economic stabilization, the focus of Nepal Rastra Bank econometric modelling is also towards developing a stabilization model rather than a growth model. The stabilization model tries to capture the effect of demand shocks emanating from the fiscal, monetary and exchange rate fronts of the economy and their effects on domestic prices, interest rates, balance of payments, and exchange rate.

4.11 Empirical evidence derived from the estimation of stabilization type of macro models exhibits fiscal and monetary shocks reflected in the balance of payments situation of the country and exchange rate shocks absorbed by prices rather than by the balance of payments. This is quite expected for an open economy like Nepal where excess demand generated through monetary and fiscal expansion is outrightly reflected in imports from India, an easily accessible market for Nepalese consumers, and subsequently on trade and balance of payments deficit. On the otherhand, as domestic prices are highly affected by foreign prices and the exchange rate of domestic

currency vis-a-vis foreign currencies, any change in the exchange rate has a significant bearing on domestic price level.

4.12 It can be observed from econometric estimation of the export and import functions that although exports are to some extent sensitive to exchange rate changes, imports are very little affected by the same. The sum of the absolute values of import and export elasticities is less than unity which doesnot meet the Marshall-lerner condition for the effectiveness of exchange rate policy in correcting trade and payment imbalances. (The Marshall-lerner condition states that for devaluation to be an effective instrument of balance of payments correction, sum of the absolute values of import and export elasticities with respect to exchange rate should exceed unity).

4.13 Macro-econometric modelling has also been exercised for economic growth and allocation of resources purpose. The Eighth Development Plan (1992-97) was formulated with a great deal of macro-econometric exercise to workout background information for the plan and implications of the plan programmes for the economy. The parameters estimated through macro-econometric models were also used for projecting growth investment requirement, and financing sources of the Eighth Plan.

5. Input-Output Model

5.1 The edge of input-output model over macro-economic models is that it takes care of the intermediate goods whereas national accounts analysis and macro models based on such national accounts tend to leave them out. The static input-output model has provided the starting point for all multisector planning models. Underlying any economic analysis, development of accounting methods is necessary. Development of Social Accounting Matrix (SAM) is a landmark step in this regard. There are three features of an accounting system: (i) what are the economic institutions or actors that are to be included, (ii) what are the markets that are to be included in the accounting framework, and (iii) what are the behavioral or technical assumptions that underlie the accounting process. These features vary according to the nature of the economy, whether it is open or closed and whether it is a market economy or a centrally planned.

5.2 The basic closed economy input-output model where production in any sector is given by the sum of technological coefficients times the flow of

intermediate goods from other sectors to that sector plus the final demand[1] for that product can be extended to open economy model where imports add up to the production vector and exports add up to final demand sector. This extension however implicitly assumes imports as perfect substitutes to domestic products. Further, fixed coefficient technology assumed in the basic model can also be modified by introducing technological change in the model.

5.3   There has been very little application of input-output model for economic analysis in Nepal. All that has been done in this area is in the context of formulating the country's Eighth Plan (1992-97). In that context, input-output analysis was done of the manufacturing and some of the services sector. An interesting result that was derived from the study was very high input-output coefficient for most of the products. The study estimated firm level input-output coefficients for import intensive products to the tune of 0.78 for plastic goods, 0.82 for synthetic textile, 0.88 for iron and steel and as high as 0.98 for vegetable ghee. This revealed very low degree of value added in these industries and subsequently demanded revisions in the then existing industrial policy.

6.   Linear Programming Models

6.1   Unlike input-output models which are just consistency models having no endogenous mechanism of choice among alternative feasible scenarios, linear programming models provide a great deal of flexibility into basic input-output structure. This is possible through introducing inequality constraints and encompassing the explicit optimization of the planner's preference function into economy wide planning models. Optimization entails the possibility of choice which in turn implies that the feasible set defined by the mathematical relationship constituting the planning model has alternative solutions. Once we talk about 'choice', it may be mentioned that the very discipline of economics revolves around scarcity of resources

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[1]   The modelling framework uses the following material balance equation as the fundamental input-output relation:

$$X = AX + F$$

where X the vector of total demand for goods, A is the inter-industry input-output coefficient matrix, F is the vector of final demand –consumption and investment.

and their alternative uses. In real life, wants are unlimited but supply of resources to meet these wants is limited, i.e., they are scarce; the scarce resources have alternative uses implying that the problem of choice is implicit there. And, use of mathematical tools like linear programming is necessary for optimal allocation of those scarce resources so as to maximize returns.

6.2   The linear programming model has been applied for both macro-economic and micro-economic exercises. The advantage of linear programming model is that one can add or subtract equations and constraints from a given model depending upon the nature of the economy. However, such a flexibility may also create problem in modelling just because of ad hoc addition or subtraction of constraints on the prior biases of the model builder.

6.3   The application of linear programming model for economic analysis ranges from determining the direction and volume of trade to allocating investible fund or managing the portfolio of the financial institutions. Linear programming model has also been used for environment management such as how to reduce air pollution subject to constraints like fuel intensity of gross domestic products, costs associated with pollution-neutral fuel, and financial and technological barriers in reducing industrial emissions and particulate matters.

6.4   Recently, a bottom-up dynamic linear programming energy model known as MARKAL (Market Allocation) model has been introduced for addressing environmental issues, mainly the air pollution mitigation. MARKAL yields not only information about pollution abatement costs but also technological details about how pollution mitigation targets could be attained. Beside the environmental issue, MARKAL model can also be applied for least cost planning and integrated resource management which so far has not been adopted in Nepal.

6.5   The application of linear programming models is very much limited in macro economic management in Nepal. This model is normally applied by the financial institutions to maximize their profit subject to various regulatory constraints imposed by the central bank and the market condition. The regulatory constraints are statutory cash reserve requirement, directed credit programmes such as the 'priority sector' and 'deprived' sector lending requirements, the size of economic activities and

resources base of the financial institutions. Application of linear programming model in the portfolio analysis of the financial institution has turned out very fruitful.

7. Computable General Equilibrium (CGE) Model

7.1 CGE model also adopts optimization techniques, permitting a choice among alternatives. This solves endogenously for prices and contain feed back mechanisms whereby these prices have an impact on other solution variables. In this process, CGE model incorporates the fundamental general equilibrium links among the production structure, income and demand in an economy. Multi-sector CGE models are adopted for analysing the impact of government policies such as trade, exchange rate, taxes, subsidies, and tariffs, and other macro-economic policies on economic activities in the business, household as well as external sectors of the economy. In fact, CGE models simulate the working of market economies and the circular flow of income or resources between different sectors of the economy.

7.2 The organizing framework of a Social Accounting Matrix (SAM) is helpful to provide unified set of accounts, particularly, the flow of funds in a market economy. The SAM presents national accounts data in a consistent format, identifying the funds-flow among various sectors of the economy. General equilibrium analysis is normally based on this SAM and is characterised by a set of relative prices, initial endowments and levels of production such that demand is equal to supply in all the markets - product or factor. The equilibrium would continue unless exogenous changes like foreign prices, exchange rate, and government policies alter relative prices and induce resources to be reallocated. The CGE model not only simulates the responses of various sectors to changes in relative prices but also estimates the set of relative prices necessary for restoring equilibrium in all the markets.

7.3 Multi-sector CGE models are normally based upon input-output or linear programming analysis. Although input-output is normally a real sector analysis, CGE analysis can explicitly incorporate macroeconomic relationships such as the balance of payments, the government budget, or the saving investment gap. However, monetary sector analysis is unsuitable with CGE model, as the latter works through relative prices only whereas monetary variables are nominal ones. It may be mentioned in this regard that the central bankers are more inclined to econometric modelling

rather than to input-output or CGE modelling just because predicting movements in the monetary variables is more suitable with statistical tools rather than with the mathematical tools.

7.4 By simulating the variables determining the working of markets, CGE models can assess the impact of exogenous policy variables such as the government tax and subsidy, exchange rate and foreign capital inflow on overall economic activities. These policy variables often alter relative prices, encourage resources into activities which in fact may not be most efficient. When policy intervention induces relative price distortions and guides resources towards less efficient areas or sectors of the economy, structural reforms are warranted. Multi-sector CGE models can help to identify such distortions and reveal whether the desired sectors are benefitted by the policy measure or not. Such models also can project the growth rates that would occur if markets function most efficiently. Thus CGE models help to analyse how an economy would react and grow in response to different policy reform measures.

7.5 In fact macro-econometric and CGE models are complementary to each other. Both of these models hint how an economy is likely to behave with a change in the given set of exogenous variables. However, neither can provide perfect foresight of the future economy. The shift in economic relationship and unpredictability of the exogenous variables result in such an uncertainty. Furthermore, macro-econometric forecasts are heavily dependent upon the stability of the underlying relationship over time for which projections are made. Thus projections done with these models should be treated as indicative. Nevertheless CGE models can best be used for analysing the reaction of the overall economy to any policy shock whereas macro-econometric models can be used for medium term forecasts.

7.6 The first application of CGE model to the analysis of the Nepalese economy was in the industrial sector study in late 1980's. The study aimed at analysing the impact of planned and proposed policy changes on the economy, designing action programmes for the implementation of industrial and trade policies and identifying requirements for sub-sector restructuring. For this purpose, the model identified world economic growth, foreign aid, remittances, tourism demand and government regular expenditure as exogenous variables. The study was conducted at a time when there was trade and transit impasse with India, Nepal's major partner

for trade and other economic relationship. In this context, the study analysed two main scenarios - one with continued trade and transit impasse with Indian and the other with renewed trade and transit treaty.

7.7 Regarding first scenario, when special trade relationship with India ceased to exist and India introduced Most Favoured Nation (MFN) status for trade with Nepal, the imposition of third country tariff rates on imports from India and introduction of higher tariff rates on Nepalese exports by India was simulated. The result was an increase in domestic production twice as large as the decrease in imports, reflecting the degree of substitutability between Indian and Nepali goods. On the whole, increase in protection allowed domestic products to substitute Indian imports leading to higher GDP growth.

7.8 In the second scenario, the reintroduction of trade and transit treaty was assumed and simulation done by taking different tariff rates into consideration. The simulation revealed a lower growth rate of the economy in the short-run. However, positive long run effects of lower tariff rates effected by renewed trade treaty were observed through more efficient allocation of resources. Policy reforms such as reduction in tariff rates, delicensing, free float of the exchange rate etc. were observed to exert long run beneficial effects on industrial efficiency, growth, efforts and employment. Adoption of these reform measures in the 1990's has in fact manifested signs of improvement in the Nepalese economy.

7.9 Efforts are also made to develop general equilibrium model for Nepal in regionally disaggregated form. In this model, the spatial equilibrium problem has been handled by introducing transportation network. The Nepalese economy being fragmented in a small number of regional economies engaged in mutual trade flowing through the existing transport (road) network having strong rural - urban differences and no sufficient transport facilities, the application of standard CGE model is supposed to be less practicable. That is why spatial disaggregation in the CGE model was done and models for regional subeconomies linked into a national model. To this end, a transportation section was introduced at the national level.

8. Concluding Remarks

8.1 The application of mathematical and econometric tools in the analysis of the Nepalese economy is limited due to factors like the data base, technical

knowledge and the low receptiveness. The most popular type of empirical economic analysis is econometric modelling. The donor communities and policy making institutions like the National Planning Commission and Nepal Rastra Bank, have been increasingly basing their resource allocation and economic decision - making on the empirical relationships or parameters derived from econometric modelling. That the use of computers has expanded and softwares for such modelling are accessible also has widened the popularity of such modelling.

8.2 Mathematical models such as input-output, linear programming and computable general equilibrium models are limited in use. The softwares for such modelling are either not easily available in the Nepalese market or experts for their use are limited. With technical assistance from the donor communities, such tools are supposed to be popularised in future course of time.