Macro Modeling Practices at Nepal Rastra Bank[#]

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Abstract

This paper presents a brief survey of macroeconomic models of Nepal. It also empirically investigates sectoral models of macroeconomic variables including inflation, monetary aggregate, fiscal and external sector upon which policymakers' concern rests during the process of monetary policy formulation. Sample period of 1975 to 2016 is used for the estimation. The Data Generating Process (DGP) identified in this paper for the variables of interest meets necessary criteria both from theory and empirical ground. These models are useful to understand general relationship from sectoral perspective and to carryout simple forecasting for making monetary and other macroeconomic policy decisions.

Keywords: Macromodels, Sectoral Models, Inflation, Money Demand, Elasticity and Buoyancy, Export-import Elasticity

JEL Classification: C22, E31, E41, F14, H20

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I. INTRODUCTION

Nepal Rastra Bank (NRB) involves in formulation of monetary policy as well as regulation and supervision of banks and financial institutions (BFIs). These policy actions of NRB are in align with Bank's multiple objectives of maintaining price and external sector stability, promoting financial stability and supporting economic growth. Decision-making process of monetary policy depends on forward-looking perspective as the effect of policy on an economy lags behind (Coletti and Murchison, 2002). NRB uses economic models along with intuitive judgment to understand expected future value of variables before making policy decision.

Forecast of the variables could be judgmental, guesswork or model based. Forecasting based on judgment (uses personal knowledge, experience and information) might be more debatable and less reliable. Judgmental forecast do not capture all available information as well as they have less theoretical and empirical backups. Policymakers, instead, prefer model-based forecast (uses data, information, assumptions, behavioral relationships, statistical methods) which utilizes set of available information by establishing the relationship of economic variables. Model-based forecast has theoretical foundation so as to become more reliable and less controversial. Forecasts based on model, however, may not fully describe reality. Shaping model-based forecasts by judgment of experts can capture a broad range of information (Westaway, 1999).

Economic models are valuable tools for monetary policymakers for a number of reasons. Monetary policymakers use models to obtain forecasts of variables as any action or inaction of monetary policy depends on how future will unfold. Such a forward-looking decision emanates mainly from recognition, decision and action lags of the effects of monetary policy. Policymakers use model to understand the uncertainty that central bankers face on policy making. The uncertainty arises partly because policymakers do not know the true model of the economy and partly because they do not know what the expectations and reactions of economic agents will be. A clear and practical economic model can communicate with the public which is capable of anchoring expectations around the desired outcome (Taylor, 1997).

II. MODELING IN CENTRAL BANKS

Central banks, in their monetary policy conduct as well as for other decision-making process, make forecasts and projections based on information of economic and corporate activities as well as developments in financial markets. Central banks develop various types of macroeconomic models for forecasting and policy simulation according to the purpose of research. Modeling category comprises of macroeconometric models that are built with structural equations, calibrated dynamic stochastic general equilibrium (DSGE) model based on micro-foundation and Vector Autoregressions (VARs) models relying more on data and statistics. In collaboration with academic researchers, central banks in their policy practice follow a suit of models under those broad categories.

Modeling practice of central banks is an evolutionary process. Central banks resort to structural macroeconometric model that focuses on the empirical estimates of a structural equation to analyze monetary policy while Jan Timbergen (1939) first time developed macroeconomic model in 1936. Central bank of Netherlands is the first bank used such a

model to analyze impact of guilder (Netherland currency)- the policy instrument- to stimulate output- the target variable (Taylor, 1997). It contained 32 stochastic equations designed under Keynesian income expenditure framework.

In collaboration with academics, the Bank of Canada developed RDX1 and RDX2 models and Federal Reserve developed MPS (MIT-PENN-SSRC) models in the 1960s (Helliwell, Officer, Shapiro, and Stewart, 1969). The econometric models so developed were used to estimate the impact of a one-time path for the policy instruments on the target variables usually through simulation. The IS-LM model, a small system of simultaneous equation, became a popular toolkit for aggregate demand analysis and academic teaching field. India began developing macroeconomic model when Narasimham (1956) for the first time constructed macroeconomic model (Valadkhani, 2004). Structural macroecnometric model flourished in the 1940s, 1950s and 1960s which were the byproduct of academic research; and various central banks used such models for policy evaluation as their need.

There was a paradigm shift in the 1970s, with the advent of Lucas critique, on the views on how models should be used for monetary policy evaluation. The new paradigm took into consideration the role of economic agents' expectation (forward and backward looking) on policy changes (Taylor, 1997). It gave rise to academic research on micro founded models that features explicitly optimizing consumers and producers' behavior to investigate optimal policy. Under this modeling framework, New Keynesian model which emphasis on nominal and real rigidities and a role of aggregate demand in output determination are the common features of central bank policy formulation. New Keynesian model in its standard form contains four basic equations (1) aggregate demand or IS curve (2) a price-setting or Phillips curve, (3) an uncovered interest rate parity (UIP) condition for the exchange rate, and (4) monetary policy rule (for setting the policy interest rate) which are increasingly popular in the name of Quarterly Projection Model (QPM) for policy analysis.

In the 1990s, a number of central banks replaced earlier structural econometric models by Quarterly Projection Models (QPM) under Forecasting and Policy Analysis System (FPAS). Two important features of that dynamic structure of QPM and FRB/US are forward-looking expectations and endogenous policy rules. Those models aim at generating forecasts and risk assessment as well as conducting policy analysis. The RDXF model was replaced at the Bank of Canada by the Quarterly Projection Model (QPM) and later on QPM was also replaced by ToTEM (for Terms-of-Trade Economic Model) in the 2000s. The FRB/US (as a Quarterly Econometric Model) replaced the MPS (MIT-PENN-SSRC) model at the Federal Reserve. Benes, et.al. (2016) developed Quarterly Projection Model (QPM) and Inflation-Forecast Targeting (IFT) models for India under DSGE framework. The model aims at generating forecasts and risk assessment as well as conducting policy analysis.

Further, Bank of England uses the Bank of England Quarterly Model (EQM), Phillips Curve models, small scale macro-econometrics model as well as VAR models for forecasting and policy analysis. Similarly, the Central Bank of Japan has Quarterly Japanese Economic Model, Medium scale Japanese Economic Model (M-JEM) and DSGE model among the suit of models. European Central Bank uses New Multi-country Model (NMCM). In the course of obtaining policy inputs for monetary policy

formulation, central banks throughout the world have been adopting various models developed by themselves and academic researchers over the period. Haider and Khan (2008) developed a small open economy DSGE model for Pakistan under new Keynesian framework. Rahman and Khato (2011) developed a small macro econometric model of the Bangladesh Economy using structural equations model.

At present a multiple-model approach called the "Suite of Models" has become popular at central banks. It means central banks use a suit of models as single model can be inadequate to answer all economic policy questions or address all needs. The suit of models include structural macroeconometric models developed under Keynesian income-expenditure framework, micro-founded models like DSGE models, error-correction model (ECM) developed in the early stages following the Lucas critique as hybrid-type models. They combine theory-based dynamics with data-matching properties. Central banks also use nonstructural model like VAR and uni-variate models for short-term forecasting. Each model in the suit can be used separately to examine the robustness of projections. Second category contains Vector Autoregressions (VARs) which is statistical in nature. It's use is important primarily for short-term macroeconomic forecasting. All these models are based on past data and ergodicity assumption.

III. MODELING PRACTICES IN NEPAL RASTRA BANK

NRB has developed several models for forecasting and policy simulation such as Nepal Macroeconometric Model (NMEM)- a large scale model, macro-econometric sectoral model (NMESM)- medium/small and satellite models, Dynamic Stochastic General Equilibrium (DSGE) model- micro-founded macroeconomic model and single equation model- indicator models that are used to make short-run predictions of inflation, money demand, revenue elasticity/buoyancy, among others. A brief overview of the economic models practiced by NRB is presented as follows.

Nepal Macroeconometric Model (NMEM)

The systematic development of macroeconometric model in Nepal began in 2005 when Asian Development Bank (ADB), for the first time developed Nepal Macro-Econometric Model (NMM) for policy analysis and forecasting of macroeconomic variables of Nepalese economy (Ra and Rhee, 2005). Prior to the development of NMM, individual researchers attempted to use statistical models for economic analysis beginning the mid-eighties (Annex 1). However, NRB first time introduced NMEM in 2011 after upgrading and updating the NMM incorporating monetary and external sector (NRB, 2011). The basic feature of NMEM has been tabulated in Annex II. The objective of the model is to derive macroeconomic forecasting and policy simulation. It has been built under Keynesian income-expenditure framework by containing 5 blocks (real, fiscal, monetary, price and external blocks), 37 equations, 119 variables, 18 exogenous, 101 endogenous and 64 identities. Model contain 39 observations (1975 to 2014), 6 years forecast horizon (2015 to 2020) and 2 alternative scenarios. The evaluation criterion is Root Mean Square Percentage Error (RMSPE).

Nepal Macro-Econometric Sectoral Model (NMESM)

NRB has sector-specific model namely NMESM as satellite models for enriching NMEM. It is also used for forecasting variables of the different sectors. The robustness

of sectoral model has an added benefit in upgrading NMEM of the bank. Also, the changing structure of the economy, shifts in the policy regimes, and recent development of econometric methodology calls for a continuous revision of the models and institutional development of macroeconomic modeling. NMESM contains 5 blocks, 54 equations, 131 variables, 75 exogenous and 75 endogenous variables, 41 observations (1975 to 2015), 4 years of forecast horizon (2016 to 2020) and 2 alternative scenarios.

Dynamic Stochastic General Equilibrium (DSGE) Model for Nepal

NRB has developed DSGE model in 2011 with technical assistant of ADB. The model was constructed under micro-foundation approach (ADB, 2011). It is a small open economy model under New Keynesian theoretical framework. The model is presented in log-linearize deviations of the model from steady-state. It has 24 equations, 32 endogenous variables including 10 forcing processes and 9 pre-determined variables. Monetary policy has been modeled in a flexible manner with either: (i) an active interest rate rule; (ii) a money supply rule or (iii) a fixed exchange rate. The basic features of the model are optimization problem of households subject to labour income and the decision to send human capital abroad; remittance flow determines current account; investment follows Tobin's Q type; prices are exogenous; exchange rate follows UIP condition; velocity shocks for financial intermediation; and a full set of linearised equations. All the equations have been derived through optimization conditions, impulse response function (IRF) and moment analysis.

Macroeconomic Model for Economic Forecasting

NRB very recently developed macroeconometric model for economic forecasting under the Bank of Korea (BOK) Knowledge Partnership Program (NRB, 2017). The program presented two tiers of macroeconometric model for policy analysis and forecasting: small scale macroecometric model and medium-size macroeconometric model. The small-scale model, in its basic form, follows New Keynesian macroeconomic modeling framework where variables of output, inflation and interest rates are determined through intertemporal IS curve, New Keynesian Phillips curve and interest rate rule (Taylor rule) respectively. This model extends with characteristics of Nepal's economy by conditioning variables like rainfall, remittance and earthquake shock of 2015. The results of model include three monetary policy scenarios including independent monetary policy, currency peg and partial currency peg. The study found partial currency peg scenario to be the best one.

Medium-size model confers macroeconomic forecasting of selected variables including GDP and inflation. It applies both demand and supply approach for determining the variables. Under former approach, model identifies equations of the variables of National Income Accounting Identity: consumption, investment, government expenditure, exports and imports. Under supply side, inflation depends on past and future inflation and output gap as postulated by New Keynesian Phillips Curve. The 2015 earthquake dummy, Official Development Assistance (ODA), world trade volume, Indian GDP are conditioning variables that brings about changes in GDP. Error Correction Model (ECM) model is used to overcome serial correlation and non-statinarity in time series data. The sample contains 20 observations ranging from the year 1996 to 2016. The ex-ante forecast constitutes three periods.

Single-equation/indicator models

Besides macro-econometric models, the NRB has developed various single equation models aiming to make short-run predictions various macroeconomic indicators such as inflation, money supply, revenue government, export and imports. While developing single equation models, the underlying theoretical and empirical aspects of the model have been taken into consideration.

IV. METHODOLOGY

We apply OLS estimator to investigate relationship between the variables of interest. Efficiency problem of OLS estimator has been addressed through GLS estimator. Models are log-linearized to account for assumed non-linear relationship between the variables and transform them as standard elasticity models. Cointegrating relationship between the variables follows Engle-Granger two-step process. We have estimated four models: inflation mdoel, money demand model, fiscal model and external model in this paper.

The Quantity Theory of Money (QTM) is the theoretical basis for inflation model. In QTM $MV = PY$. Where, M is money supply, V velocity of money, P is price level and Y is real output. Solving QTM for price and assuming price is non-linear function of money, output and velocity with their respective parameter of α, β and θ yields $P = \frac{M^{\alpha}}{Y^{\beta}} V^{\theta}$. Taking logarithmic both sides and assuming Y and V constant in the short-run making the equation in stochastic form represents estimable equation for demand form real balance as:

$$ln(cpi)_t = \mu + \alpha \ln(m2)_t - \beta ln(Y_t) + \varepsilon_t \quad \text{..... (1)}$$

Where, $\alpha, and\ \beta$ are the price elasticity of money supply and income respectively. Considering the open border with India and pegged exchange rate system, we also use India's inflation as an explanatory variable in the inflation model. In addition, other explanatory variables like exchange rate, crude oil price and interest rate are also considered in the inflation model. In a study, NRB (2007) found that, in the short term, inflation is determined by both the narrow money supply and inflation in India, but in the long run, inflation in Nepal and India tend to have one-to-one relationship yielding trivial impact of money supply on inflation. Ginting (2007)'s finding also confirms the similar inflation dynamics in Nepal.

Theories of demand for money reveal that the data generating processes (DGP) of real balance in its multiplicative functional form can be represented as: $M^d = \alpha P^{\beta} Y^{\delta} R^{\gamma} \varepsilon^u$. Where, M^d is money demand in nominal term, α is constant, P is price level, Y is real GDP and R is interest rate. Assuming price elasticity of nominal money is unity, the equation transforms as: $\frac{M^d}{P^{\beta}} = \alpha Y^{\delta} R^{\gamma} \varepsilon^u$. Expressing the equation in log form for estimating in our data as:

$$\ln\left(\frac{M^d}{p^{\beta}}\right) = \ln(\alpha) + \delta ln Y_t + \gamma ln R_t + \varepsilon^u \quad \text{..... (2)}$$

Where, α is intercept, β is price elasticity of nominal money demand, δ income elasticity of real money balance, γ is interest rate elasticity of money demand. Given the stage of financial development in the Nepalese economy, it is still believed that money demand is a stable function of few explanatory variables.

Fiscal literature reveals that the DGP of revenue components can be represented by a multiplicative function of $Y = \alpha X^{\beta}$, where, Y is revenue head, (X) revenue bases/rates, β is elasticity/buoyancy of revenue components with respect to their respective bases. Taking logarithm both sides gives $\log(Y_t) = \log(\alpha) + \beta \log(X_t)$ which can be used for estimation as:

$$\log(Y_t) = \log(\alpha) + \beta \log(X_t) + u_t \quad \text{..... (3)}$$

While computing elasticity, revenue series is adjusted to remove the impact of discretionary changes. We apply the Sahota (1961) method to generate adjusted series.

Standard trade literature postulates that elasticity of exports and imports can be represented by an exponential form as: $X_t = AY_t^{\alpha}P_t^{\beta}V_t^{\delta}$. Where, A is constant, X_t is total export/import Y_t is real foreign/domestic activities (GDP), P_t relative price measuring competitiveness, V_t is the measure of exchange rate volatility. Real exchange rate can also be taken as the proxy of relative price. Taking the model into logarithmic form yields equation for estimation.

$$\log(X_t) = \log(A) + \alpha \log(Y_i) + \beta \log(P_t) + \log(V_t) + \varepsilon_i \quad \text{..... (4)}$$

Impact of government expenditure on imports has also been estimated by using government expenditure as an additional explanatory variable.

V. DATA AND SAMPLE PERIOD

Lack of high frequency data especially on real sector make it difficult to apply the sophisticated models. However, some attempts have been done as in the paper to explain the long term forecasting of different macroeconomic variables. As such, we have estimated single equation models for different sectors separately. We use 41 observations of annual data ranging from 1975 to 2016 for the estimation of variables of interest. The source of data for monetary aggregate, CPI, exports and imports are from Quarterly Economic Bulletin of NRB while that of revenue components of the Government of Nepal are obtained from various issues of Economic Survey. Data for GDP of India and the World are taken from World Development Indicator (WDI), World Bank publication.

VI. EMPIRICAL RESULTS

Inflation Model

The quantity theory of money (QTM) is the theoretical building block of inflation model in Nepal. Assuming constant velocity of money during short-run, inflation is positively related to money supply and negatively to real output. Monetarists' hypothesis that 'inflation is always and everywhere a monetary phenomenon' is an empirical concern for central banks (Friedman, 1963). There is, however, a growing consensus that inflation in Nepal is not only determined by domestic factors like output and money supply but also by cost push factors like international price as well as supply-side constraints like transportation bottlenecks, market price distortion imposed by middleman and syndicate. Table 1 presents empirical results of inflation model.

Table 1: Determinants of inflation (Sample: 1975-2016)

Variables	Expec. Sign	Order of Integration		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
		Level	1st Diff							
M2 Aggregate	(+)	I(1)	I(0)	0.47***	0.20***	0.25***	0.37***	0.35***	0.29***	0.20**
Real GDP	(-)	I(1)	I(0)	0.10	-0.62***	-0.57***	-0.65***	-0.92***	-0.87***	-0.66***
Indian CPI[&]	(+)	I(1)	I(0)		1.02***	0.74***	0.55***	0.65***	0.54***	0.74***
Exchange Rate (US$)^	(+)	I(1)	I(0)			-0.17***	-0.15***	-0.22***	-0.17***	-0.12**
TB Rate[&]	(+)	I(1)	I(0)				0.005***	0.005***	0.005***	0.004**
Crude Oil (Brant)	(+)	I(1)	I(0)							-0.0005
Lag Inflation[%]									0.23*	0.14
Dummy_2005[+]								0.07***	0.07***	0.06***
Cointegration Test#				Not cointegrated	Not Cointegrated	Cointegrated	Cointegrated	Cointegrated	Cointegrated	Cointegrated
ARCH Effect[b]	No			Yes	Yes	No	No	No	No	No
Constant Variance[a]	Yes			Yes	Yes	Yes	Yes	Yes	Yes	Yes
Serial Correlation[!]	No			Yes	Yes	Yes	Yes	No	No	No
Conditioning Variables[@]					CPI_Ind	CPI_Ind, Exrate	CPI_Ind, Exrate, TB Rate	CPI_Ind, Exrate, TB Rate, Dum_005	CPI_Ind, Exrate, TB Rate, Dum_005, Lag_ CPI	CPI_Ind, Exrate, TB Rate, Dum_005, Lag_CPI, crude oil
Model Identification (Decision)				Not cointegrated	Not cointegrated	Residual Serial Corelation	Residual Serial Correlation	Inflation Expectation not included	Model satisfies statistical criteria	And lag inflation not signification

** significant at 10 percent level, ** at 5 percent level and *** at 1 percent level. # applying Granger two step procedure. ^ Exchange rate of NC per US$, therefore, expected to be (+ve) sign. & Data for TB rate and Indian CPI are taken from IFS. + capture shift parameter. All variables except 'TB Rate' transformed to logarithmic value, coefficients read as elasticity coefficient. % capture inflation expectation. @ results not presented for the control variables like petroleum price (diesel) and remittance as they are found statistically not significant. ! applying Breusch-Godfrey LM test. a applying Breusch-Pagan test for heteroskedasticity. b LM test for ARCH. Model 1 relies on QTM. Model 2 is extended with Indian inflation (imported inflation). Model 3 captures exchange rate (foreign competitiveness). Model 4 incorporates TB rate (proxy of opportunity cost variable). Model 5 identifies structural shift in 2005. Model 6 captures inflation expectation (lag inflation). Model 7 extends with crude oil price (Brant Crude oil).*

All the covariates are I(0) variables[1]. CPI equation extends with bi-variate to multi-variate to capture both demand pull and cost push factors. Model 6 of Table 1 is identified the DGP of Nepal's CPI theoretically and under diagonestic criteria. The conditioning variables of the model comprises of M2 monetary aggregate, real income, Indian CPI, exchange rate and interest rate. Domestic currency per unit US dollar and 91 days' treasury bill rate are taken proxy of exchange rate and interest rate variables respectively. The estimated equation is cointegrated and error term satisfying iid based on ARCH effect, constant variance and no serial correlation.

Since, the fitted model includes lag of regressand, the estimated coefficients show short-run ones. If we represent those coefficient as long run ones, the elasticity coefficient of CPI with respect to M2 aggregate is found to be 0.38, ceteris paribus. Similarly, a one percent increases in Indian CPI triggers 0.70 percent surge in Nepal's CPI. It shows the phenomenon of imported inflation under the prevalence of IC-NC fixed exchange rate and long open border between Nepal and India. Further, the CPI elasticity with respect to exchange rate is 0.22 showing exchange rate pass-through effect as per the Model 6.

Money Demand Model

Income elasticity of demand for money function is the central relationship to predict supply of money. As money supply is equal to money demand in equilibrium, central bank uses money demand function to forecast money supply. Theories of demand for money instruct that real GDP (as transaction purpose) and interest rate (opportunity cost of money) are the principal determinants of real money balance. Therefore, supplying money in align with demand for it requires identifying demand for money function. Estimated coefficient of income elasticity of demand for money and growth projection of inflation as well as income are the inputs for monetary growth projection. Table 2 presents elasticity coefficient of M1, M2 and currency in circulation (CUC) with respect to income and interest rate. Since, right opportunity cost variable for monetary aggregate is not available in Nepal, we have used 91- day's TB rate in this model.

Table 2: Income Elasticity of Real Balance (1975-2016)

Models	M1	Currency in circulation (CIC)	M2	TbRate	Breusch-Pagan LM test Residuals	Cointegration Residual Test I(0)	Breusch-Godfrey Test for null of no autocorrelaiton
1	1.43***	1.37***	1.94***	-	No Hetrosdescidity	I(0)	Fail to Reject
2	1.36***	-	-	-0.01	No Hetrosdescidity	I(0)	Fail to Reject
3	-	1.30***	-	-0.002	No Hetrosdescidity	I(0)	Fail to Reject
4	-	-	1.82***	-0.02***	No Hetrosdescidity	I(0)	Fail to Reject
5*	-	-	1.80***	-0.01**	No Hetrosdescidity	I(0)	Fail to Reject
6*	-	1.27***	-	-0.01	No Hetrosdescidity	I(0)	Fail to Reject
7*	1.38***	-	-	-0.0003	No Hetrosdescidity	I(0)	Fail to Reject

Note: Every equations contains intercept terms dollar. The estimator of models 5, 6, and 7 is GLS.

[1] Unit root tests are not shown due to space constraint

The income elasticity of M1, M2 and CIC in bi-variate specification are 1.43, 1.37 and 1.94 respectively (Model 1). Conditioning on the treasury bill rate as opportunity cost variable, elasticity coefficients of M2 aggregate declined to 1.82 and further down to 1.80 if correction is made for non-sphericity and non-orthogonality problem in the class of method of moment estimators. Interest rate has trivial effect on real balance on all specifications, which may be due to the fact that the chosen interest rate in the model may not represent real opportunity cost for the money demand given the underdeveloped bond market in Nepal.

Fiscal Models

Estimation of elasticity and buoyancy coefficients of revenue components with respect to their respective bases is a popular modeling technique to forecast revenue of the government. It is used to know the extent to which revenue is sufficient to meet expenditure needed for the development activities (Jenkins, et.al., 2000). NRB conduct forecasts on different revenue heads using elasticity and buoyancy coefficients that are estimated based on historical data. Ministry of Finance (MOF) also applies macro-fiscal framework as developed by World Bank for the same (MOF, 2016).

When a country has buoyancy and elasticity of taxation greater than unity, it has a revenue growth larger than the growth rate of national income. Less buoyant and inelastic tax system warrants to enhancing allocative efficiency, fiscal reforms and strengthening institutional capacity to generate more resources. It also signals revenue being more responsive to discretionary changes due to tax rates and tax bases, prevalence of revenue leakages, tax evasion, lack of tax compliance as well as administrative inefficiency in the tax system.

As revenue heads are functionally related to their respective revenue bases, there is consensus that variables of imports, consumption, output and industrial GDP are taken as bases of custom, VAT, income and excise duty respectively. The results of elasticity and buoyancy coefficient of various country reveals heterogeneous findings. Acharya (2011) and Yousuf & Jakaria (2013) found greater than unity of both the elasticity and buoyancy coefficients for India and Bangladesh whereas Bilquees (2004) found less than unity coefficients of elasticity and buoyancy coefficient for Pakistan. However, all the elasticity and buoyancy coefficients in case of Nepal are consistently found less than unity elasticity and greater than unity buoyancy respectively (Table 3).

Table 3: Elasticity and Buoyancy Coefficients

Dependent Variables	Model 1		Model2		Model3		Model4		Model5		Average	
	Elasticity	Buoyancy	Elasticity	Buoyancy	Elasticity	Buoyancy	Elasticity	Buoyancy	Buoyancy	Effective Tax Rate	Elasticity	Buoyancy
Total Revenue	0.65	1.10	0.59	1.14	0.64	1.27	0.57	1.16	-	-	0.61	1.17
Custom Duty	0.40	0.80	0.54	1.05	0.63	0.99	0.65	0.81	0.90	7.5	0.56	0.91
VAT Revenue	0.73	1.05	0.55	1.15	0.56	1.35	1.20	1.10	1.2	2.2	0.76	1.16
Income Tax	0.59	1.78	0.41	1.37	0.72	1.42	0.47	1.31	0.90	5.1	0.55	1.47
Excise Duty	-	-	0.49	0.98	.053	1.52	-	-	1.2	10.6	0.51	1.23
Authors	Adhikari.(1995)		Timsina (2008)		IRD (2014)		NRB (2016)		MOF (2016)*			
Estimator	GLS		GLS		OLS		ARDL		Ratio			
Sample	1975-1994		1975-2005		1999-2014		1975-2016		2016			

*Note: The base of the custom duty, income tax and consistently imports and GDP for all studies. NRB (2016) controls income tax exemption and as well as income tax exemption and inflation for consistent estimate. GLS models controls ARMA (p,q) of residuals. * Following Macro-Fiscal framework.*

Reviewing the available literature as summarized in Table 3, the elasticity coefficient of government revenue ranges from 0.57 to 0.65 averaging 0.61. Buoyancy coefficients, however, ranges from 1.10 to 1.27 which yields an average of 1.17. Nepalese tax system characterizes with low built in flexibility indicating scope for administrative reform, controlling tax evasion and revenue leakages. Average elasticity coefficients for custom, VAT, income and excise are 0.56, 0.76, 0.55 and 0.51 respectively. The buoyancy coefficient for those revenue components estimated at 0.91, 1.16, 1.47 and 1.23. These findings indicate government relying on discretionary policy to raise revenue rather than built-in-stabilizing feature.

NRB (2016) revisited elasticity and buoyancy coefficients of revenue components of the government of Nepal using Autoregressive Distributed Lag (ARDL) approach. Using the data ranging from 1975 to 2016, long run coefficients of revenue components (Model 4 Table 3) are consistently found less than unitary elasticity except VAT and greater than buoyancy coefficients of all revenue components except custom revenue.

MOF (2016), with the technical assistance of the World Bank, has developed Macro-Fiscal Framework for revenue forecasting. Under this framework, inputs of revenue forecasting such as (a) revenue base forecasts (forecast of imports, consumption, aggregate GDP, industrial GDP variables) and (b) calculation of effective tax rate (based on historical trend, assumptions, and expert judgment) are applied for final outcome. The framework estimated the buoyancy coefficients of revenue components that ranges from 0.90 to 1.20 as presented in Model 5 in Table 3.

Further, we examined the robustness of elasticity of custom revenue with respect to imports using partitioning approach. Under this approach, elasticity of tax can be decomposed into the product of the elasticity of tax-to-base and the elasticity of the base-to-income. Former effect assesses responsiveness of the tax system and the latter assesses system's equity and efficiency effects (Kotut and Menjo, 2015).

Table 4: Elasticity of Custom Revenue to Imports (1975-2016)

Relationship	Buoyancy	Relationship	Elasticity
Tax- to-base buoyancy	0.88***	Tax-to-base elasticity	0.50***
Base-to-income	1.20***	Base-to-income	1.20***
Net buoyancy coefficient	1.056***	Net elasticity coefficient	0.6***

Notes: *Significant at 10 percent level, **at 5 percent level and ***at 1 percent level.

Model extends with tax rate as an additional variable to ensure consistency of the estimate which satisfies orthogonality condition. Net elasticity and buoyancy of custom revenue are found to be 0.60 and 1.06 respectively. These coefficients are found greater than that are estimated in the previous studies.

Trade Models

Nepalese economy is risk to unfavorable trade balance. Policy intervention through exchange rate has not shown desired outcome. Nepal has a dual system of exchange rate (ER) determination. It has adopted a fixed ER with Indian currency and ER for other currencies are market determined. Fixed ER policy is expected to serve the stabilization function of domestic macroeconomic policies. However, it does not mean that economic behaviors are also independent of the price adjusted ER, that is, real ER. Exporters and importers may monitor the real ER (RER) as an integral part of export and import decisions and hence trade balance.

Marshall-Lerner Condition (MLC) and J-curve are the concepts that explain how exchange rate affects trade balance in the economy. The former gives long run effect (more elastic) whereas latter the short run effect (Hegerty et al., 2012). Keeping these things in view, empirical estimation on whether elasticity of demand for exports and imports tends to be inelastic in the short run or more elastic in the long run has policy implication to confirm MLC. According to MLC, the balance of trade will improve (constant/ deteriorate) if the sum of price elasticity of demand for export and price elasticity of demand for import is greater than unity (equal/less than unity). If exchange rate is taken as the proxy of foreign price, devaluation or depreciation of exchange rate improves the BOP through two ways: goods imported exported become cheaper which encourages exports; goods become costlier which reduces imports. Thapa (2002) has examined MLC in case of Nepal and found it to be confirmed using OLS estimator.

As in the standard trade literature, we specify export as a function of world income and REER; and imports as a function of national income and REER (Bahmani-Oskooee, 1986). We augment both the functions with exchange rate volatility. Gravity model takes into account the role of space in determining trade. Anderson and Wincoop (2003) conditioned distance (physical, economic, cultural) between two trading partners as an additional variable and found inverse relation with trade flows. We investigate export and import functions in our data and Table 4 presents the result.

Table 5: Export and Import Elasticity

Covariates	Export(x)	Export(x)[&]	Import(m)	Import Trade (m)#	Import Trade (m)$
World Income	1.10***	-		-	
National Income	-	-	3.08***	2.51***	0.71**
REER	-1.22***	-1.14***	-0.37***	-0.14*	-0.32***
^Volatility of REER	-3.51	0.18	0.71	-1.31	-1.19
Total Expenditure of GoN	-	-	-	-	0.77***
Capital Expenditure of GoN	-	-	-	0.39***	-
Cointegration test	Cointegrated	Cointegrated	Cointegrated	Cointegrated	Cointegrated
Breusch-Godfrey Test	Fail to Reject null of no autocorrelation	Fail to Reject null of no autocorrelation	Fail to Reject null of no autocorrelation	Fail to Reject null of no autocorrelation	Fail to Reject null of no autocorrelation
Breusch-Pagan LM test OLS Residuals	Fail to reject the null of no Heteroscedasticity	Fail to reject the null of no Heteroscedasticity	Fail to reject the null of no Heteroscedasticity	Fail to reject the null of no Heteroscedasticity	Fail to reject the null of no Heteroscedasticity
LM Test of ARCH effects of OLS Residuals	Fail to Reject null of no ARCH effects	Fail to Reject null of no ARCH effects	Fail to Reject null of no ARCH effects	Fail to Reject null of no ARCH effects	Fail to Reject null of no ARCH effects

** denote significant at 10 percent level, ** at 5 percent and *** at 1 percent level. All scale variables are in nominal scale and log transformed, ^ counterfactual series of the volatility of REER is derived through the log difference of REER. # model extended with covariate of capital expenditure of the government. $ model extended with covariate of total expenditure. The data of world income is taken from World Bank data.*

We estimated five forms of equations to explore income and price elasticities of both the exports and imports demand function. Total exports and imports are found greater than unitary elasticity to world income (1.1) and domestic income (3.08) respectively. Hypothesis of the positive relationship between imports and government capital expenditure cannot be ruled out. Result shows that a one percent increase in total expenditure has impact of 0.77 percent increase in imports, and that of 0.39 percent in case of capital expenditure.

Currency devaluation cannot be an instrument tool to improve trade balance in Nepal. The imports demand is found to be inelastic as indicated by the coefficient of 0.37. It signifies that the Nepalese imports cannot be controlled by devaluation of Nepalese currency with respect to real exchange rate weight by trade share as represented by real effective exchange rate (REER). Contrarily, exports is deteriorated marginally due to currency devaluation as indicated by contrary sign of exchange rate elasticity of exports demand.

VII. CONCLUSION

This paper presents a brief survey on macroeconomic models of Nepal. In addition, it empirically investigates some sectoral macro models such as inflation, monetary aggregate, fiscal and external sector model. Single equation model estimation incorporates data ranging from 1975 to 2016. The selection of model rests on standard literature of QTM, demand for real money balance, elasticity of revenue components and trade theory. Consistency and efficiency of the estimated parameters do satisfy both theoretical and diagonestic criteria. Income elasticities of monetary aggregates, the degree to which factors affecting the inflation, elasticity and buoyancy of government revenue, income elasticity of exports and imports have been examined.

The DGP of present inflation model found money price relationship with 0.38 elasticity coefficient. Indian CPI triggers 0.70 percent surge in Nepal's CPI. Empirical estimates of money demand function yields income elasticity of 1.43 for M1 and 1.37 for CIC while that of 1.80 for M2. The elasticity coefficients of revenue components stood at 0.61 and buoyancy at 1.17. Similarly, income elasticity of exports and imports are found 1.1 and 3.08 respectively. Imports is sensitive to government expenditure as well, one percent increase in government expenditure can increase the imports by 0.77 percent.

This paper identifies the single equation models for the variables of interest. Models can be used particularly for understanding the basic relationship among selected macroeconomic variables. The results so estimated help in reshaping model-based decision making process to the policymakers. Further, it opens an avenue for developing partial and general equilibrium models in future.

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Annex : I

Macro Model since 1980 to 2005

Institution/Author (Year)	Model Type	Assistant	Uses of the Model
Khanal, Thapa and Elbers (1987)	Multi-sector model	Integrated with SAARC	Implication of regional trade
Sharma (1989)	Macroeconometric model	Personal	Policy Simulation
NPC (1990)	RMSM-X, Accounting	(IMF and WB)	Policy analysis
Cruikshank, E.D. and R.H. Nord (1990).	Macroeconomic accounting	-	Policy Coordination
Sapkota and Sharma (1998)	SAM and CGE	MIMPA	Poverty Analysis
Guru-Gharana (2000)	Macroeconometric Model	-	Impact of Trade Link of 5 SAARC countries
Alamgir and Ra (2001)	Macroeconomic Model	-	Policy analysis and forecasting
Ministry of Finance (2005)	Macro Dynamic Model	ADB	Debt Sustainability

Annex : II

History of Macro-econometric models in Nepal

Macro Model/ Description	Nepal Macro-econometric Model (NMM)	Nepal Macro-econometric Model (NMEM)	MDG Consistent Macro-econometric Model (MDGcMEM)	LDC Graduation Macro-econometric Model (LDCgMEM)	Nepal Macro-econometric Sectoral Model (NMESEM)	Oil Price Shock, Pass-through (India)
Motivation	Macroeconomic Planning and Forecasting	Macroeconomic policy simulation and Forecasting	MDG consistent macroeconomic inter-relationship and forecasting	GNI Forecast for LDC Graduation	Projection of macro variables of sectors of the economy	Impact of oil pass through on macro variables
Implementing Institution/Agency	NPC (2005)	NRB (2011)	NPC (2012)	NPC (2014)	NRB (2015)	N. Bhanumurthy and et.all. (2012)
Modeling Framework	Keynesian Income-expenditure	Keynesian Income-expenditure	Keynesian Income-expenditure	Keynesian Income-expenditure	Keynesian Income-expenditure	Tinbergen-Goldberger-Klein (1955 & 1967) tradition.
Demand/Supply Side	Demand Side	Both demand supply sides	Both demand supply sides	Both demand supply sides	Both demand supply sides	Both demand supply sides
Blocks	5: final demand, prices, credit and money,government, BOP	5 (real, monetary, fiscal, external sector, price	6 (real, social, government, monetary, BOP, price)	6 (real, social, government, monetary, BOP, price)	5 (real, government, monetary, BOP, price)	4 (macroeconomic block, the government block, the external block, and the monetary block).
Equations	37	37	74	60	54	25
Variables	59	119	91	97	131	
Exogenous		18	17	37	75	
Endogenous	37	101	74	60	56	25
Identities	17	64	31	25		
Sample	1975-2004	1975-2014	1992-2010	1975-2014	1975-2015	1992-2010
Evaluation Criteria	RMSPE	RMSPE	RMSPE	RMSPE	RESPE	RESPE
Forecst Horizon	5 years	2015-2020	2011-2015	2016-2020	2016-2020	
Scenario	3 (baseline and 2 alternative)	2 (baseline and alternative)	2 (baseline and alternative)	2 (baseline and alternative)	2 (baseline and alternative)	