

Long-run Relationships of Macroeconomic Variables in Nepal: A VAR Approach

T. P. Koirala, Ph.D.*

This paper utilizes cointegration procedure of Johansen and Juselius (1990) in estimating the long run economic relationships of macroeconomic variables comprising M2 monetary aggregate, Real Gross Domestic Product (RGDP), Consumer Price Index (CPI) and Interest Rate (RT) using annual data ranging from 1975 to 2006. Since one cointegrating vector is found to be statistically significant among the variables under consideration, the result is tantamount to deducing the coefficients of Error Correction Model (ECM). In an application of the Augmented Dickey and Fuller (ADF) test to examine the presence of unit roots in the variables prior to the variables used in estimating long run relationships, the ADF sequential search procedure supports an existence of unit roots in all the variables. This paper also estimates the demand for money function in Nepal as an application of long run relationships between the variables using the said procedure. The coefficients of income and interest rate elasticity of M1 so estimated as depicted by the normalized cointegrating vector are in line with theoretical underpinning. Since the coefficients estimated in this paper rely on restricted VAR method that are contrary to the past practices in estimating cointegrating vector using the Engle-Granger (1987) two-step procedure in Nepal, the coefficients are supposed to be robust and consistent owing to the stronger restrictions imposed by cointegrating vector as against the a theoretical VAR approach.

I. INTRODUCTION

The methodological revolutions of economics and econometrics over the periods call for a fundamental change in our way of thinking about modelling economic phenomena. The test of unit roots and the ECM augmented by the vector of cointegrating variables particularly within the Vector Autoregressive (VAR) framework are the major landmarks in the dynamic econometrics that have attracted not only the attention of the specialist econometricians but also a large number of policy-oriented applied economists in the methods of estimation of economic relationships as well as modelling fluctuations in economic activities.

* Nepal Rastra Bank, Birgunj, Nepal, E-mail: Koiralat@nrb.org.np.

The problem of spurious regression invoked an emergence of methodological revolution in the estimation technique of economic variables. The static regression results can be considered as the long run equilibrium relationship and hence are free of the problem of spurious regression (Granger and Newbold, 1974) only when the time series under consideration show common trends instead of their own individual trends (Granger, 1981) and the accompaniment of an Error Correction Term (ECT) in the estimated model (Davidson, Hendry, Srba and Yeo, 1978) so that the resultant residuals are stationary. The trend is analyzed by looking at the 'order of integration' of the variables. If the polynomial has a unit root then the variable is said to be linear trend. The unit root test statistics introduced by Dickey and Fuller (1979), Phillips (1987), and Phillips and Perron (1988) are the tools of analysis to examine the presence of unit root in the variables.

The economic implication of the unit root tests emerges from the assumption of stability of the long run trend rate of growth of output. The untenable aggregate output in many countries is characterized by the non-stationarity in nature. This finding casts a doubt on the usefulness of the determinants of the trend rate of growth of output and cycles. The alternative macroeconomic models that have treated economic fluctuations as temporary deviations from a stable trend rate of growth of output as found by unit root tests offer different explanations for these fluctuations leading to the disagreement between the choices of alternative short run stabilization policies to the policymakers.

A technique that has gained tremendous popularity in the estimation of the long run relationships between the variables with the unit root variables is cointegration analysis. In a situation when the long run parameters estimated by utilizing static model is not in accordance with an economically realistic long run relationship, an ECT in the model is introduced by way of parameter restriction (Vogelvang, 2005).¹ The ECM, therefore, is the modelling technique for the short run dynamics with a given long run relationship between the variables (Davidson, Hendry, Srba and Yeo, 1978). It is an equation specified with variables in first differences augmented by an ECT where the latter term makes sense when the variables under estimation are unit roots. The essence of this technique is that the equilibrium theories involving non-stationary variables require the existence of a combination of the variables that is stationary though the individual variable has trend. In other words, within any equilibrium framework, the deviations from equilibrium must be temporary or the linear combination represents long term equilibrium for the system and the system cannot depart from this equilibrium in a substantial way. The main advantage of cointegration is that it can be used directly to test or falsify the

¹ The restriction can conveniently be imposed when the short run model: $Y_t = \beta_0 + \gamma_0 X_t + \gamma_1 X_{t-1} + \beta_1 Y_{t-1} + u_t$ is taken first differences and corrected for the newly introduced lags (the equation remains unchanged), gives a model like: $\Delta Y_t = \beta_0 + \gamma_0 \Delta X_t + (\beta_1 - 1)(Y_{t-1} - \frac{\gamma_0 + \gamma_1}{\beta_1 - 1} X_{t-1}) + u_t$. The parameter in parentheses for X_{t-1} is exactly equal to the long run parameter and can easily be restricted. If long run relationship is imposed: $Y = X$. This gives a restriction on the parameter of the long run response as: $\frac{\gamma_0 + \gamma_1}{\beta_1 - 1} = 1$. Substituting this value in the short run model results in the restricted short run model: $\Delta Y_t = \beta_0 + \gamma_0 \Delta X_t + (\beta_1 - 1)(Y_{t-1} - X_{t-1}) + u_t$. This is the ECM. The term $(Y_{t-1} - X_{t-1})$ is the ECT.

underlying theory. Together with unit roots, this has an important implication for the specifications and estimations of dynamic economic models.

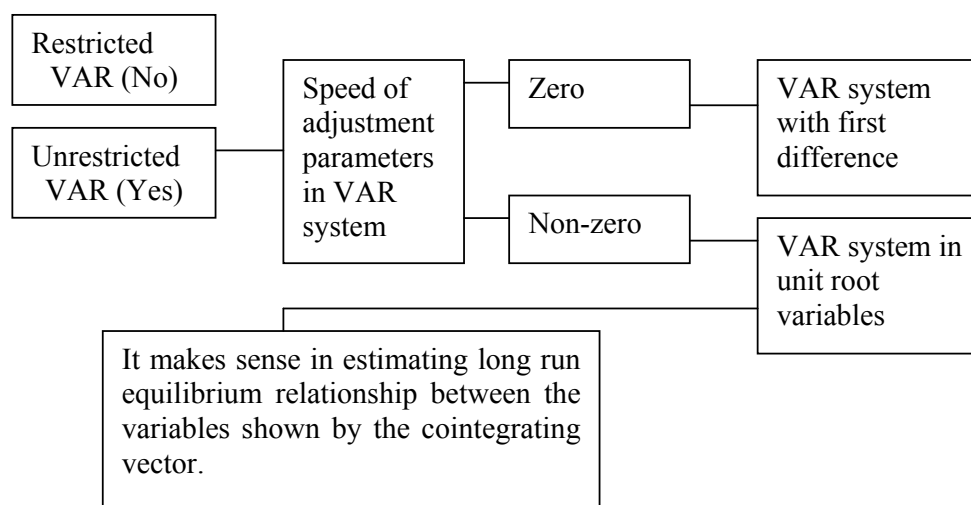
The ECM is a n -variables VAR in first differences augmented by the error-correction terms accompanied with respective speed of adjustment parameters. The VAR is a relatively new tool of macroeconometrics, yet it has rapidly become popular because of the inability of macroeconomists to agree on the correct structural model of the economy (Sims, 1980). Though the initiation of VAR model in estimation can be traced back to Jevons (1962), the arrival of VAR models on the scene was around 1980s only after Sims' (1980) challenge to structural econometric models as imposing incredible identifying restrictions based on casual interpretation of economic theory. The VAR treats all variables symmetrically without taking reference to the issue of dependent versus independent as against the major limitation of intervention and transfer function models that treat many economic systems and exhibit feedback (Enders, 2004). Sims (1986) argues that the primary advantage of this atheoretical VAR approach is that it does not specify restrictions from a particular structural model; yet under relatively weak conditions, the VAR provides a reduced form model 'within which tests of economically meaningful hypotheses can be executed. The critics of atheoretical VARs put an initiation of the structural VAR (SVAR) approach employed particularly by Blanchard (1989), Blanchard and Watson (1986), Bernanke (1986) and Keating (1989). The SVAR models identify economic structure through contemporaneous exclusion restrictions (Lucas and Sargent, 1978).

If the speed of adjustment parameters are equal to zero for the ECT under the restricted VAR system, the long run equilibrium relationship does not exist and the models are not one of ECM but that of first difference VAR. In this case, there is no matter of establishing the long run equilibrium relationships by way of cointegrating vector of the unit root variables (Enders, 2004). A cointegration necessitates coefficient restrictions in a VAR model. It is important to realize that a cointegrated system can be viewed as a restricted form of a general VAR model. Cointegrating vectors are obtained from the reduced form of a system where all of the variables are assumed to be jointly endogenous. Consequently, they cannot be interpreted as representing structural equations because, in general, there is no way to go from the reduced form back to the structure (Dickey, Jansen and Thornton, 1991). Nevertheless, they might be thought of as arising from a constraint that an economic structure imposes on the long run relationship among the jointly endogenous variables. For example, economic theory suggests that arbitrage will keep nominal interest rates, especially those on assets with the same or similar maturity, from getting too far away from each other. Thus, it is not surprising that such interest rates are cointegrated (Stock and Watson, 1988).

It is inappropriate to estimate a VAR of cointegrated variables using only first differences. The number of cointegrating vectors is determined by the rank of $(I - A)$ where I and A stand for identity matrix and $(n \times n)$ matrix of coefficients respectively. From a purely statistical point of view, cointegration places some restrictions on the matrix A . From an economic perspective, economic theory determines the matrix A and, therefore, places some restrictions on the long run behaviour of Y_t . If the matrix $\psi = (I - A_1 - A_2 - \dots - A_p)$ is full rank, then any linear combination of Y_t will be a unit root process and, hence, nonstationary. This leaves an intermediate case where ψ is not a

matrix of zeros, but is less than full rank. The rank of ψ , r , is the number of linearly independent and stationary linear combinations of Y_t that can be found. In other words, it is the number of linearly independent cointegrating relations among the variables in Y_t . The estimate of ψ and $\hat{\psi}$ will almost always be of full rank in a numerical sense. The objective of tests for cointegration is to test for the rank of ψ by testing whether the eigenvalues of $\hat{\psi}$ are significantly different from zero (Theil and Boot, 1962). As discussed in the previous paragraphs, there are certain linkages between unit root variables, ECM and cointegration relationship in the VAR framework as presented in Figure 1.

FIGURE 1: Linkages between Unit Root, ECM, and Cointegration in the VAR Framework



Keeping this linkage in view, this paper has dual objectives in its empirical analysis. The first part of the analysis attempts to find equilibrium or long run parameters in a relationship with unit root variables. As far as unit root testing is concerned, the focus is placed on the application of the ADF sequential search procedure. With regard to the estimation of equilibrium relationships among the variables, the use of the Johansen and Juselius (1990) procedure in identifying the number of cointegrating relationships between a set of variables is applied. This paper also estimates the demand for money function in Nepal as an application of long run relationships between the variables using the Johansen and Juselius (1990) procedure. In order to achieve the said objectives, the relevant theoretical as well as empirical literatures are reviewed in the next section. The methodology, including the variables, the models to be utilized and the hypotheses to be tested is discussed in Section III. Section IV presents the results of long run equilibrium relationships of the macroeconomic variables followed by an estimation of demand for money in Nepal by applying the said procedure in examining long run relationships between the variables. The conclusion of this paper is presented in the last section.

II. LITERATURE REVIEW

A number of evidences in the examination of the long run relationships among the macroeconomic variables and methodologies adopted to obtain the results have been found both in the theories of economics and the empirical findings. Firstly, this paper discusses some issues relating to methodological perspectives and empirical evidences are presented subsequently. Macroeconomists have been aware that many macroeconomic time-series are not stationary in their levels but are stationary after differencing. Non-stationarity in the level form in the variables gives rise to several econometric problems. Variables whose means, variances and covariance change over time are known as non-stationary or unit-root variables and absence of such dependency in the variables are called stationary variables.² It can give rise to the possibility of a spurious relationship among the levels of the economic variables. If the means and variances of the unit root variables change over time, all the computed statistics in a regression model, which use these means and variances, are also independent and fail to converge to their true values as the sample size increases. Therefore, the conventional tests of hypothesis will be seriously biased towards rejecting the null hypothesis of no relationship between the dependent and independent variables. There is a serious problem if the null hypothesis is true. Unit root tests are applied to determine if the variables in a regression are stationary or non-stationary.

A number of alternative approaches are available to the research interested in estimating long run economic relationships. Two are of special interest: VAR and Structural econometric modelling. The VAR analysis accords a very limited role for the theory and restriction based analysis and emphasizes the importance of model selection on data based criteria. Structural econometric modelling, on the other hand, focuses on role of economic theory in the design and specification of the econometric model. Cointegration analysis can be viewed as effecting a reconciliation of these two approaches, since the existence of one or more cointegrating relationships between a set of variables implies that there are restrictions connecting the parameters in the VAR.

The technique of cointegration as an important tool of analysis for the economic relationships has been given due emphasis by different postulations. Friedman (1957) in his Permanent Income Hypothesis (PIH) postulated that a long run equilibrium relationship between consumption and permanent income holds true since the transitory component of consumption function is to be an I(0) variable.³ Barro (1979) has also given a similar argument in his tax smoothing hypothesis that the tax rate should be set on the basis of permanent government expenditure, with transitory expenditure fluctuations financed by issuing debt. Barro's hypothesis implies the existence of cointegration

² Suppose y_t is a time series (or stochastic process) that is defined as stationary if

$$E(y_t) = \mu$$

$$E[(y_t - \mu)^2] = \text{var}(y_t) = \chi(0)$$

$$E[(y_t - \mu)(y_{t-\tau} - \mu)] = \text{cov}(y_t, y_{t-\tau}) = \chi(\tau), \tau = 1, 2, \dots$$

³ $c_t = c_{p_t} + c_{T_t} = \beta y_{p_t} + c_{T_t}$ where, c_t , c_{p_t} , c_{T_t} are total consumption, permanent income and transitory income respectively and β is factor of proportionality.

between tax rate and government expenditure. The purchasing power parity theory asserts that the difference between logarithms of domestic and world WPI and logarithm of the exchange rate are cointegrated provided that residual term is interpreted as the PPP deviations.⁴ Therefore, the method of cointegration is considered as a technique which helps in establishing dynamic relationships accompanied with long run relationships between the variables under the VAR framework.

So far as the available empirical analysis using cointegration approach is concerned, Dickey, Jansen and Thornton (1991) compare the robustness of the findings made by three different proposed tests of cointegration viz., Johansen Test, Stock-Watson Test and Engle-Granger Test. A stable long run relationship has been found among the variables comprising income, interest rates and different monetary aggregates using 144 observations starting from first quarter of 1993 to the fourth quarter of 1988. Johansen test produced results that were markedly different from those obtained using the Engle-Granger and the Stock-Watson methodologies on the ground that the results estimated on the basis of latter tests are found to be more sensitive to the variable chosen as the dependent variable in the process of normalizing equation.

Using decennial wage and price indices for England by Phelps Brown and Hopkins (1957) over the period 1401 to 1900, Nachhane (2006) compares the DW statistic obtained from the linear bi-variate model of price as a function of wage and found the variables having an absence of cointegration. Further, the null hypothesis of no cointegration is not rejected in case of the application of an auxiliary regression in testing cointegration.⁵ Therefore, there does not seem to be any evidence to support the hypothesis that wages and prices in England have historically moved in tandem.

Beyer (1998) analyzed the demand for money for Germany using the quarterly data from 1975 to 1994. The long run demand for money function for Beyer's study in terms of M3 is : $(m-p)^* = \delta_0 + \delta_1 y + \delta_2 RS + \delta_3 RL + \delta_4 \Delta_4 p$, where RS is a short-term interest rate, RL is a long term interest rate, and $\Delta_4 p$ is the annual inflation rate. In order for the model to be a valid one, there must be at least one cointegrating vector that transforms the function: $z_t = [(m-p)^*, \delta_1 y, \delta_2 RS, \delta_3 RL, \delta_4 \Delta_4 p]$ to stationary. He used Johansen trace test in the VAR consisting of five I(1) variables. The test rejected hypothesis of $r=0$ but was unable to reject the hypothesis of $r \leq 1$ and hence found the presence of a single cointegrating vector. The cointegrating vector examined in his study is $(m-p) = 0.936y + 1.601RS - 3.279RL - 1.780\Delta_4 p$.

Nachane (2006) estimated the number of cointegrating vectors employing Maximum Likelihood (ML) method of Johansen using monthly data on Wholesale Price Index (WPI), Index of Industrial Production (IIP) and M3 for India over the period 1986 to 1996. The trace statistic rejects the null of $r = 0$ against the alternative of $r \geq 1$. But the

⁴ $e_t = p_t - p^* + \eta_t$ where, e_t , p_t , p^* and η_t are logarithm of exchange rate, domestic WPI, world WPI and residual respectively. The η_t is interpreted as the PPP deviations which is $\eta_t = e_t - p_t + p^*$ and is assumed stationary.

⁵ $\Delta y_t = \alpha_0 + \sum_{i=1}^p \alpha_i \Delta y_{t-i} + \sum_{j=1}^q \beta_j \Delta x_{t-j} + c z_{t-1} + \varepsilon_t$ where, $z_{t-1} = y_{t-1} - \lambda x_{t-1}$ is ECT.

null of $r \leq 1$ is not rejected against the alternative of $r \geq 2$. Thus, the trace statistic indicates the presence of one cointegrating vector (i.e. $r=1$). The λ_{max} statistic also supports the existence of a single cointegrating vector. The cointegrating vector normalized in terms of M3 is in the form of: $M3 = 0.745 WPI_t + 1.804 IIP_t - 2.66$. It shows a long run positive relationship between M3 and WPI and between M3 and IIP as economic reasoning would lead to believe.

Using quarterly data for Denmark over the sample period 1974:1 to 1987:3, Johansen and Juselius (1990) analyzed the number of cointegration for x_t vector represented by $x_t = (M2_t, y_t, i_t^d, i_t^b)'$. The null hypothesis of $r=0$ against the general alternative $r=1, 2, 3$ or 4 as given by λ_{trace} statistic is accepted even at 10 percent significant level implying no cointegration among the variables. However, one cointegrating vector is found to be statistically significant (i.e. $r=1$) using λ_{max} statistic.

A number of empirical studies are available on the demand for money function generally. The theory of demand for money converts Irving Fisher's equation of exchange identity i.e. $\ln M + \ln V - \ln P - \ln q = 0$ into an equation of Velocity (V) as a function of a number of economic variables. In the theory of demand, V is unobservable and is proxied with some function of economic variable V^* , where $V^* = \ln V + \varepsilon$ and ε denoting a random error associated with the use of the proxy for V. The proxy is a function of one or more observed variables, other than income and prices, that are hypothesized to determine the demand for money. If the proxy is good, the expected value of ε should be zero, and hence ε is stationary. The ε can be found to be stationary by the choice of different monetary aggregates in the Fisher's equation of exchange. Failure to find the cointegrated variables imply either V^* is a poor proxy for V or that the long run demand for money does not exist in any meaningful sense. The Fisher relationship embodies a long run relationship among money, prices, output and velocity. It hypothesizes the existence of cointegrating vector like: (1,1,-1,-1). The vector combines the four series into an uni-variate series, ε . Given this known cointegrating vector $(\beta_1, \beta_2, \beta_3, \beta_4)$, a test for cointegration can be performed by applying the conventional unit root tests on ε .

The relationship between money and income is embedded in the demand for money which is represented by income velocity of money. Various empirical findings indicate that M1 and income (i.e. income velocity of M1) are not cointegrated, or in other words, M1 and nominal GDP are not of (1,-1) (Nelson and Plosser, 1982, and Engle and Granger, 1987). However, according to Engle and Granger, (1987), M2 and income (i.e. M2 velocity of income) are cointegrated. In order to tests for cointegration, the theory of demand for money is reviewed. Accordingly, the reduced form demand for money function for estimation purpose is: $m^d/q = h(Z)$ where, m^d is demand for real money balance, q is real income, $h(Z)$ is the famous k in the Cambridge Cash Balance Equation which is the reciprocal of the income velocity of money. In equilibrium, the demand for real money balance equals the supply of real money, m^s , so that $h(Z)$ is observed simply as the ratio of real money stock to real income.

Khatriwada (1997) estimated the demand for money in Nepal assuming log of real narrow money balance ($\ln RM1$) as a function of log of real income ($\ln y$) and interest rate (r) utilizing the Engle-Granger methodology. His finding reveals significant underlying relationship between real money balance, real income and interest rate. However, no such relationship was observed when narrow money ($M1$) was replaced by broad money ($M2$). The demand for money estimated by him is $\ln RM1 = -4.44 + 1.25 \ln y - .034r$.

Pandey (1998) makes use of co-integration analysis and error correction modelling techniques to examine the money demand function in Nepal utilizing annual data ranging from 1965 to 1995. He uses the ECM based co-integration test which he found more powerful than that of Engle-Granger test in small sample size. The logarithms of narrow money ($M1$), agricultural GDP (YAG), non-agriculture GDP ($YNAG$) are found to be integrated of order one using DF and ADF test. The adjustment coefficient and cointegrating vector normalized with narrow monetary aggregate ($M1$) are -0.62499 and $[1, 6.866, -0.6811, -0.9199]$ respectively. He concludes that a statistically robust demand for $M1$ can be estimated for Nepal using an error-correction dynamic specification. Considering the theoretical and empirical literatures as reviewed in this section, the approach of this paper is to examine the long run relationship between the macroeconomic variables employing Johansen and Juselius (1990) procedure, and make an application of the model in examining the demand for money in Nepal utilizing the latest available observations.

III. METHODOLOGY

Among the major important macroeconomic variables, this paper utilizes variables like broad monetary aggregate ($M2$), Real Gross Domestic Product ($RGDP$), Consumer Price Index (CPI), long term government yield (RT) and others for the analysis. The 32 annual time series data observations ranging from 1975 to 2006 is also used. The sources of secondary data are *Quarterly Economic Bulletin* (NRB publication), *Economic Survey* (GON publication) and *International Financial Statistics* (IMF publication). The three-period deflation is worked out on GDP to obtain $RGDP$. The variable for the long term interest rate is proxied by one year government bond yield and short term interest rate by 90-day treasury bills rate.

With regard to the model for the estimation, it is taken for granted from other representative work available in estimating long run relationship of macroeconomic variables. Among them, Engle and Granger (1987) suggested a simple two-step approach in testing cointegration in a bi-variate system. The first step in the Engle-Granger procedure is to estimate $y_t = \alpha + \beta x_t + u_t, (t = 1 \dots T)$ using OLS where both the variables that are tested for cointegration should be $I(1)$. The null hypothesis of a unit root on \hat{u}_t corresponds to the absence of cointegration between the variables as against the alternative hypothesis of \hat{u}_t being $I(0)$, that is, variables are cointegrated. However, in order to overcome the possible problem of spurious cointegration for an application of \hat{u}_t in deducing cointegration relationship, the proposed auxiliary regression is:

$$\Delta \hat{u}_t = a \hat{u}_{t-1} + \sum_{j=1}^p b_j \Delta \hat{u}_{t-j} + \varepsilon_t \cdot \text{Cointegrating Regression Durbin-Watson (CRDW) Test}$$

proposed by Bhargava (1986) corresponds to the rejection of the null of no cointegration if DW statistic of the two I(1) variables is positive and significant. Kremers, Ericsson and Dolado (1992) have proposed a test based on the ECM directly rather than on the unit root properties of the cointegrating regression residuals, provided cointegrating vector hypothesized a priori. The coefficient of the ECT is tested using *t* statistic under the null hypothesis of no cointegration against the significantly negative coefficient.⁶

The large sample properties on which the results were derived utilizing Engle and Granger (1987) may not be applicable to the sample sizes usually available to the researchers. Further, it is possible to find that one regression indicates that the variables are cointegrated, whereas reversing the order indicates no cointegration. This is a very undesirable feature of the Engle and Granger (1987) procedure because the test for cointegration should be invariant to the choice of the variable selected for normalization. In view of these difficulties, this study utilizes the Johansen and Juselius (1990) approach in examining long run equilibrium and short run dynamic of macroeconomic variables in Nepal.

Before employing the test of cointegration among the macroeconomic variables, test of unit roots among the variables is conducted to examine order of integration utilizing the ADF method. The method considers three different regression equations with difference between them that are concerned with the presence of the deterministic elements (such as intercept or drifts parameter) and time trend in their autoregressive process. In their Monte Carlo Study, Dickey and Fuller (1979) found that the critical values of $\gamma = 0$ depend on the form of the regression whether that is pure random walk or explicit introduction of deterministic elements and their corresponding statistics labeled as τ_τ , τ_μ and τ as shown in Table 1.

TABLE 1 : Equations in Estimating Unit Roots Using ADF

Eqn.	Model	Hypotheses (single and joint)	Test Statistic
		$\gamma = 0$	τ_τ
1.	$\Delta y_t = \alpha_0 + \alpha_2 t + \gamma y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + \varepsilon_t$	$\gamma = \alpha_2 = 0$	ϕ_3
		$\alpha_0 = \gamma = \alpha_2 = 0$	ϕ_2
2.	$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + \varepsilon_t$	$\gamma = 0$	τ_μ
		$\alpha_0 = \gamma = 0$	ϕ_1
3.	$\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + \varepsilon_t$	$\gamma = 0$	τ

⁶ $\Delta y_t = \alpha_0 + \sum_{i=1}^p \alpha_i \Delta y_{t-i} + \sum_{j=1}^q \beta_j \Delta x_{t-j} + c z_{t-1} + \varepsilon_t$ where, $c z_{t-1} = y_{t-1} - \lambda x_{t-1}$ is ECT.

Dickey and Fuller (1981) provides three additional F-statistics (called ϕ_1, ϕ_2 and ϕ_3 in their terminology) to test joint hypotheses on the coefficients. These statistics are constructed as $\phi_i = \frac{(SSR_{Restricted} - SSR_{Unrestricted})/r}{SSR_{Unrestricted}/(T-K)}$ where, ϕ_i ($i=1,2,3$) are the F-statistics, $SSR_{Restricted}$ and $SSR_{Unrestricted}$ stand for the sum of squared residual from the restricted and unrestricted models respectively, r is number of restrictions, T is number of usable observations and K is number of parameters estimated on the unrestricted model. Comparing the calculated values of ϕ_i to the appropriate values reported in Dickey and Fuller (1981) determines the significance level at which the restriction is binding. The null hypothesis is that the data are generated by the restricted model (an acceptance of the null hypothesis implies the choice of restricted model and hence restriction is not considered binding) against the alternative hypothesis of the data generated by unrestricted model.

With the unit root variables provided, this paper employs the Johansen (1988) and Johansen and Juselius (1990) procedure to examine the number of cointegrating vector and hence estimates the long run relationships between the variables. The procedure proposes a Maximum Likelihood (ML) estimation approach for the estimation and evaluation of multiple cointegrated vectors. This method considers the following model:

Let X_t be a vector of N time series, each of which is I(1) variable, with a vector autoregressive (VAR) representation of order k ,

$$X_t = \pi_1 X_{t-1} + \dots + \pi_k X_{t-k} + \varepsilon_t \quad (1)$$

where, π_i are $(N \times N)$ matrices of unknown constants and ε_t is an independently and identically distributed (i.e. iid) n -dimensional vector with zero mean and variance matrix \sum_e i.e. $N(0, \sum_e)$. The estimable equation for the cointegration relationship is as follows:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \pi X_{t-k} + \varepsilon_t \quad (2)$$

where,

(a) Δ is the first difference operator

⁷ Subtracting X_{t-1} from both sides of Equation 1:

$$(a) \Delta X_t = [\pi_1 - I]X_{t-1} + \pi_2 X_{t-2} + \dots + \pi_k X_{t-k} + \varepsilon_t$$

From the RHS of (a) add and subtract $[\pi_2 - I]X_{t-2}$:

$$(b) \Delta X_t = [\pi_1 - I]X_{t-1} + [\pi_2 + \pi_1 - I]X_{t-2} + \dots + \pi_k X_{t-k} + \varepsilon_t$$

Once again to the RHS of (b) add and subtract $[\pi_3 + \pi_2 - I]X_{t-3}$:

$$(c) \Delta X_t = [\pi_1 - I]X_{t-1} + [\pi_2 + \pi_1 - I]X_{t-2} + [\pi_3 + \pi_2 + \pi_1 - I]X_{t-3} + \dots + \pi_k X_{t-k} + \varepsilon_t$$

Continuing this process will eventually lead to Equation 2.

$$(b) \Gamma_i = \left(I - \sum_{j=1}^i \pi_j \right), i = 1 \dots (k-1)$$

$$(c) \pi = \left(I - \sum_{j=1}^k \pi_j \right)$$

In Equation 2, all terms are in the first difference form except the term πX_{t-k} which is in levels. According to Johansen and Juselius (1990) method, the rank of π determines the number of cointegrating vectors among the variables in X where π is an $(N \times N)$ matrix. If matrix π is of zero rank, the variables in X_t are said to be integrated of order one or a higher order implying the absence of a cointegrating relationship between the variables. In this case, the matrix π is null and Equation 2 reduces to a VAR in first differences. Similarly, if π is full rank, i.e. $Rank(\pi) = N$, all the components of the system of equations are $I(0)$ rather than $I(1)$, that is, the variables in the system are stationary and the cointegration analysis is irrelevant. If $Rank(\pi) = 1$, then there is a single cointegrating vector and the expression πX_{t-1} is the Error-Correction Term (ECT). Further, if the rank of π is $1 \leq Rank(\pi) < (N-1)$, then there is the cointegration case with the number of linearly independent cointegrating vectors being $r = Rank(\pi)$. If π is of reduced rank, $0 < r < n$, π can be expressed as $\pi = \alpha\beta'$ where α and β are $(n \times r)$ matrices, with r denoting the number of cointegrating vectors. Hence, although X_t itself is not stationary, the linear combination given by $\beta'X$ is stationary. Johansen and Juselius (1990) propose two likelihood ratio tests for the determination of the number of cointegrated vectors. One is the maximum eigenvalue test which evaluates the null hypothesis that there are at most r cointegrating vectors against the alternative of $r+1$ cointegrating vectors. The maximum eigenvalue statistic is given by,

$$\lambda_{max} = -T \ln(1 - \lambda_{r+1}) \tag{3}$$

where $\lambda_{r+1}, \dots, \lambda_n$ are the $n-r$ smallest squared canonical correlations and T = the number of observations. The second test is based on the trace statistic which tests the null hypothesis of r cointegrating vectors against the alternative of r or more cointegrating vectors. This statistic is given by,

$$\lambda_{trace} = -T \sum \ln(1 - \lambda_i) \tag{4}$$

In order to apply the Johansen and Juselius (1990) procedure, a lag length must be selected for the VAR. The lag length is selected on the basis of the Akaike Information Criterion (AIC). Let T be the number of usable observations, m the number of components of the vector series X_t and p the lag being considered, the model with intercept terms to determine AIC statistics is calculated by,

$$AIC(p) = T \ln \left| \sum (p) \right| + 2(m + pm^2) \tag{5}$$

where, $\sum(p)$ is the variance-covariance matrix of the OLS residual from the reduced form VAR model which may be written as:

$$X_t = \alpha + A_1 X_{t-1} + \dots + A_p X_{t-p} + \varepsilon_t \quad (6)$$

where α is an $(m \times 1)$ vector of constants, $A_1 + \dots + A_p$ are $(m \times m)$ matrices of constant coefficients and ε_t is an $(m \times 1)$ vector of serially uncorrelated errors with mean vector 0 and contemporaneous variance-covariance matrix \sum_0 . Similarly, another criteria for the selection of lags is Schwarz Information Criterion (SBC) and is calculated by,

$$SBC(p) = T \ln \left| \sum(p) \right| + (m + pm^2) \ln(T) \quad (7)$$

The value of p which is selected is the one yielding the minimum of $AIC(p)$ and $SBC(p)$. In the following section, the results of the analysis are presented by using the methodologies outlined earlier.

IV. RESULTS OF THE ANALYSIS

With regard to the first objective of this study, that is, to find equilibrium or long run relationships between the macroeconomic variables, a test of unit roots is conducted on the variables under consideration before examining cointegrating relationships between the variables using the method suggested by Johansen and Juselius (1990). So far as unit root testing is concerned, focus is placed on the application of the ADF sequential search procedure. The variables examined for unit root consists of CPI, RGDP, M2 and RT. Every variable is transformed to logarithms. The parameter of interest for the test of unit root in the different autoregressive model as presented in Table 1 is γ coefficients. If $\gamma = 0$, the time series sequence is considered as a non-stationary or having unit root. The critical values of γ depend on the form of regression whether that is pure random walk or explicit introduction of deterministic elements (drift term and time trend) and their corresponding statistics labeled as τ_τ (pure random walk), τ_μ (drift term) and τ (time trend). While selecting the lag length (ρ) of the first difference of the dependent variable, that has been introduced to overcome the problem of serial correlation of the dependent variable as depicted in Equation 2 in Table 1, this study resorts to the AIC.

TABLE 2: Unit Root Test of CPI, RGDP, M2 and RT (1975-2006)

Variables	α	@ trend	$\beta_1(\rho_1)$	γ	τ_τ	ϕ_3	ϕ_2	τ_μ	ϕ_1	τ
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CPI	.1912	.0028	.3041	-.0451	-.5219	-	-	-	-	-
	.1148	no	.2746	-.0138	-	0.07	-	-1.56	-	-
	no	no	.4756	.0101	-	-	2.95	-	-	2.792
	no	-.004	.2451	.0319	-	-	-	-	.432	-
RGDP	3.298	.0140	-.231	-.2803	-	-	-	-	-	-
	-	-	-	-	2.2659	-	-	-	-	-
	-.228	no	-.352	-.0233	-	3.26	-	1.97	-	-
	no	no	-.2703	.0046	-	-	3.25	-	-	6.05
M2	0.311	0.002	0.252	-0.021	-0.205	-	-	-	-	-
	0.243	no	0.238	-0.011	-	0.004	-	-2.011	-	-
	no	no	0.664	0.005	-	-	3.30	-	-	2.17
	no	-0.006	0.198	0.021	-	-	-	-	0.09	-
RT	8.05	-0.127	0.054	-0.59	-3.27	-	-	-	-	-
	2.317	no	-.100	-.245	-	-	2.03	-1.53	-	-
	no	no	.324	-.251	-	-	2.81	-	-	-.963
	no	-.0018	-.225	-0.030	-	-	-	-	2.82	-

Columns (6), (9) and (11) of the results presented in Table 2 show the calculated values of tau (τ) statistics for the three different models representing presence of both the constant and time trend (τ_τ), presence of drift term but no time trend (τ_μ), and pure random walk model (τ) respectively. The calculated values of τ_τ , τ_μ and τ at 5 percent significant level respectively are -3.60, -3.00 and -1.95 in making use of 32 samples in this study. If the calculated τ_τ s values of CPI, RGDP, M2 and RT, as shown in Column (6), are compared with table value of -3.60, no single statistic is found to be greater than table value depicting the variables under consideration are unit root in the deterministic trend (both drift term and time trend). Similarly, if the table value of -3.00 at 5 percent significant level, in case of the model in presence of drift term but no time trend, is compared to (τ) values, the variables comprising CPI, RGDP, M2 and RT are found to be non-stationary or unit root. The calculated statistics possessing positive sign are ruled out because the rejection of null should be significantly negative.

The results explained above are further supported by the calculated larger values of ϕ_i comprising 7.24, 5.68 and 5.18 at 5 percent significant level under the joint hypotheses of $\phi_3(\gamma=\alpha_2=0)$, $\phi_2(\alpha_0=\gamma=\alpha_2=0)$ and $\phi_1(\alpha_0=\gamma=0)$ respectively. Since the calculated values of ϕ_3 , ϕ_2 and ϕ_1 , as presented in Columns (7), (8) and (10), all the variables under the test viz., CPI, RGDP, M2 and RT are found to be less than that of the critical values, under the model with different restriction, the variables are said to be unit root. In summing up the result of unit root test as explained above, the variables analyzed in this study are unit root variables in their level form and hence can be applied for the estimation of equilibrium relationship by way of cointegration.

With regard to the estimation of equilibrium relationships among the variables, the use of the Johansen and Juselius (1990) procedure is applied in identifying the number of cointegrating vectors and using them to obtain long run relationships between a set of variables. The number of distinct cointegrating vectors can be obtained by checking the

significance of the characteristics roots of ($N \times N$) matrix π of level variables of restricted VAR model as shown in Equation 2. It is known that the rank of a matrix π is equal to the number of its characteristics roots that differ from zero. In the cointegration analysis, only estimates of π and its characteristics roots are worked out. As mentioned in the methodology, the test for the number of characteristic roots that are insignificantly different from unity can be conducted using 'trace statistics' and 'maximum eigenvalue statistics'. The objective of tests for cointegration is to test for the rank of π by testing whether the eigenvalues of estimated, $\hat{\pi}$ are significantly different from zero (Theil and Boot, 1962). Two statistics are used to test for the number of cointegrating vectors in the Johansen and Juselius (1990) methodology: the trace and maximum eigenvalue statistics. In the trace test, the null hypothesis is that the number of cointegrating vectors is less than or equal to k , where k is 0, 1, 2 or 3. In each case, the null hypothesis is tested against the general alternative. The maximum eigenvalue test is similar, except that the alternative hypothesis is explicit. The null hypothesis $k=0$ is tested against the alternative that $k=1$, $k=1$ against the alternative $k=2$, etc. The critical values for these tests are tabulated by Johansen and Juselius (1990). Both the test statistics and the estimated cointegrating vector, setting the coefficient of M2 equal to one, are reported in Tables 3 and 4.

As the objective of this study is to examine long run equilibrium relationships among the major macroeconomic variables of Nepal viz, M2, RGDP, CPI and RT utilizing the procedure outlined earlier, the test of maximum eigenvalue and the trace statistics are employed in order to obtain the number of cointegrating vectors and hence examine the long run parameters by way of normalization. Since the individual variable show no visible trend, it is decided to use a model where time trend $b=0$ and $\mu \neq 0$ and unrestricted (Johansen and Jesileus, 1990). The estimated values of the characteristic roots (eigenvalues) of the matrix π in descending order are $\hat{\lambda}_1 = .64140$, $\hat{\lambda}_2 = .42218$, $\hat{\lambda}_3 = .18706$ and $\hat{\lambda}_4 = .11698$. The trace (λ_{trace}) and maximum eigenvalues (λ_{max}) statistic corresponding to $\hat{\lambda}_1$, for example, are calculated as $\lambda_{(0)} = -32[\ln(1-.64140) + \ln(1-.42218) + \ln(1-.18706) + \ln(1-.11698)] = 59.0712$ and $\lambda_{(0,1)} = -32\ln(1-0.64140) = 31.7922$ respectively. The calculated values of λ_{trace} and λ_{max} for the various possible values of r are reported in Column (4) of Tables 3 and 4.

TABLE 3 : Test Based on Maximum Eigenvalue (λ_{max})
Four Variable VAR (M2, RGDP, CPI, RT), Order of VAR = 1 (1975 to 2006)

Null Hypothesis	Alternative Hypothesis	Eigenvalues (λ_i)	Max-Eigen Statistics (λ_{max})	0.05 Critical Value	0.10 Critical Value
$r = 0^*$	$r = 1$	.64140	31.7922	27.4200	24.9900
$r \leq 1$	$r = 2$	.42218	17.0031	21.1200	19.0200
$r \leq 2$	$r = 3$	.18706	6.4199	14.8800	12.9800
$r \leq 3$	$r = 4$	.11698	3.8568	8.0700	6.5000

*denotes rejection of the hypothesis at the 0.05 level

Maximum eigenvalue test indicates 1 cointegrating vector, that is, $r = 1$

TABLE 4 : Test Based on Trace Statistic(λ_{trace})
 Four Variable VAR (M2, RGDP, CPI, RT), Order of VAR = 1 (1975 to 2006)

Null Hypothesis	Alternative Hypothesis	Eigenvalues (λ_i)	Trace Statistics (λ_{trace})	0.05 Critical Value	0.10 Critical Value
$r = 0$	$r \geq 1$	.64140	59.0719	48.8800	45.7000
$r \leq 1$	$r \geq 2$	.42218	27.2798	31.5400	28.7800
$r \leq 2$	$r \geq 3$	.18706	10.2767	17.8600	15.7500
$r \leq 3$	$r \geq 4$	.11698	3.8568	8.0700	6.5000

*denotes rejection of the hypothesis at the 0.05 level
 Trace test indicates 1 cointegrating vector, that is, $r = 1$

Using first order VAR of the four variables under investigation, the hypothesis of $r=0$ is uniformly rejected in favor of the alternative $r=1$ employing the maximum eigenvalue tests.⁸ The maximum eigenvalue test of $r=1$ versus $r=2$ fails to reject the null hypothesis of $k=1$ implying one cointegrating vector. Turning to the trace test, $r \leq 1$, $r \leq 2$ and $r \leq 3$ cannot be rejected while the hypothesis $r=0$ can be rejected at 5 percent significant level (i.e. $59.0719 > 48.880$). However, all the trace statistics found other than first row are smaller than the 5 percent critical value which is tantamount to rejection of more than one cointegrating vector. Consequently, this test indicates that M2 is cointegrated with RGDP, CPI and RT. Moreover, there appears to be a single cointegrating vector. If $\text{rank}(\pi) = 1$, then there is a single cointegrating vector and the expression πX_{t-1} is the ECT. In practice the cointegrating vectors $\hat{\beta}_i (i = \dots, r)$ are normalized by setting one of the elements arbitrarily to 1. Let the estimated number of cointegrating vectors be r and cointegrating vectors are $\hat{\beta}_1 \dots \hat{\beta}_r$ corresponding to the r largest roots $\hat{\lambda}_1 \dots \hat{\lambda}_r$ and corresponding adjustment vectors be $\hat{\alpha}_1 \dots \hat{\alpha}_r$, which can be written as $\hat{\beta} = [\hat{\beta}_1 \dots \hat{\beta}_r]$ and $\hat{\alpha} = [\hat{\alpha}_1 \dots \hat{\alpha}_r]$ or it can be shown as $\hat{\pi} = \hat{\alpha} \hat{\beta}'$. In the present study, since the estimated number of cointegration vector $r=1$, then the eigen vector (cointegrating vectors) is β_1 corresponding to the r largest root $\hat{\lambda}_1$ with the corresponding adjustment vectors be $\hat{\alpha}_1$.

⁸ VAR Lag Order Selection Criteria (Endogenous variables: M2 RGDP CPI and RT)

Lag	LogL	LR	FPE	AIC	SBC	HQ
1	197.1966	NA	2.84e-11*	-12.94261*	-12.18135*	-12.70989*
2	202.0188	6.888866	6.67e-11	-12.14420	-10.62168	-11.67875
3	215.2170	15.08373	9.67e-11	-11.94407	-9.660296	-11.24590
4	226.7435	9.879785	1.97e-10	-11.62453	-8.579494	-10.69363

Where, * indicates lag order selected by the criterion, LR: sequential modified LR test statistics (each test at 5% level, FPE: final prediction error, AIC: Akaike Information Criterion, SBC: Schwarz Information Criterion, and HQ: Hanna-Quinn Information Criterion.

Analyzing the normalized cointegrating vector and speed of adjustment coefficients in the present study, single cointegrating vector $r=1$ has been selected. The estimated cointegrating vector corresponds to $\beta' = (\hat{\beta}_1 \hat{\beta}_2 \hat{\beta}_3 \hat{\beta}_4)$ is $\beta' = (3.4705, -2.8379, -5.1788, -0.0401)$ which if normalized with respect to $\hat{\beta}_1$, is $\beta' = (-1.0000, 0.8177, 1.4922, 0.0115)$. The economic interpretation of the normalized coefficient is that there is long term positive relationship between M2 and RGDP, CPI and RT with the coefficient shown by normalized cointegrating vector. The corresponding speed of adjustment or vector weight for the variables M2, RGDP, CPI and RT respectively are $\hat{\alpha} = [-.07710 \ .00857 \ .01246 \ 2.0863]$. In this vector, one and only coefficient of ECT is found to be statistically significant with Student t statistics of -5.4272, R^2 is 0.5039 and DW statistics of 1.88.

Johansen (1995) also gives more formal tests for discriminating between the alternative models. The test statistics involve comparing the number of cointegrating vectors under the null and alternative hypotheses. Denoting the two sets of ordered characteristic roots of the unrestricted and restricted models respectively by $\hat{\lambda}_1, > \hat{\lambda}_2 \dots > \hat{\lambda}_r$ and $\hat{\lambda}^*_1, > \hat{\lambda}^*_2 \dots > \hat{\lambda}^*_r$, asymptotically, the statistic $-\tau \sum_{i=r+1}^n [\ln(1-\hat{\lambda}_i^*) - \ln(1-\hat{\lambda}_i)]$ has a χ^2 distribution with $(n-r)$ degrees of freedom. The results interpreted above are based on Model C, i.e. unrestricted intercepts and no trends in VAR model. If the use of Case C is not justified after the examination, Case B is considered to be preferable. The eigenvalues in the restricted and unrestricted version of Models B and C as well as other specifications are presented in Table 5 for the purpose of comparing the models under different restrictions.

TABLE 5: Test of Model based on Different Restriction
(Variables: M2, RGDP, CPI and RT) (1975 to 2006)

Model specification	Eigen Values ($\hat{\lambda}_i$ or $\hat{\lambda}_i^*$)			
Case A No intercepts or trends in VAR	.9770	.4280	.2260	.1300
Case B Restricted intercepts, no trends in VAR	.9771	.5235	.1351	-
Case C Unrestricted intercepts, no trends in VAR	.6414	.4221	.1870	.1169
Case D Unrestricted intercepts, restricted trends in VAR	.6480	.4231	.3575	.1584
Case E Unrestricted intercepts, unrestricted trends in VAR	.5788	.4225	.3569	.0061

The eigenvalues in the unrestricted version of Model B are $\hat{\lambda}_i$: .9771, .5235, and .1351 and those in the restricted version of Model C are $\hat{\lambda}_i^*$: .6414, .4221, .1870, and .1169. The statistic to test the model selection assumes the value $-32 \sum_{i=2}^3 [\ln(1-\hat{\lambda}_i^*) - \ln(1-\hat{\lambda}_i)] = 4.1922$ (since $T=32$ and $r=1$). This is distributed as a χ^2 with $(N-r)=(4-1)=3$ d.f. The 5% critical value is 7.88 and hence the statistic is insignificant. Therefore, the restriction imposed by the chosen model viz. Model C is accepted.

TABLE 6 : Test of Parameter Restriction (Variables: M2, RGDP, CPI and RT)
(1975 to 2006)

Restriction on	Long run Coefficient				χ^2 Value
	M2	RGDP	CPI	RT	
M2 = 0	none	none	none	none	10.367
RGDP = 0	-1	0.000	1.903	0.018	3.5324
CPI = 0	-1	1.704	0.000	-0.487	11.555
RT = 0	-1	0.759	1.476	0.000	3.3192
M2	M2=1	RGDP=1	CPI=1	RT=1	12.0407
M2	M2=0	RGDP=0	CPI=0	RT=0	31.7922

So far, as the test of parameter restriction is concerned, the restriction of the parameters of normalized cointegrating vector such that either $\beta_1 = 0$ or $\beta_2 = 0$ or $\beta_3 = 0$ or $\beta_4 = 0$ entails one restriction each on one cointegrating vector, where the likelihood ratio test has a χ^2 distribution with $r(N-s)$ or $1(4-3)=1$ d.f. (where r is the number of cointegrating vector, N the number of variables and s the number of independent cointegrating parameters). The calculated value of χ^2 for each variable restricted equals to zero are presented in the last column of Table 6. Since the tabulated value with 1 degree of freedom is 3.841 at 5 percent significant level, the zero restrictions in case of RGDP and RT cannot be rejected while such restrictions are rejected in case of M2 and CPI.

The subsequent part of the analysis, in turn, is to analyze demand for money function in Nepal as an application in examining long run relationship between the variables using the methodology of Johansen and Juselius (1990). Unavailability of disaggregated data particularly in developing countries like Nepal is one of the big constraints for the econometric research work. The selection of the relevant variables that are considered important for the empirical analysis have been chosen on the basis of the different theories of demand for money and empirical analysis related to this area. As there are no quarterly time series on GDP, annual data have been used. Two interest rate variables are included in the VAR system: 90-day treasury bill rate proxied for the short-term interest rate and one year bond yield proxied for the long term interest rate. This study examines whether M1 or M2 monetary aggregates are the appropriate variable included in the VAR system in explaining the demand for money in Nepal. M1 monetary aggregate consists of currency held by the public and demand deposits of commercial banks whereas M2 incorporates time deposits in M1 monetary aggregate. As guided by various theoretical as well as empirical findings, the regressors consist of different proxies of RGDP, interest rate variables.

A general specification of the long run demand for money is $M^d = f(P, Q, Z)$ where M^d , P , Q and Z denote the nominal money stock, the level of prices, nominal income level and all other variables that affect money demand respectively. Assuming that economic agents do not suffer from money illusion, M^d can be written as

$M^d/P = m^d = f(Q/P, Z) = f(q, Z)$. This indicates that demand for real money balance m^d is a function of real income q , and some other variables. Keeping these theoretical underpinning, this study selects three variables VAR comprising M1, RGDP and RT to examine demand for money in Nepal. The results of maximum eigenvalue (λ_{max}) and trace statistics (λ_{trace}) are presented in Table 7 and Table 8 respectively.

TABLE 7: Test Based on Maximum Eigenvalue (λ_{max})
Three Variable VAR (M1, RGDP and RT), Order of VAR = 1 (1975 to 2006)

Null Hypothesis	Alternative Hypothesis	Eigenvalues (λ_i)	Max-Eigen. Statistics (λ_{max})	0.05 Critical Value	0.10 Critical Value
$r = 0$	$r = 1$ **	0.4852	19.9199	21.1316	19.0200
$r \leq 1$	$r = 2$	0.3098	11.1244	14.2646	12.9800
$r \leq 2$	$r = 3$	0.0605	1.8733	3.8414	6.5000

* denotes rejection of the hypothesis at the 0.05 level

** denotes rejection of the hypothesis at the 0.10 level

Max-eigenvalue test indicates 1 cointegrating vector, that is, $r = 1$

TABLE 8: Test Based on Trace Statistic (λ_{trace})
Three Variable VAR (M1, RGDP and RT), Order of VAR = 1 (1975 to 2006)

Null Hypothesis	Alternative Hypothesis	Eigenvalues (λ_i)	Trace Statistics (λ_{trace})	0.05 Critical Value	0.10 Critical Value
$r = 0$ *	$r \geq 1$	0.4852	32.9177	29.7970	28.7800
$r \leq 1$	$r \geq 2$	0.3098	12.9977	15.4947	15.7500
$r \leq 2$	$r \geq 3$	0.0605	1.8733	3.8414	6.5000

* denotes rejection of the hypothesis at the 0.05 level

Trace test indicates 1 cointegrating vector, that is, $r = 1$

Analyzing the normalized cointegrating vector and speed of adjustment coefficients, single cointegrating vector $r=1$ has been found. The estimated cointegrating vector corresponds to $\beta' = [\beta_1 \ \beta_2 \ \beta_3]$ or $[-6.545 \ -8.685 \ -0.562]^9$ which if normalized with respect to $\hat{\beta}_1$, becomes $\beta' = [1.000 \ 1.3269 \ -0.086]$. The t statistics for RGDP is 15.09 and for TR 4.59. The economic interpretation of the normalized coefficient is that there is long term positive relationship between M1 and RGDP and between M1 and RT

⁹ The corresponding Eigenvector is:
$$\begin{bmatrix} M1 & RGDP & SR \\ -6.545 & -8.685 & 0.562 \\ -1.815 & 0.050 & 0.301 \\ 4.113 & 6.792 & -0.187 \end{bmatrix}$$

as shown by the normalized cointegrating vector. The corresponding speed of adjustment or weight vector for the vector of variables [M1 RGDP SR] is $\hat{\alpha} = [-0.2032 \quad -0.0631 \quad -6.461]$ with standard error of (0.056 0.062 2.267).

The coefficient for our dynamic specification confirms the fact that the rate of growth of M1 depends positively and significantly on both the rate of growth on the real GDP and interest rate (short-term). However, the positive and significant coefficient in the long run relationship prompts it to opine that money is a luxury good because higher the level of income, the more rapid is the rate of growth of money. Notwithstanding various theories and empirical studies related to demand for money both in case of developed as well as developing countries have an unanimity to include interest rate as an argument in the demand for money, there is a controversy regarding the choice of interest rate as the proxy for opportunity cost of holding money. The appropriate choice rests on long as well as short-term interest rate with due emphasis on former in the Keynesian demand for money.

So far, a single cointegrating vector was found in case the demand for real money balance is proxied by M1, as the results presented in Tables 7 and 8; a test conducted replacing M1 by M2 in the system of VAR yields an absence of even a single cointegrating vector.

TABLE 9 : Test Based on Maximum Eigenvalue (λ_{max})
Three Variable VAR (M2, RGDP and RT), Order of VAR = 1 (1975 to 2006)

Null Hypothesis	Alternative Hypothesis	Eigenvalues (λ_i)	Max-Eigen Statistics (λ_{max})	0.05 Critical Value	0.10 Critical Value
$r = 0$	$r = 1$	0.365	13.635	21.132	18.034
$r \leq 1$	$r = 2$	0.277	9.765	14.264	16.659
$r \leq 2$	$r = 3$	0.083	2.624	3.841	8.006

Max-eigenvalue test indicates no cointegrating vector in the VAR

TABLE 10: Test Based on Trace Statistic(λ_{trace})
Three Variable VAR (M2, RGDP and RT), Order of VAR = 1 (1975 to 2006)

Null Hypothesis	Alternative Hypothesis	Eigenvalues (λ_i)	Trace Statistics (λ_{trace})	0.05 Critical Value	0.10 Critical Value
$r = 0$	$r \geq 1$	0.365	26.024	29.797	27.321
$r \leq 1$	$r \geq 2$	0.277	12.389	15.494	13.683
$r \leq 2$	$r \geq 3$	0.083	2.624	3.841	8.007

Trace test indicates no cointegrating vector in the VAR. system

Test based both on the maximum eigenvalue statistics and trace statistic can not reject the null hypothesis of no cointegration, i.e. ($r = 0$) as against the general alternative of

one or more cointegrating vectors (i.e. $r > 0$) (in case of maximum eigenvalue statistics) and specific alternative of $r = 1, 2, 3$ cointegrating vector (in case of trace statistic) since the values of computed (λ_{max}) and (λ_{trace}) statistics are found to be less than the critical values as shown in Table 9 and 10. Therefore, both the (λ_{max}) and (λ_{trace}) statistics supports the hypothesis of no cointegration among the variables. Hence, what can be concluded is that the choice of the monetary aggregate variables, i.e. M1 versus M2 can have significant bearings on the determination of cointegrating vectors. Single cointegrating vector is obtained in case of choice of M1 as against no cointegration among the variables using M2 monetary aggregate.

V. CONCLUSION

Among the alternative approaches available to the researchers interested in estimating long run economic relationships, this paper employs cointegration method of Johansen and Juselius (1990) in examining economic relationships among macroeconomic variables. The variables used for the analysis are M2, RGDP, CPI and RT. By utilizing 32 annual data observations covering the period from 1975 to 2006 and the said variables under consideration, one cointegrating vector is found to be statistically significant and hence the result is the same as interpreting the coefficients of ECM. The ADF sequential search procedure supports an existence of unit roots in the variables. This paper also estimates the demand for money function in Nepal as an application of long run relationships between the variables using the method outlined earlier. The coefficients of income and interest rate elasticity of M1 monetary aggregate so estimated are possessing theoretical a priori as represented by the normalized cointegrating vector contrary to an absence of cointegrating relationships in case of the replacement of M1 by M2. As the coefficients derived in this paper belong to restricted VAR method as opposed to the past practices in estimating cointegrating vector using the Engle-Granger (1987) two-step procedure, the coefficients are supposed to be robust and consistent because of the imposition of stronger restrictions. Further, estimating long run relationships by merging structural models and time series econometrics utilizing SVAR approach is an area of further research in Nepal.

REFERENCES

- Barro, R.J. 1979. "On the Determination of the Public Debt." *Journal of Political Economy* 87: 940-971.
- Bernanke, B. 1986. "Alternative Explanations of the Money-income Correlation." *Carnegie-Rochester Conference Series on Public Policy* 25: 49-100.
- Beyer, A. 1998. "Modelling Money Demand in Germany." *Journal of Applied Econometrics* 13: 57-76.
- Bhargava, A. 1986. "On the Theory of Testing for Unit Roots in Observed Time Series." *Review of Economic Studies* 53: 369-384.
- Blanchard, O. 1989. "A Traditional Interpretation of Macroeconomic Fluctuations." *American Economic Review* 79: 1146-1164.
- Blanchard, O. and M. Watson. 1986. "Are Business Cycles Alike?." In Robert J. Gordon, eds., *The American Business Cycle*. Chicago: University of Chicago Press: Chicago.
- Davidson, J.E.H., Hendry, D.F., Srba, F. and S. Yeo. 1978. "Econometric Modeling of the Aggregate Time-series Relationship between Consumers' Expenditure and Income in the United Kingdom." *The Economic Journal* 88: 661-692.
- Dickey, D.A. and W.A. Fuller. 1979. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *Journal of the American Statistical Association* 74: 427-431.
- Dickey, D.A. and W.A. Fuller. 1981. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root." *Econometrica* 49: 1057-1072.
- Dickey, D.A., D.W. Jansen and D.L. Thornton. 1991. "A Primer on Cointegration with an Application to Money and Income." *Federal Reserve Bank of St. Louis* : 58-78.
- Enders, W. 2004. *Applied Econometric Time Series*. New York: John Wiley & Sons.
- Engle, R.F. and C.W.J. Granger. 1987. "Co-integration and Error Correction: Representation, Estimation and Testing." *Econometrica* 55: 251-276.
- Friedman, M. 1957. *A Theory of the Consumption Function*. Princeton: Princeton University Press.
- Goldfeld, S. 1973. "The Demand for Money Revisited." *Brookings Paper on Economic Activity* 3: 577-638.
- Jevons, W.S. 1862. "On the Study of Periodic Commercial Fluctuations." in D. F. Hendry and M.S. Morgan, 1995 (eds.) *The Foundations of Econometric Analysis*. Cambridge: Cambridge University Press.
- Johansen, S. 1988. "Statistical Analysis of Cointegration Vectors." *Journal of Economic Dynamics and Control* 12: 231-254.
- Johansen, S. and K. Juselius. 1990. "Maximum Likelihood Estimation and Inference on Cointegration - with Applications to the Demand for Money." *Oxford Bulletin of Economics and Statistics* 52: 169-210.
- Johansen, S. 1995. *Likelihood based Inference in Cointegrated Vector Autoregressive Models*. Oxford: Oxford University Press.
- Keating, John W. 1989. "Monetary Policy Regimes and Macroeconomic Fluctuations." *Working Paper* 139, Washington University, St. Louis.

- Khataiwada, Y.B. 1997. "Estimating the Demand for Money in Nepal: Some Empirical Issues." *Economic Review, NRB Occasional Paper* 9.
- Lucas, R. Jr. and T. J. Sargent. 1978. "After Keynesian Macroeconomics." In *After the Phillips Curve: Persistence of High Inflation and High Unemployment*, Federal Reserve Bank of Boston Conference Series 19: 49-72.
- Nachane, D.M. 2006. "*Econometrics-Theoretical Foundations and Empirical Perspectives.*" New Delhi: Oxford University Press. .
- Nelson, C.R. and C.I. Plosser. 1982. "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications." *Journal of Monetary Economics* 10: 139-162.
- Pandey, R.P. 1998. "An application of Cointegration and Error Correction Modelling: Towards Demand for Money in Nepal." *Economic Review, NRB Occasional Paper* 10.
- Phelps, B.E.H. and S.V. Hopkins. 1957. "Wage Rates and Prices: Evidence for Population Pressure in the Sixteenth Century." *Economica* 24: 289-306.
- Phillips, P.C.B. 1987. "Towards a Unified Asymptotic Theory for Autoregression." *Biometrika* 74: 535-547.
- Phillips, P.C.B. 1987. "Time-series Regression with a Unit Root." *Econometrica* 55: 277-301.
- Phillips, P.C.B. and P. Perron. 1988. "Testing for a Unit Root in Time-series Regression." *Biometrika* 75: 335-346.
- Sims, C.A. 1980. "Macroeconomics and Reality." *Econometrica* 48: 1-48.
- Sims, C.A. 1986. "Are Forecasting Models Usable for Policy Analysis?." *Quarterly Review Federal Reserve Bank of Minneapolis*, Winter: 2-16.
- Stock, J.H. and M. Watson. 1988. "Testing for Common Trends." *Journal of the American Statistical Association* 83: 1097-1107.
- Theil, H. and J.C.G. Boot. 1962. "The Final form of Econometric Equation systems." *Review of the International Statistical Institute* 30: 136-152.
- Vogelvang, B. 2005. "*Econometrics: Theory and Applications with EView.*" Pearson Education Limited.

