CHAPTER – III

Data and Methodology

3.1 Source and Nature of Data

In the present study the relationship between output level and money supply for the period 1959 to 2003(45 Years) has been analyzed. For this study, we have used the data sets of GDP (1990=100) for output and both M1 & M2 for money supply. Though the data series for GDP has been given in different bases in various issues, we have changed all bases in the same year i.e. 1990 as a base year. M1 includes currency held by non-bank public and demand deposit held at monetary sector.M2 consists of M1 and time deposits held at commercial banks. The source of the data sets of the present study is International Financial Statistics (IFS), a publication of International Monetary Fund (IMF). The line 34 of IFS represents M1 while the line 35 represents quasi money compromising time, savings and foreign currency deposits of resident sectors other than Central Govt. M2, therefore, gives a broader measure of money supply. We have used various issues of IFS for the collection of data.

3.2 Methodology Adopted

For the analysis of the study we have used various econometric tools. Several models, which are based on econometric analysis, have been used for the present work. Testing for stationarity has been applied based on unit root test and ACF / PACF (correlogram). Cointegration test, UVAR modeling, Vector Error Correction modeling, Granger

Causality Test, ARIMA structure and Chow Test are some of the examples of econometric tools used in the present study.

3.3 Unit Root Tests

When time series data are used in econometric analyses, the preliminary statistical step is to test the stationary of each individual series. Unit root tests provide information about stationarity of the data. Nonstationarity data contain unit roots. The main objective of unit root tests is to determine the degree of integration of each individual time series. Various methods for unit root tests have been used in the present study. Some of which are being stated and explained below:

3.3.1 Dickey Fuller unit root test

The test of unit root was proposed by David A. Dickey and Wayne A. Fuller in 1976. To discuss the Dickey-Fuller tests, the model has been considered as following:

$$y_t = \beta_0 + \beta_1 t + u_t \tag{3.1}$$

$$u_t = \alpha u_{t-1} + \varepsilon_t \tag{3.2}$$

Where ε_t is a covariance stationary process with zero mean. The reduced form for this model is

$$yt = \gamma + \delta t + \alpha y_{t-1} + \varepsilon_t \tag{3.3}$$

Where $\gamma = \beta_0 (1-\alpha) + \beta_1 \alpha$ and $\delta = \beta_1 (1-\alpha)$.

This equation is said to have a unit root if $\alpha=1$(in which case $\delta=0$)

3.3.2 Augmented Dickey Fuller unit root test

In order to test for the existence of unit roots, and to determine the degree of differencing necessary to induce stationarity, we have applied the augmented Dickey-Fuller test. Dickey and Fuller (1976, 1979), Said and Dickey (1984), Phillips (1987), Phillips and Perron(1988), and others developed modifications of the Dickey-Fuller tests when ε_t is not white noise. These tests are called "augmented" Dickey-Fuller (ADF) tests. The results of the augmented Dickey-Fuller test (ADF) determine the form in which the data should be used in any subsequent econometric analyses. The test is based upon estimating the following equations:

$$\Delta y_t = \gamma + \alpha y_{t-1} + \sum_{j=2}^{k} \theta_j \Delta y_{t-j+1} + e_t \quad (3.4)$$

$$\Delta y_t = \gamma + \delta t + \alpha y_{t-1} + \sum_{j=2}^{k} \theta_j \Delta y_{t-j+1} + e_t \quad (3.5)$$

$$\Delta y_t = \alpha y_{t-1} + \sum_{j=2}^{k} \theta_j \Delta y_{t-j+1} + e_t \quad (3.6)$$

Where, y_t = GDP of Nepal; Δy_t = First differenced series of y_t.

Δy_{t-j+1} = First differenced series of y_t at $(t-j+1)^{th}$ lags. (j = 2 -------- k)

The equation (3.4) is related to ADF test with constant as exogenous, equation (3.5) is based on constant and linear trend as exogenous and ADF test with no exogenous is presented in equation (3.6).

3.3.3 The D-F GLS unit root test

The DF-GLS test developed by Elliott, Rothenberg and Stock (1996), which has greater power than standard ADF test, also is employed in the present study.

The DF-GLS t-test is performed by testing the hypothesis $a_0=0$ in the regression

$$\Delta y_t^d = a_0 y_t^d + a_1 \Delta y_{t-1}^d + \text{-----} + a_p \Delta y_{t-p}^d + \text{error} \tag{3.7}$$

Where y_t^d is the locally de-trended series y_t. The local de-trending depends on whether we consider a model with drift only or a linear trend.

(i) DF-GLS unit root test without time trends (a model with drift only)-

$$y_t^{\mu} = \alpha y^{\mu}_{t-1} + \sum_{i=1}^{k} \Psi i \,\Delta y^{\mu}_{t-i} + u_t \tag{3.8}$$

(ii) DF-GLS unit root test with time trends (a model with linear trend)-

$$y_t^{\tau} = \alpha y^{\mu}_{t-1} + \sum_{i=1}^{k} \Psi i \,\Delta y^{\tau}_{t-i} + u_t \tag{3.9}$$

3.3.4 Phillips –Perron Unit root test

Phillips(1987), Phillips and Perron (1988) generalized the DF tests to situations where disturbance processes, ε_t are serially correlated, other than by augmenting the initial regression with lagged dependent variables as in the ADF procedure. The PP approach is to add a correction factor to the DF test statistic.

Suppose the AR (1) model is,

$$Yt = \mu + \varphi_1 Y_{t-1} + \varepsilon_t \quad \{t = 1, \text{---------}, T\} \tag{3.10}$$

With $Var(\varepsilon_t) \equiv \sigma_\varepsilon^2$.

If ε_t is serially correlated the ADF approach is to add lagged ΔY_t to 'whiten' the residuals. To illustrate the alternative approach the test statistic $T(\varphi_1-1)$ has been considered which is distributed as ρ_μ from the maintained regression with an intercept but no time trend. The PP modified version is,

$$Z\rho_\mu = T(\varphi_1-1) - CF \tag{3.11}$$

Where the correction factor CF is

$$CF = 0.5(s^2_{Tl} - s_\varepsilon^2) / \left(\sum_{t=2}^{T}(Y_{t-1} - \bar{Y}_{-1})^2/T^2\right) \tag{3.12}$$

And,

$$s_\varepsilon^2 = T^{-1}\sum_{t=1}^{T}\varepsilon_t^2 \tag{3.13}$$

$$s^2_{Tl} = s_\varepsilon^2 + 2\sum_{s=1}^{l} W_{sl}\sum_{t=s+1}^{T}\varepsilon_t\varepsilon_{t-s}/T \tag{3.14}$$

$$W_{sl} = 1 - s/(l+1) \quad \text{and} \quad \varepsilon_t = Y_t - \mu - \varphi_1 Y_{t-1}$$

$$\bar{Y}_{-1} = \sum_{t=2}^{T} Y_t/(T-1) \tag{3.15}$$

(Patterson 2002:264)

3.3.5 The KPSS unit root test

There are many tests for unit roots with stationarity as null but the most common one is the KPSS test due to Kwiatowski et al. All the tests for moving average unit roots can be regarded as tests with stationarity as null. The KPSS test is an analog of Phillips-Perron test. The model for KPSS test is;

$$\varphi(L)y_t = \alpha_t + \beta t + \varepsilon_t \qquad (3.16)$$

$$\alpha_t = \alpha_{t-1} + \eta_t \quad \alpha_0 = \alpha \quad (t = 1,2,\text{---------}T)$$

where $\varepsilon_t \sim IID(0, \sigma_\varepsilon^2)$, $\eta_t \sim IID(0, \sigma_\eta^2)$

ε_t and η_t are independent and $\varphi(L)$ is a p^{th}- order autoregression. The test for stationarity in this model is,

H_0: $\sigma_\eta^2 = 0$ vs. $H_1 > 0$. Under H_1 the model has been an ARIMA model.

It has been argued that tests with stationarity as null can be used to confirm the results of the usual unit root tests. The two tests are:

Test 1 (usual test)	Test 2 (KPSS test)
H_0: y_t is nonstationary (unit root) H_1: y_t is stationary	H_0: y_t is stationary H_1: y_t is nonstationary(unit root)

If both tests reject their nulls, their will be no confirmation. But if test 1 rejects the null but test 2 does not (or vice versa) the confirmation can be drawn (Maddala 2001:553).

3.3.6 ERS Point Optimal Test

The ERS Point Optimal test is based on the following quasi-differencing regression equation:

$$d(y_t/\alpha) = d(x_t/\alpha)'\delta(\alpha) + \eta_t \qquad (3.17)$$

where x_t stands for either a constant or a constant along with trend and $\delta(\alpha)$ be the OLS estimates from this regression. The residual from this equation is:

$$\eta_t(\alpha) = d(y_t/\alpha) - d(x_t/\alpha)'\delta(\alpha) \qquad (3.18)$$

Let SSR (α) = $\sum \eta_t^2(\alpha)$ be the sum of squared residuals function. The ERS point optimal test statistic of the null that $\alpha = 1$ against the alternative that $\alpha = \bar{\alpha}$, is then defined as;

$$P_T = \text{SSR}(\bar{\alpha}) - \bar{\alpha}\,\text{SSR}(1)/f_0 \qquad (3.19)$$

where f_0 is an estimator of the residual spectrum at frequency zero. In order to compute the ERS test, it is necessary to specify the set of exogenous regressors x_t and a method for estimating f_0.

3.3.7 Ng and Perron (NP) Tests

Ng and Perron (2001) construct four test statistics that are based upon the GLS de-trended data y_t^d. These test statistics are modified forms of Phillips and Perron Z_α and Z_t statistics, the Bhargava(1986) R_1 statistics and the ERS Point Optimal statistic. Defining the term:

$$k = \sum_{t=2}^{T} (y^d_{t-1})^2 \Big/ T^2 \qquad (3.20)$$

The modified statistics can be written as;

$$MZ^d_\alpha = [T^{-1}(y_t^d)^2 - f_0]/2k$$

$$MZ^d_t = MZ_\alpha \times MSB$$

$$MSB^d = (k/f_0)^{1/2} \qquad (3.21)$$

$$MP^d_t = \{ \ \bar{c}^2 k - \bar{c} T^{-1} (y^d{}_T)^2 \Big/ f_0 \qquad \text{if } x_t = \{1\}$$

$$= \{ \bar{c}^2 k - (1-\bar{c}) T^{-1} (y^d{}_T)^2 \Big/ f_0 \quad \text{if } x_t = \{1, t\}$$

$$\text{Where, } \bar{c} = \{-7 \qquad \text{if } x_t = \{1\}$$

$$= \{-13.5 \quad \text{if } x_t = \{1, t\}$$

The NP tests require a specification for x_t and a choice of method for estimating f_0.

3.4 Correlogram

Testing for stationarity of the variables, the correlogram of the variables has also been presented. Correlogram is simply a graphical representation of Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). The nature of stationarity can also be found tentatively with the help of Correlogram.

3.5 Cointegration test

The co- integration test presents the long run equilibrium relationships between two variables say y_t and x_t. Suppose that $y_t \sim I(1)$ and $x_t \sim I(1)$. Then y_t and x_t are said to be co-integrated if there exists a β such that $y_t - \beta x_t$ is $I(0)$.This is denoted by saying y_t and x_t are CI (1, 1). Several co-integration techniques are available for the time series analyses. These tests include the Engle and Granger test (1987), Stock and Watson procedure (1988) and Johansen's method (1988).

3.5.1 Engle-Granger Cointegration test

The Engle and Granger approach is also known as a residual test. If variables in an equation are integrated of the same order, say (1), the error term should be stationary, i.e., I (0). Let us consider M time series (Y_{t1}-----Y_{tM}), each of which is I(1), and the following two regression models, the first with drift and no trend and the second with drift and trend:

$$Y_{t1} = \beta_0 + \sum_{j=2}^{M} \sum \beta_j y_{t-j+1} + \varepsilon_t \tag{3.22}$$

$$Y_{t1} = \beta_0 + \beta_1 t + \sum_{j=2}^{M} \beta_j y_{t-j+1} + \varepsilon_t \tag{3.23}$$

A test for no cointegration is given by a test for a unit root in the estimated error terms e_t of ε_t. This can be achieved by applying ADF test to the residuals using the following equation:

$$\Delta e_t = \alpha e_{t-1} + \sum_{j=1}^{p} \Phi_j e_{t-j} + v_t \tag{3.24}$$

The null hypothesis $\alpha = 0$ is tested using the τ statistic.

3.5.2 Johansen Maximum Likelihood Cointegration Test

The Johansen procedure analyses the relationship among stationary or non-stationary variables using the following equation:

$$Xt = \sum_{i=1}^{p} \prod_i Xt-1 + \varepsilon_t \tag{3.25}$$

This function can be presented according to the following VAR system:

$$\Delta Xt = \prod X_{t-1} + \sum_{i=1}^{r-1} \phi i \Delta X_{t-1} + \mu + \varepsilon_t \qquad (3.26)$$

in which Xt is an $n \times 1$ random vector, ε_t is NIID (0, Σ_ε), and μ is deterministic terms. The long-run relationships are captured in the the coefficient matrix of $\prod$, denoted by r, is between 0 and n. Then there are r linear combinations of the variables in the system that are I (0) or cointegrated. Under Johansen (1991), and Johansen and Juselius (1990) procedures, two tests are available for the determination of cointegrating vectors and for the estimation of their values. These tests are the trace test and the eigen value test. In Johansen's method, a two-stage testing procedure has been implemented. In the first stage, the null hypothesis of no cointegration is tested against the alternative that the data are cointegrated with an unknown cointegrating vector. If the null hypothesis is rejected, a second stage test is implemented with cointegration maintained under both the null and alternative.

Gonzalo (1994) has suggested that Johansen's procedure has properties which are superior to alternative co-integration testing methods.

3.6 Vector Error Correction Modeling

Vector Error Correction modeling provides important information on the short run relationship between any two cointegrated variables. Vector Error Correction test has provided empirical evidence on the short run causality between real GDP and money supply(M1 &M2) in Nepal.

In the present study the vector error correction estimates have been specified using the following model. The model has been used in both cases i.e. involving M1 & M2.

$$\Delta \ln Y_t = \gamma_1 + \rho_1 z_{t-1} + \alpha_1 \Delta \ln Y_{t-1} + \alpha_2 \Delta \ln Y_{t-2} + \alpha_3 \Delta M_{t-1} + \alpha_4 \Delta M_{t-2} + \varepsilon_{1t} \tag{3.27}$$

$$\Delta M_t = \gamma_2 + \rho_2 z_{t-1} + \beta_1 \Delta \ln Y_{t-1} + \beta_2 \Delta \ln Y_{t-2} + \beta_3 \Delta M_{t-1} + \beta_4 \Delta M_{t-2} + \varepsilon_{2t} \tag{3.28}$$

The focus of the vector error correction analysis is on the lagged z_t terms. These lagged terms are the residuals from the previously estimated cointegration equations. In the present case the residuals from two lag specifications of the cointegrating equations have been used in the vector error correction estimates. Lagged z_t terms provide an explanation of short run deviations from the long run equilibrium for the two test equations. Lagging these terms means that disturbance of the last period impacts the current time period. Statistical significance tests are conducted on each of the lagged z_t term in equations (3.27) and (3.28). In general, finding a statistically insignificant coefficient of the z_t term implies that the system under investigation is in the short run equilibrium as there are no disturbances present. If the coefficient of the z_t term is found to be statistically significant, then the system is in the state of the short run disequilibrium. In such a case the sign of z_t term gives an indication of the causality direction between the two test variables.

3.7 Unrestricted Vector Auto regression

The model for the Unrestricted Vector Auto regression of the variables in the present study is based on the following equations:-

$$\Delta \ln Y_t = \gamma_1 + \alpha_{11} \Delta \ln Y_{t-1} + \alpha_{12} \Delta M_{t-1} + \beta_{11} \Delta \ln Y_{t-2} + \beta_{12} \Delta M_{t-2} + \varepsilon_{1t} \tag{3.29}$$

$$\Delta M_t = \gamma_2 + \alpha_{21}\Delta M_{t-1} + \alpha_{22}\Delta \ln Y_{t-2} + \beta_{21}\Delta M_{t-1} + \beta_{22}\Delta M_{t-2} + \varepsilon_{2t} \quad (3.30)$$

Where, $\Delta \ln Y_t$= first difference of output level (real & nominal).

ΔM_t = first difference of money supply (narrow & broad).

α_{ij}, β_{ij}, γ_i are the parameters to be estimated.

3.8 Conventional Granger Causality Test

The model for Conventional Granger causality test is based on the following equations:

$$Y_t = \sum_{j=1}^{m} a_j M_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + \varepsilon_t \quad (3.31)$$

$$M_t = \sum_{j=1}^{m} a_j Y_{t-j} + \sum_{j=1}^{m} b_j M_{t-j} + \eta_t \quad (3.32)$$

Where Yt and Mt represents first difference of output level (real and nominal) and money supply (narrow and broad) respectively.

3.9 The ARIMA model

In order to identify the anticipated and unanticipated part of money supply the ARIMA structures of the series have been applied. The model has been explained as follows:

$$\Phi(L)\, Y_t = \mu + \theta(L)\, \varepsilon_t \quad (3.33)$$

Where $\Phi(L) = 1 - \sum_{i=1}^{p} \phi_i L^i$, $\theta(L) = 1 + \sum_{j=1}^{q} \theta j L^j$ and ε_t is white noise.

This is known as an autoregressive moving average model of orders p and q or more simply an ARMA (p,q) model. A simple MA (1) model is;

$$Y_t = \mu + (1+\theta_1 L)\,\varepsilon_t \tag{3.34}$$

This has an alternative representation as an AR (∞) model provided $|\theta_1|<1$, in which case the MA model is said to be invertible. Multiplying through by the inverse of $(1+\theta_1 L)^{-1}$ = $1-\theta_1 L-\theta_1^2 L^2-\theta_1^3 L^3-\ldots\ldots-\theta_1^s L^s-,\ldots,$ gives

$$(1-\theta_1 L-\theta_1^2 L^2-\theta_1^3 L^3-\ldots\ldots-\theta_1^s L^s-,\ldots,)Y_t = \mu^* + \varepsilon_t \tag{3.35}$$

so that

$$Y_t = \mu^* + (\theta_1 L+\theta_1^2 L^2+\theta_1^3 L^3+\ldots\ldots+\theta_1^s L^s+,\ldots,)Y_t + \varepsilon_t$$

$$= \mu^* + \sum_{j=1}^{\infty}\theta_j L^j Y_t + \varepsilon_t \tag{3.36}$$

Where $\mu^* = (1+\theta_1 L)^{-1}\mu$.

If Φ (L) contains a unit root, then it can be factored into $\Phi(L) = \Phi^*(L)(1-L)$, and the ARMA(p,q) model $\Phi(L)Y_t = \mu + \theta(L)\,\varepsilon_t$ can be rewritten as $\Phi^*(L)(1-L)Y_t = \mu + \theta(L)\,\varepsilon_t$. In this case Y_t is integrated of order 1, and the model is referred to as an ARIMA (p,d,q) model, with d=1 in this case. (Patterson 2002:254)

3.10 The Chow Test

In order to test for the stability of the regression equation, Chow has presented a test statistic which is based on F-statistic which can be calculated as:

$$F = \frac{(RRSS - URSS)(T - k)}{URSS(g)} \tag{3.37}$$

Where RRSS is the residual sum of squares from a restricted version of a more general model from which the unrestricted residual sum of squares, URSS, is calculated.

Equivalently RRSS comes from the regression model with the null hypothesis imposed and URSS comes from the regression model according to the alternative hypothesis. In this case the restricted model imposes just one set of regression coefficients for T observations with

residual sum of squares $\sum_{t=1}^{T_1} \varepsilon_{1t}^2 = \varepsilon_1'\varepsilon_1$ and $\sum_{t=T_1+1}^{T} \varepsilon_{2t}^2 = \varepsilon_2'\varepsilon_2$

with $T_1 - k + T_2 - k = T - 2k$ degrees of freedom.

Chow has used the model for test statistic as;

$$CT\ (k, T-2k) = \frac{\varepsilon'\varepsilon - (\varepsilon'_1\varepsilon_1 + \varepsilon'_2\varepsilon_2)(T - 2k)}{(\varepsilon'_1\varepsilon_1 + \varepsilon'_2\varepsilon_2)(k)} \tag{3.38}$$

(Patterson 2002:186)

In order to find the structural breaks in the period of study, Chow breakpoint test has been applied in the present work.

Table 3.1: DATABASE FOR GDP (Yt) & MONEY SUPPLY (M1 &M2)

(In million Rs.)

Year	Yt (1990=100)	M1	M2	ln Y	ln M1	ln M2
1959	44658	133.1	152.8	10.70679	4.891101	5.029130
1960	42695	182.2	209.6	10.66184	5.205105	5.345201
1961	44146	223.6	256.3	10.69526	5.409859	5.546349
1962	45253	227.9	266.7	10.72002	5.428907	5.586124
1963	44716	294	335.1	10.70809	5.683580	5.814429
1964	45603	378.7	418.6	10.72773	5.936744	6.036916
1965	46743	481.4	525.4	10.75242	6.176699	6.264160
1966	49413	506.3	555.9	10.80797	6.227129	6.320588
1967	48638	531.7	601.6	10.79216	6.276079	6.399593
1968	48698	595.8	718.1	10.79339	6.389905	6.576609
1969	51152	739.4	922.4	10.84256	6.605839	6.826979
1970	52470	699.2	931.1	10.868	6.549937	6.836367
1971	51844	784.3	1108.5	10.85599	6.664792	7.010763
1972	53459	841.7	1293.1	10.88667	6.735424	7.164798
1973	53204	1090.2	1663.4	10.88189	6.994116	7.416619
1974	56574	1289.8	1948.2	10.9433	7.162242	7.574661
1975	57398	1333.5	2180.1	10.95776	7.195562	7.687126
1976	59923	1635.8	2810.7	11.00082	7.399887	7.941189
1977	61731	1932.5	3400.9	11.03054	7.566570	8.131795
1978	64451	2200.2	4070	11.07366	7.696304	8.311398
1979	65978	2534.3	4712.1	11.09708	7.837673	8.457889
1980	64447	2864.4	5525.8	11.0736	7.960114	8.617183
1981	69823	3204.7	6579.9	11.15372	8.072374	8.791775
1982	72462	3704.8	7987.4	11.19082	8.217385	8.985621
1983	70304	4366	9594.4	11.16058	8.381603	9.168935
1984	77111	4942.3	10841.2	11.253	8.505586	9.291109
1985	81849	5615.9	13014.1	11.31263	8.633357	9.473789
1986	85663	6951	15542.9	11.35818	8.846641	9.651359
1987	87349	8632	19024	11.37767	9.063232	9.853457
1988	93349	9826	23219	11.4441	9.192787	10.05273
1989	98567	11720	28106	11.49849	9.369052	10.24374
1990	103416	14205	33304	11.54651	9.561349	10.41343
1991	110078	17614	40855	11.60894	9.776449	10.61778
1992	115166	20428	49316	11.65413	9.924662	10.80600
1993	118951	25320	61537	11.68647	10.13935	11.02739
1994	127600	30524	72696	11.75666	10.32627	11.19404
1995	125735	33553	84043	11.7872	10.42088	11.33908
1996	132906	35544	94288	11.8432	10.47853	11.45411
1997	139247	38596	109151	11.89179	10.56090	11.60049
1998	144031	45509	135359	11.92468	10.72567	11.81569
1999	150474	55107	164628	11.96904	10.91703	12.01144
2000	160170	63028	195578	12.02792	11.05133	12.18371
2001	169457	72161	218111	12.07376	11.18666	12.29276
2002	168227	77156	229375	12.03307	11.25358	12.34311
2003	179461	83754	255395	12.09771	11.33564	12.45057

(Source-INTERNATIONAL FINANCIAL STATISTICS YEAR BOOK 1987, 1996, AUGUST 2002, 2004 -IMF)