CHAPTER - V

Cointegration, Vector Error Correction and Causal Relationships

5.1 Introduction

In econometric analysis, it is necessary to integrate short-run dynamics of the time series data with long-run equilibrium. The analysis of short-run dynamics is often done by first eliminating trends in the variables, usually by differencing. The concept of co-integration was developed by Granger in 1981 and elaborated by Engle and Granger in 1987. They addressed the issue of integrating short run dynamics with long run equilibrium. If separate economic series are stationary only after differencing but a linear combination of their levels is stationary, it can be said that the variables are co-integrated. When variables are cointegrated, it is possible to test for the existence of a long run relationship among a group of economic variables. It means that the variables track each other over time and even though there may be deviations from the long run path, they only last for a finite time. When the variables are co-integrated the long run relationship is best represented by an error correction model. The idea is simply that a proportion of the disequilibrium from one period is corrected in the next period.

The seminal papers of Phillips (1957) and Sargan (1964) have opened new ground in economic modeling and the foundation for what are now called error correction models. The pioneering efforts of Phillips and Sargan have been followed by a number of studies, notably the paper by Davidson, Hendry, Srba and Yoo

(1978).Engle and Granger (1987) introduced co-integration based error correction modeling. If there exists a co-integrating relationship between some variable Yt and a vector of related explanatory variables Xt, then by the Granger Representation Theorem (Granger and Weiss, 1983), there exists a valid error correction model for that variable Yt.

The cointegrating relationship between the variables can be achieved from CRDW, Engle-Granger or from Johansen's method.

5.2 Engle-Granger method of Cointegration: Relation between Output and Money Supply

The Engle-Granger method, which is also called residual test of the cointegration, has been explained as follows:

Suppose two series of the variables Y_t and X_t which are integrated of order 1 or I (1) and the relationship between Y_t and X_t is,

$$Y_t = \alpha + \beta X_t + \mu_t \qquad \text{or,} \qquad \mu_t = Y_t - \alpha - \beta X_t \qquad (5.1)$$

If the residual term (μt) is stationary at level or I (0), then it can be said that the variables Yt and Xt are co-integrated, so to speak, they are on the same wavelength.

5.2.1 The Model

The estimable cointegration models (5.2, 5.3, 5.4 and 5.5) for the present study of the long run relationship between GDP (Real & Nominal) and Money Supply (M1 & M2) are given below:

$$\ln Y_t = \alpha_1 + \beta_1 \ln M1_t + \mu_{1t} \quad \text{or,} \quad \mu_{1t} = \ln Y_t - \alpha_1 - \beta_1 \ln M1_t \tag{5.2}$$

$$\ln Y_t = \alpha_2 + \beta_2 \ln M2_t + \mu_{2t} \quad \text{or,} \quad \mu_{2t} = \ln Y_t - \alpha_2 - \beta_2 \ln M2_t \tag{5.3}$$

$$\ln NY_t = \alpha_3 + \beta_3 \ln M1_t + \mu_{3t} \quad \text{or,} \quad \mu_{3t} = \ln Y_t - \alpha_3 - \beta_3 \ln M1_t \tag{5.4}$$

$$\ln NY_t = \alpha_4 + \beta_4 \ln M2_t + \mu_{4t} \quad \text{or,} \quad \mu_{4t} = \ln Y_t - \alpha_4 - \beta_4 \ln M2_t \tag{5.5}$$

Where, Y_t= Real output, NY_t = Nominal output, $M1_t$ = Narrow money supply,

$M2_t$ = Broad money supply: μ_{1t}, μ_{2t}, μ_{3t} & μ_{4t} = Residual terms

5.2.2 Estimation of the Models

Equations (5.2, 5.3, 5.4 and 5.5) have been estimated. The corresponding estimated equations are given by equations (5.6, 5.7, 5.8 and 5.9) below.

$$\ln Y_t = 9.302611 - 0.237618 \ln M1_t \tag{5.6}$$

S.E. =(0.051067) (0.006053) R^2=0.972858 Adj. R^2= 0.972227

t-stat. = [182.1659] [39.25885] Durbin-Watson stat.= 0.245629

$$\ln Y_t = 9.474255 - 0.201495 \ln M2_t \tag{5.7}$$

S.E. = (0.050394) (0.005525) R^2= 0.968678 Adj. R^2= 0.967950

t-stat. = [188.0023] [36.46702] Durbin-Watson stat.= 0.181409

$$\ln NY_t = 3.736079 - 0.816837 \ln M1_t \tag{5.8}$$

S.E. = (0.092335) (0.010945) R^2= 0.992339 Adj. R^2= 0.992161

t-stat. = [40.46208] [74.63235] Durbin-Watson stat.= 0.508229

$$\ln NY_t = 4.316805 - 0.693649 \ln M2_t \quad (5.9)$$

S.E. = (0.091593) (0.010043) R^2= 0.991067 Adj. R^2= 0.990860

t-stat. = [47.13044] [69.07126] Durbin-Watson stat.= 0.326543

From the estimated equations (5.6, 5.7, 5.8 &5.9) the residual series have been estimated. Testing Stationarity of the residual series has been tested for assessing the cointegration between the variables concerned.

5.2.3 Tests of Stationarity of Residuals

Stationarity of the residuals (μ_{1t} ------ μ_{4t}) have been tested through ADF and Phillips-Perron methods. The results of the tests are being presented through the Tables 5.1 and 5.2.

Table 5.1: Augmented Dickey Fuller Unit Root Test on Residuals

(Null Hypothesis: The residual has a unit root)

Exogenous: Constant Lag length :-(Automatic based on SIC, MAXLAG=9)

Variable	ADF test statistic	Prob* value	Lag length	Test critical values 1%	5%	10%
μ_{1t}	-1.576357	0.4856	2	-3.596616	-2.933158	-2.604867
μ_{2t}	-1.330444	0.6068	1	-3.592462	-2.931404	-2.603944
μ_{3t}	-4.776468	0.0003	0	-3.588509	-2.929734	-2.603064
μ_{4t}	-3.447093	0.0144	0	-3.588509	-2.929734	-2.603064
Exogenous: None						
μ_{1t}	-3.285493	0.0016	0	-2.618579	-1.948495	-1.612135
μ_{2t}	-2.533729	0.0125	0	-2.618579	-1.948495	-1.612135

- MacKinnon (1996) One-sided P-values

The ADF unit root test on residuals shows that the null hypothesis (Ho: The residual has a unit root) has been accepted for the residuals (μ_{1t} & μ_{2t}) of the regression equation of real output and both money supplies (M1 & M2) when exogenous as constant. But the result is quite different in the case of 'None Exogenous'. Here both residuals are stationary at 1% and 5% level respectively. Consequently, on the basis of the second case it can be concluded that there is cointegration between real output and money supplies even though first case does not support this statement.

The null hypothesis has been rejected for the residuals (μ_{3t} & μ_{4t}) of the regression of nominal output and money supplies (M1 & M2). This indicates that there is cointegrating relationship between nominal output and both money supplies.

The Phillips-Perron unit root test on residuals has been presented in Table 5.2.

Table 5.2: Phillips-Perron Unit Root Test on Residuals

(Null Hypothesis: The residual has a unit root)

Exogenous: Constant Lag length :-(Automatic based on SIC, MAXLAG=9)

Variable	P-P test statistic	Prob* value	Band** Width	Test critical values 1%	5%	10%
μ_{1t}	-3.293422	0.0212	3	-3.588509	-2.929734	-2.603064
μ_{2t}	-2.547112	0.1117	4	-3.588509	-2.929734	-2.603064
Exogenous: None						
μ_{1t}	-3.273232	0.0016	4	-2.618579	-1.948495	-1.612135
μ_{2t}	-2.554266	0.0118	4	-2.618579	-1.948495	-1.612135

* MacKinnon (1996) One-sided P-values **Newey-West using Bartlett kernel

The PP unit root test on residuals depicts that the test statistic is insignificant at 5% level of significance for 'μ_{1t}' but it is significant for 'μ_{2t}' even at 10% level of significance in the first case (i.e. exogenous-constant). This mean there is cointegration between real output and narrow money supply and no cointegration between real output and broad money supply on the basis of first case. The second case (exogenous-none) presents slightly different result from the first case. Both residuals are stationary at 1% and 5% level respectively. Hence it can be concluded that there is cointegration between real output and both money supplies on the basis of second case.

5.3 Durbin-Watson method of Cointegrating Regression (CRDW)

An alternative and quicker method of finding out whether the variables are cointegrated is the CRDW test, whose critical values were first provided by Sargan and Bhargava (Gujarati, 1995:727). In CRDW, the Durbin-Watson statistic (d value) obtained from the cointegrating regression is used. Here the null hypothesis is that d=0 rather than the standard d=2. The findings of CRDW test which are based on along with critical values have been presented in Table 5.3.

Table 5.3: Durbin-Watson test for Cointegrating Regression (CRDW)

Null hypothesis	D-W statistic	Critical values 1%	5%	10%
No cointegration between lnY&lnM1	0.245629	0.511	0.386	0.322
No cointegration between lnY&lnM2	0.181409	0.511	0.386	0.322
No cointegration between lnNY&lnM1	0.508229	0.511	0.386	0.322
No cointegration between lnNY&lnM2	0.326543	0.511	0.386	0.322

From the table it is observed that the null hypothesis of no cointegration between real output and both money supplies have been accepted. But this hypothesis has been rejected between nominal output and narrow money supply at 5% level of significance and nominal output and broad money supply at 10% level of significance.

5.4: Johansen's method of Cointegration

The Johansen method of cointegration is quite different from Engle-Granger and CRDW method. This test is based on trace statistic and max-eigen statistic (λ_{-max}). The results, which have been obtained from E-views 4.1 software package, have been presented in Table 5.4.

Table 5.4: Johansen Cointegration Test

Unrestricted Cointegration Rank Test — Lags interval (in first differences): 1 to2

Series: lnY lnM1 — Trend assumption: Linear deterministic trend

Null Hypothesis.	Alternative Hypo. λ_{max}-tests	Alternative Hypo. Trace tests	Eigen value	Trace statistic	5% critical value	1% critical value	Max-eigen statistic	5% critical value	1% critical value
$r=0^{**}$	$r=1$	$r\geq1$	0.4266	23.553	15.41	20.04	23.360	14.07	18.63
$r\leq1$	$r=2$	$r\geq2$	0.0046	0.1926	3.76	6.65	0.1926	3.76	6.65
Series: lnY lnM2									
$r=0^{**}$	$r=1$	$r\geq1$	0.3588	21.894	15.41	20.04	18.666	14.07	18.63
$r\leq1$	$r=2$	$r\geq2$	0.0739	3.2278	3.76	6.65	3.2278	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5 %(1%) level. Trace & Max-eigen value tests indicate 1 cointegrating equation at both 5% and 1% levels.

Hence, according to Johansen's method cointegrating relationship can be achieved in both series (real output and both money supplies) when they are in level like the Engle-Granger method in 'None Exogenous' case. The null hypothesis of no cointegration (i.e. r =0) has been rejected on the basis of trace statistic and max-eigen statistic because in this case both statistic levels are greater than critical values of these statistic.

5.5 Vector Error Correction Modeling

Error-correction modeling involves regression of the first difference of each variable in the cointegrating equation onto lagged values of the first differences of all the variables plus the lagged value of the error correction term. Suppose that two I (1) variables y_t and z_t are cointegrated and that the cointegrating vector is [1, -θ]. Then all three variables $\Delta y_t = y_t - y_{t-1}$, Δz_t, and $(y_t - \theta z_t)$ are I (0). The error correction model is,

$$\Delta y_t = \beta' x_t + \gamma (\Delta z_t) + \lambda (y_t - \theta z_t) + \varepsilon_t \qquad (5.10)$$

The model describes the variation in y_t around its long-run trend in terms of a set of I(0) exogenous factors x_t, the variation of z_t around its long-run trend, and the error correction ($yt- \theta z_t$), which is the equilibrium error in the model of cointegration. There is a tight connection between models of cointegration and models of error correction. The model in this form is reasonable as it stands, but in fact, it is only internally consistent if the two variables are cointegrated. If not, then the third term, and hence the right-hand side, cannot be I (0), even though the left-hand side must be.

5.5.1 VEC and the Estimable Models

In the present study the estimable Vector Error Correction models are as following:

$$\Delta \ln Y_t = \gamma_1 + \rho_1 z_{t-1} + \alpha_1 \Delta \ln Y_{t-1} + \alpha_2 \Delta \ln Y_{t-2} + \alpha_3 \Delta M_{t-1} + \alpha_4 \Delta M_{t-2} + \varepsilon_{1t} \tag{5.11}$$

$$\Delta M_t = \gamma_2 + \rho_2 z_{t-1} + \beta_1 \Delta \ln Y_{t-1} + \beta_2 \Delta \ln Y_{t-2} + \beta_3 \Delta M_{t-1} + \beta_4 \Delta M_{t-2} + \varepsilon_{2t} \tag{5.12}$$

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

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

z_{t-1} :- first lag of error term of cointegrating equation.

ε_{1t} and ε_{2t} are white noise errors.

α_1 --------- α_4 are the coefficients of lagged ($\Delta \ln Y_t$, ΔM_t) in equation (5.11) and β_1 ------- β_4 are the coefficients lagged ($\Delta \ln Y_t$, ΔM_t) in equation (5.12). In the estimation of vector error correction model at least one of ρ_1 and ρ_2 should be nonzero. γ_1 and γ_2 are intercepts of equations (5.11) and (5.12).

5.5.2 Vector Error Correction Estimates for Real Output and Narrow Money Supply

The vector error correction estimates for real output and narrow money supply based on equations (5.11) and (5.12) have been presented in Table 5.5.

Table 5.5: Vector Error Correction Estimates ($\ln Y_t$ & $\ln M1_t$)

Dependent variable	Explanatory variables	Coefficient	't' statistics
$\Delta \ln Y_t$	Constant (γ_1)	0.038700	2.89489**
	z_{1t-1}	-0.176737	-4.91940**
	$\Delta \ln Y_{t-1}$	-0.412791	-3.03055**
	$\Delta \ln Y_{t-2}$	-0.358243	-2.51381*
	$\Delta \ln M1_{t-1}$	0.082036	1.52950
	$\Delta \ln M1_{t-2}$	0.053466	1.00950
$\Delta \ln M1_t$	Constant (γ_2)	0.131745	3.20819**
	Z_{1t-1}	0.092874	0.84156
	$\Delta \ln M1_{t-1}$	0.093302	0.56629
	$\Delta \ln M1_{t-2}$	-0.199732	-1.22767
	$\Delta \ln Y_{t-1}$	0.184459	0.44086
	$\Delta \ln Y_{t-2}$	0.609102	1.39139

*(**) Indicates statistical significance at the 5% (1%) level

The significant value of the coefficient of cointegrating equation (ρ_1) in the table indicates that the system is in the state of the short run dynamics. The negative sign shows that the change in the value of real output level depend inversely on the past error (deviation of actual value from its long run equilibrium path). The insignificant value of the coefficient of cointegrating equation (ρ_2) in second equation indicates that short run disequilibrium is insignificant in second equation. The estimates of the model also present the Granger causality between output and money supply. In the present case z_t Granger causes real output since lagged value of the z_t entering equation (5.11) is statistically significant. The't'-statistic of the coefficient of explanatory variables depicts that the real output has also been affected significantly by its own first and second lag at

1% and 5% respectively despite the effectiveness of lagged value of z_t. The significance of the coefficients of the constants (γ_1 & γ_2) is significant at 1% level.

5.5.3 Vector Error Correction Estimates for Real Output and Broad Money Supply

The estimates of VEC model for real output and broad money supply have been presented in Table 5.6.

Table 5.6: Vector Error Correction Estimates ($\ln Y_t$ & $\ln M2_t$)

Dependent variable	Explanatory variables	Coefficient	't' statistics
$\Delta \ln Y_t$	constant(γ_1)	0.027719	1.48447
	Z_{2t-1}	-0.111065	-4.46998**
	$\Delta \ln Y_{t-1}$	-0.424678	-2.93877**
	$\Delta \ln Y_{t-2}$	-0.342278	-2.32644*
	$\Delta \ln M2_{t-1}$	0.148654	2.21488*
	$\Delta \ln M2_{t-2}$	0.034169	0.48366
$\Delta \ln M2_t$	constant(γ_2)	0.214207	4.64346**
	Z_{2t-1}	1.79E-05	-0.00029
	$\Delta \ln M2_{t-1}$	-0.010975	-0.06619
	$\Delta \ln M2_{t-2}$	-0.335276	-1.90559
	$\Delta \ln Y_{t-1}$	0.173622	0.48633
	$\Delta \ln Y_{t-2}$	0.118463	0.32592

*(**) Indicates statistical significance at the 5% (1%) level

The table presents the same findings as in previous table (Table 5.5). Short run deviation is significant and Z_t Granger causes real output since its lagged value is statistically significant. Real output has been affected by its own first and second lag at 1% and 5% respectively. This level is also affected by first lag of broad money supply at 5% level of significance.

5.5.4 Vector Error Correction Estimates for Nominal Output and Money Supply

The estimates of VEC model for nominal output and money supply (M1 &M2) have been presented in Tables 5.7 and 5.8.

Table 5.7: Vector Error Correction Estimates ($\ln NY_t$ & $\ln M1_t$)

Dependent variable	Explanatory variables	Coefficient	't'-statistics
$\Delta \ln NY_t$	Constant (γ_1)	0.058432	1.80670
	z_{1t-1}	-0.278311	-3.17980**
	$\Delta \ln NY_{t-1}$	0.020618	0.14733
	$\Delta \ln NY_{t-2}$	-0.079649	-0.61445
	$\Delta \ln M1_{t-1}$	0.344601	2.58833*
	$\Delta \ln M1_{t-2}$	0.072646	0.54312
$\Delta \ln M1_t$	Constant (γ_2)	0.128131	3.28611**
	z_{1t-1}	0.204062	1.93387
	$\Delta \ln M1_{t-1}$	0.155745	0.97032
	$\Delta \ln M1_{t-2}$	-0.314019	-1.94731
	$\Delta \ln NY_{t-1}$	0.248257	1.47147
	$\Delta \ln NY_{t-2}$	0.088770	0.56803

*(**) Indicates statistical significance at the 5% (1%) level

Table 5.8: Vector Error Correction Estimates ($\ln NY_t$ & $\ln M2_t$)

Dependent variable	Explanatory variables	Coefficient	't' statistics
$\Delta \ln NY_t$	Constant (γ_1)	0.056608	1.23447
	z_{1t-1}	-0.178726	-2.62504*
	$\Delta \ln NY_{t-1}$	-0.004993	-0.03438
	$\Delta \ln NY_{t-2}$	-0.115672	-0.82960
	$\Delta \ln M2_{t-1}$	0.414386	2.41140*
	$\Delta \ln M2_{t-2}$	0.000936	0.00537
$\Delta \ln M2_t$	Constant (γ_2)	0.202879	4.74900**
	z_{1t-1}	0.011237	0.17716
	$\Delta \ln M2_{t-1}$	0.003674	0.02295
	$\Delta \ln M2_{t-2}$	-0.395683	-2.43617*
	$\Delta \ln NY_{t-1}$	0.235657	1.74180
	$\Delta \ln NY_{t-2}$	0.027000	0.20786

*(**) Indicates statistical significance at the 5% (1%) level

5.5.5 Overall Findings from Tables (5.7 & 5.8)

Tables 5.7and 5.8 present the estimations of error correction modeling related to nominal output and money supply (M1& M2). Both tables present the same result that the coefficient value (ρ_1) of cointegrating equation is significant while the coefficient (ρ_2) is insignificant in both cases. This result indicates that there is unidirectional Granger causality from money supply to nominal output. The negative sign shows that the first difference of nominal output inversely related with past error correction term. From the table 5.7, it is shown that the coefficient of first lag of money supply is significant. The same case is in table 5.8 i.e. the first lag of broad money supply has the significant role to influence the nominal output at 5% level of significance.

5.6 Unrestricted Vector Auto regression Model (UVAR) of the Variables

The vector auto regression (VAR) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The VAR approach sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all the endogenous variables in the system. The mathematical representation of a VAR is,

$$Y_t = A_1 Y_{t-1} + \text{------} + A_p Y_{t-p} + Bx_t + \varepsilon_t \qquad (5.13)$$

Where Yt is a k vector of endogenous variables, x_t is a d vector of endogenous variables, A_1, ----, A_p and B are matrices of coefficients to be estimated. ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

5.6.1 The UVAR Model under Study

The UVAR model of the variables in the present study is based on the following equations:

$$\Delta \ln Y_t = \gamma_1 + \alpha_{11}\Delta \ln Y_{t-1} + \alpha_{12}\Delta M_{t-1} + \beta_{11}\Delta \ln Y_{t-2} + \beta_{12}\Delta M_{t-2} + \varepsilon_{1t} \quad (5.14)$$

$$\Delta M_t = \gamma_2 + \alpha_{21}\Delta M_{t-1} + \alpha_{22}\Delta \ln Y_{t-2} + \beta_{21}\Delta M_{t-1} + \beta_{22}\Delta M_{t-2} + \varepsilon_{2t} \quad (5.15)$$

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.

5.6.2 The UVAR Estimates of the Variables under Study

The UVAR estimates of the variables in the present study, which are based on equations (5.14 and 5.15), have been presented in four different parts. The first part is related to the estimations of real output and narrow money supply. The second part is related to the real output and broad money supply. The third and the fourth parts have presented the estimations of nominal output - narrow money supply and nominal output – broad money supply respectively. The variables have been regressed with its own first two lags and first two lags of corresponding second variable. The estimations have been presented in the following table (Table 5.9)

Table 5.9: Unrestricted Vector Auto regression Estimates of the Series

Estimable variables	Dependent variable	Explanatory variables	Coefficient	't'-statistics
(I) ΔlnY_t & $\Delta lnM1_t$	ΔlnY_t	Constant (γ_1)	0.016514	[1.02873]
		ΔlnY_{t-1}	- 0.19964	[-1.21201]
		ΔlnY_{t-2}	- 0.00646	[-0.04111]
		$\Delta lnM1_{t-1}$	0.140862	[2.11205]**
		$\Delta lnM1_{t-2}$	0.022152	[0.33030]
	$\Delta lnM1_t$	Constant (γ_2)	0.143408	[3.72452]***
		ΔlnY_{t-1}	0.072451	[0.18338]
		ΔlnY_{t-2}	0.424227	[1.12480]
		$\Delta lnM1_{t-1}$	0.062372	[0.38988]
		$\Delta lnM1_{t-2}$	-0.183285	[-1.13932]
(II) $\Delta lnYt$ & $\Delta lnM2_t$	$\Delta lnYt$	Constant	0.002647	[0.12082]
		ΔlnY_{t-1}	-0.210260	[-1.25401]
		ΔlnY_{t-2}	0.002448	[0.01588]
		$\Delta lnM2_{t-1}$	0.212747	[2.63787]***
		$\Delta lnM2_{t-2}$	0.012041	[0.13891]
	$\Delta lnM2t$	Constant	0.214215	[4.93579]***
		ΔlnY_{t-1}	0.173570	[0.52254]
		ΔlnY_{t-2}	0.118415	[0.38785]
		$\Delta lnM2_{t-1}$	-0.011000	[-0.06885]
		$\Delta lnM2_{t-2}$	-0.332574	[-1.93667]**
(III) $\Delta lnNYt$ & $\Delta lnM1_t$	$\Delta lnNYt$	Constant	0.041752	[1.17191]
		$\Delta lnNY_{t-1}$	0.022665	[0.14508]
		$\Delta lnNY_{t-2}$	-0.043651	[-0.30280]
		$\Delta lnM1_{t-1}$	0.025609	[0.17256]
		$\Delta lnM1_{t-2}$	0.041752	[1.17191]
	$\Delta lnM1t$	Constant	0.140363	[3.52010]***
		$\Delta lnNY_{t-1}$	0.246753	[1.41124]*
		$\Delta lnNY_{t-2}$	0.062376	[0.38660]
		$\Delta lnM1_{t-1}$	0.056450	[0.35817]
		$\Delta lnM1_{t-2}$	-0.279528	[-1.68292]*
(IV) $\Delta lnNYt$ & $\Delta lnM2_t$	$\Delta lnNYt$	Constant	0.029139	[0.60619]
		$\Delta lnNY_{t-1}$	0.016961	[0.10865]
		$\Delta lnNY_{t-2}$	-0.059960	[-0.40412]
		$\Delta lnM2_{t-1}$	0.539105	[3.03197]***
		$\Delta lnM2_{t-2}$	-0.010378	[-0.05531]
	$\Delta lnM2t$	Constant	0.204610	[4.98504]***
		$\Delta lnNY_{t-1}$	0.234275	[1.75764]**
		$\Delta lnNY_{t-2}$	0.023494	[0.18544]
		$\Delta lnM2_{t-1}$	-0.004182	[-0.02754]
		$\Delta lnM2_{t-2}$	-0.394976	[-2.46506]***

*, **, *** Indicates statistical significance at the 10%, 5% and 1% level respectively.

5.6.3 Findings

The first part of the above table presents the findings that the real output has been affected only by first lag of narrow money supply at 5% level of significance, while this variable (Narrow money supply) has not been influenced significantly by any lags of other variables. Only the autonomous part (constant) has affected it at 1% level of significance.

The second part of the table expresses the effectiveness of real output and broad money supply to influence each other. The real output has been influenced by first lag of broad money supply at 1% level of significance, while the broad money supply is affected only by autonomous part(constant) at 1% level of significance like first case.

The third part of the table presents the relationship between nominal output and narrow money regarding the effectiveness of these variables to influence each other. No variable has affected significantly the nominal output at any lags; even the autonomous part has no significant effect to influence nominal output. The narrow money supply has been influenced by first lag of nominal output and second lag of its own level at 10% level of significance. The autonomous part (constant) has also significant role to influence the narrow money supply.

The fourth part has presented the findings that the nominal output level has been affected significantly by first lag of broad money supply at 1% level of significance, while the broad money supply has been influenced by its own second lag at 1% level of significance and first lag of nominal output at 5% level of significance. This is also affected by autonomous part (constant) at 1% level of significance.

5.7 Conventional Granger Causality Tests:

Conventional Granger Causality Tests present the causal relationships between the variables (Real / Nominal output and Narrow/Broad money supply). The estimations for the model of Granger Causality tests, which are based on equations (3.31 and 3.32), have been presented in following table (Table 5.10).

Table 5.10: Estimations of Conventional Granger Causality Tests

Null Hypothesis	Observation	lags	F-statistics	Probability
DM1T does not Granger Cause DYT DYT does not Granger Cause DM1T	42	2	2.29647 0.64124	0.11478 0.53239
DM1T does not Granger Cause DYT DYT does not Granger Cause DM1T	41	3	1.34064 0.20546	0.20546 0.89190
DM1T does not Granger Cause DYT DYT does not Granger Cause DM1T	40	4	2.19225* 0.44036	0.09297 0.77845
DM1T does not Granger Cause DYT DYT does not Granger Cause DM1T	39	5	1.94460 0.49046	0.11847 0.78050
DM2T does not Granger Cause DYT DYT does not Granger Cause DM2T	42	2	3.48455** 0.21100	0.04107 0.81075
DM2T does not Granger Cause DYT DYT does not Granger Cause DM2T	41	3	3.01981** 0.06999	0.04309 0.97557
DM2T does not Granger Cause DYT DYT does not Granger Cause DM2T	40	4	3.47416** 0.26985	0.01862 0.89512
DM2T does not Granger Cause DYT DYT does not Granger Cause DM2T	39	5	2.79778** 0.36940	0.03589 0.86521
DM1T does not Granger Cause DNYT DNYT does not Granger Cause DM1T	42	2	5.95442*** 1.14262	0.00573 0.32998
DM1T does not Granger Cause DNYT DNYT does not Granger Cause DM1T	41	3	4.66556*** 0.49556	0.00778 0.68778
DM1T does not Granger Cause DNYT DNYT does not Granger Cause DM1T	40	4	7.07859*** 1.01413	0.00036 0.41529
DM1T does not Granger Cause DNYT DNYT does not Granger Cause DM1T	39	5	5.81947*** 1.90675	0.00083 0.12498
DM2T does not Granger Cause DNYT DNYT does not Granger Cause DM2T	42	2	4.59646** 1.60479	0.01648 0.21460
DM2T does not Granger Cause DNYT DNYT does not Granger Cause DM2T	41	3	5.74546*** 1.17956	0.00272 0.33197
DM2T does not Granger Cause DNYT DNYT does not Granger Cause DM2T	40	4	5.86748*** 1.31562	0.00123 0.28597
DM2T does not Granger Cause DNYT DNYT does not Granger Cause DM2T	39	5	5.51747*** 1.60018	0.00117 0.19261

*, **, *** Indicates statistical significance at the 10%, 5% and 1% level respectively

Source: author's calculations based on data from various issues of International Financial Statistics, IMF.

5.7.1 Findings

The F-statistic and its corresponding probability value show that the null hypothesis has not been rejected at all lags (2, 3, 4, and 5) for the series DYt and DM1t. Only at lag 4 the null hypothesis that DM1t does not Granger Cause DYt has been rejected at 10% level of significance. This mean there is unidirectional causality from narrow money supply to real output at lag 4. For the series real output (DYt) and broad money supply (DM2t), the null hypothesis that DM2t does not Granger Cause DYt has been rejected at all lags at 5% level of significance but the null hypothesis has not been rejected at all lags. This indicates there is strong unidirectional causality from broad money supply to real output level. The finding is same for the series nominal output (DNYt) and both money supplies (DM1t and DM2t) that is there is strong unidirectional causality from DM1t to DNYt and DM2t to DNYt.

5.8 Summary

The present chapter is devoted to the analysis of the cointegration test, vector error correction modeling, unrestricted vector auto-regression modeling and conventional Granger causality test. The Cointegration test has been performed with the help of Durbin -Watson test, Engle-Granger's method and Johansen's Cointegration test. The summary of the present chapter has been presented in following points:

(i) The Durbin-Watson test (CRDW) has provided the result that there is no cointegration between real output and both forms of money supplies but the long run relationship has been found between nominal output and both money supplies.

(ii) The Engle-granger's method of cointegration, which is based on the stationarity test of the residual series from the OLS regression equation between two variables, has provided mixed findings from the different cases.

(iii) The ADF unit root test on the residual between real output and money supplies with exogenous as constant shows that there is no cointegration between these variables even though there is cointegration between nominal output and both level of money supplies. The same unit root test with no exogenous provides the result that there is cointegration between the real output and money supplies (M1 & M2).

(iv) The Phillips- Perron unit root test on residual with constant as exogenous provides the finding that there is cointegration between real output and narrow money supply (M1) at 5% level of significance but there is no cointegration between real output and broad money supply. The same unit root test on residual with no exogenous presents the finding that there is cointegration between real output and both level money supplies. The residual is stationary at 1% level for real output and M1 while it is stationary at 5% level for real out and M2.

(v) The Johansen's method of cointegration test is quite different method than earlier two methods. It is based on trace statistic and max-eigen statistic. Comparing these statistic values with critical values, the finding shows that there is long run relationship between real output and both money supplies (M1 and M2).

(vi) Vector Error Correction modeling and Conventional Granger Causality test provided the result that there is unidirectional causality from money to output.

(vii) The unrestricted vector auto regression (UVAR) modeling has provided the finding that the real output has been affected by first lag of both money supplies. The broad money supply has also been affected by its own second lag. In the case of nominal output and money supplies, the narrow money supply (M1) has been influenced by first lag of nominal output and its own second lag at 10% level of significance. Again nominal output has been affected by first lag of broad money supply (M2) at 1% level and M2 has also been influenced by first lag of nominal output (at 5 %) and its own second lag (at 1%).

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