CHAPTER EIGHT

DISTRIBUTED LAG MODEL FOR MONEY SUPPLY AND PRICE RELATIONSHIP

8.1 Distributed Lag Model[32]

The economic variable Y is affected by not only the value of X at the same time t but also by its lagged values plus some disturbance term, $X_t, X_{t-1}, X_{t-2} \ldots\ldots, X_{t-k}, \varepsilon_t$.this can be written in the functional form as:

$Y_t = f(X_t, X_{t-1}, X_{t-2} \ldots\ldots, X_{t-k}, \varepsilon_t)$

In linear form,

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \cdots + \beta_j X_{t-k} + \varepsilon_t \quad (8.1)$$

Where, β_0 is known as the short run multiplier, or impact multiplier because it gives the change in the mean value of Y_t following a unit change of $X_t$in the same time period. If the change of X_t is maintained at the same level thereafter, then, (β_0+β_1) gives the change in the mean value of Y_t in the next period, ($\beta_0 + \beta_1 + \beta_2$) in the following period, and so on. These partial sums are called interim or intermediate multiplier. Finally, after k periods, that is

$\sum_{i=0}^{k} \beta_i = \beta_0 + \beta_1 + \beta_2 + \ldots + \beta_k = \beta$, therefore $\sum \beta_i$ is called the long run multiplier or total multiplier, or distributed-lag multiplier. If we define the standardized $\beta_i^* = \frac{\beta_i}{\sum \beta_i}$ then it gives the proportion of the long run, or total, impact felt by a certain period of time. In order for the distributed lag model to make sense, the lag coefficients must tend to zero as $k \to \infty$. This is not to say that β_2 is smaller than β_1; it only means that the impact of X_{t-k}on Y_t must eventually become small as k gets large.

The distributed lag plays vital role in determining the value of dependent variable at time t. But a problem arises regarding the selection of appropriate lag to be employed in independent variable. However, the problem of selection of suitable lag can be solved by using the techniques developed by various econometricians. One of the

[32] The Distributed Lag Models are also called Autoregressive Distributed Lag Models.

methods of selection of appropriate lag length is Ad Hoc approach popularized by Alt[33] and Tinbergen[34] for money-price relationship. The following method can be applied in Ad Hoc estimation of distributed-lag models.

First regress Y_t on X_t, then regress Y_t on X_t and X_{t-1}, then regress Y_t on X_t, X_{t-1} and X_{t-2}, and so on as given below

$Y_t = \alpha + \beta_0 X_t$

$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1}$

$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2}$

$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \beta_3 X_{t-3}$

$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \beta_3 X_{t-3} + \beta_4 X_{t-4} +$

… …

This sequential procedure stops when the regression coefficients of the lagged variables start becoming statistically insignificant and / or the coefficient of at least one of the variables change signs. However, the Ad Hoc method of distributed lag models have different problems such as there is no priori guide as to what is the maximum length of the lag, as number of lags rises there will be fewer degrees of freedom left and it makes the statistical inference somewhat shaky. Likewise, successive lags suffer from multi-colinearity, which lead to imprecise estimation and it needs long enough data to construct the distributed-lag model.

The Koyck approach can also be applied to estimate the distributed lag model. However, the Koyck approach also suffers from many drawbacks such as autoregressiveness, serial correlation, violation of Durbin-Watson D-test and non-linearity of parameter etc.. Similarly, Shirley Almon has also developed polynomial distributed lag model. However, the Almon approach involves the selection of the maximum lag length in advance, which in itself is the problem. Hence, the Almon approach also does not provide solution to the problem. Next, Schwarz and Akaike have developed formal test of lag length, which are popularly known as Schwarz Criterion and Akaike Information Criterion respectively. According to these criteria, the maximum lag length is selected based on *the least value of the lag. Both Schwarz*

[33] Alt, Franz L. 1942 Distributed Lags. *Econometrica* 10: 113–128

[34] Tinbergen, Jan 1949 Long-term Foreign Trade Elasticities. Metroeconomica 1:174–185.

criterion and Akaike information criterion is used to determine the optimum length of the lag.

Of the various approaches for selection of suitable lags of independent variable, the Ad Hoc approach is used in the present analysis of money-price relationship. It is because; the Ad Hoc approach suffers fewer problems as compared to other approaches. However, Almon approach of Polynomial distributed lags is also applied to find the total impact of distributed lags of independent variables (Money Supply) on the dependent variable (Price Level).

8.2 Almon Approach to Distributed Lag Models

(Polynomial Distributed Lag models)

The general form of distributed lag model is:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \cdots + \beta_j X_{t-k} + \varepsilon_t \quad (8.2)$$

$$\Rightarrow Y_t = \alpha + \sum_{i=0}^{t} \beta_i X_{t-k} + \varepsilon_t$$

Almon (1965)[35] assumes that β_i can be approximated by a suitable-degree polynomial in $\boldsymbol{i}$ which is the length of lags. For example, if there is a second degree of polynomial of β_i

That is, $\beta_i = a_0 + a_1 i + a_2 i^2$ (8.3)

Then,

$$Y_t = \alpha + \sum (a_0 + a_1 i + a_2 i^2) X_{t-k} + \varepsilon_t \quad (8.4)$$

$$Y_t = \alpha + a_0 \sum X_{t-k} + a_1 \sum i X_{t-k} + a_2 \sum i^2 X_{t-k} + \varepsilon_t \quad (8.5)$$

After transforming the variables, the distributed-lag model becomes:

$$Y_t = \alpha + a_0 Z_{0t} + a_1 Z_{1t} + a_2 Z_{2t} \varepsilon_t \quad (8.6)$$

Hère,

$$Z_{0t} = \sum X_{t-k} = X_t + X_{t-1} + X_{t-2}$$

$$Z_{1t} = \sum i X_{t-k} = X_{t-1} + 2X_{t-2}$$

$$Z_{2t} = \sum i^2 X_{t-k} = X_{t-1} + 4X_{t-2}$$

[35] Almon, Shirley (1965), "The distributed lag between capital appropriations and net expenditures,"*Econometrica* **33**: 178-196.

After transforming the Z_{0t}, Z_{1t}, Z_{2t}, run the regression on Y_t against on all Z_{kt} to find the estimated coefficient values of $\hat{a}_0$, $\hat{a}_1$, $\hat{a}_3$, then deduces the estimated values of $\hat{\beta}_i$'s for the original postulated model.

If $\beta_i = a_0 + a_1 i + a_2 i^2$, then a second degree of polynomial gives

$\beta_i = a_0$

$\beta_2 = a_0 + 2a_1 + 4a_2$

$\beta_3 = a_0 + 3a_1 + 9a_2$

$\dots$

$\beta_i = a_0 + ia_1 + i^2 a_2$

Other degree of Polynomials can also be analyzed by the similar procedures.

8.3 Distributed Lag Models: Price Level and Narrow Money Supply

In order to find the magnitude of relationship between M_1 Money Supply and price Level, it is necessary to run the OLS regression with Price Level dependent variable and M_1 Money Supply independent variable. However, the regression results will be spurious as non-stationary variables are used in regression. So for robust regression results we should use the stationary variables in the regression. Being the time series variables M_1 Money Supply and Price Level transformed in logarithmic form stationary at their first difference, we have used $dLnCPI_t$ as dependent variable and $dlnM_{1t}$ and its lags are used as independent variables in our regression to find the impact of M_1 money supply on price level under Autoregressive Distributed Lag Models.

Selection of optimum lag length of independent variable is inevitable before running the OLS regression. There are various approaches for selecting appropriate lag length. Of which, the present study has used the ad hoc estimation of distributed–lag model popularized by Alt and Tinbergen. According to this approach, first $dLnCPI_t$, dependent variable is regressed on $dLnM_{1t}$, current independent variable, and then $dLnCPI_t$ is lagged one period, two periods and so on until the coefficient of lagged variable is statistically insignificant or algebraic sign of the variable changes. In the present money-price model, the dependent variable $dLnCPI_t$ is regressed on the independent variable $dLnM_{1t}$ at lag 1, 2, 3 and 4. The coefficient of $dLnM_{1t}$ at lag 4 is statistically significant but algebraic sign changes from positive to negative. Therefore, lag 3 is taken as the appropriate lag for independent variable $dLnM_{1t}$ in the present regression. Thus, the regression model of $dLnCPI_t$ on $dLnM_{1t}$ is given by equation (8.7).

$$dLnCPI_t = \alpha + \beta_0 dLnM_{1t} + \beta_1 dLnM_{1t-1} + \beta_2\, dLnM_{1t-2} + \beta_3\, dLnM_{1t-3} + \varepsilon_t \tag{8.7}$$

The results of the regression ($dLnCPI_t$ on $dLnM_{1t}$) have been presented through Table 8.1.

Table-8.1: Regression of $dLnCPI_t$ on Lagged $dLnM_{1t}$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	α = 0.0110	0.0055	1.9987	0.0476
$dLnM_{1t}$	$\beta_0 =$ -0.2007	0.0528	-3.7964	0.0002
$dLnM_{1t-1}$	β_1 = 0.2210	0.0528	4.1862	0.0001
$dLnM_{1t-2}$	β_2 = 0.1481	0.0527	2.8082	0.0057
$dLnM_{1t-3}$	β_3 = 0.1076	0.0528	2.0366	0.0436

R^2 =0.3981 $\overline{R}^2$ =0.3806, S.E.of Regression=0.0202, D-W statistic=1.9937

From the Table-8.1, it is observed that the coefficients of $dLnM_{1t-1}$ and $dLnM_{1t-2}$ and $dLnM_{1t-3}$ have positive sign and these are statistically significant at 1% and 5% level. However, the coefficient $dLnM_{1t}$ has theoretically opposite sign even if it is statistically significant. The independent variable $dLnM_{1t}$ has the negative coefficient, which is not in the line of Quantity Theory of Money. So the independent variable $dLnM_{1t}$ should be avoided from our regression equation. However, the decision to avoid this variable from the regression equation or not, depends on the Redundant test.

8.3.1Redundant Test

The redundant test allows testing for the statistical significance of a subset of included variables in the equation. More formally, the test is for whether a subset of variables in an equation all have zero coefficients and might thus be deleted from the equation. Under Redundant test, the null hypothesis is that the regression of $dLnCPI_t$

on $dLnM_{1t}$ has the redundant variable $dLnM_{1t}$. The variable $dLnM_{1t}$ will be deleted only when the null hypothesis is not rejected. (Eviews 7: User's Guide II)

When the redundant test is applied to the regression model (8.7), the null hypothesis is strongly rejected as reported by t-statistic F-statistic and Log Likelihood Ratio in Table-8.2, and it can be concluded that $dLnM_{1t}$ is not redundant that should not be withdrawn from the above regression model.

Table- 8.2: Redundant Test of Equation (8.7)

Redundant Variables: $dLnM_{1t}$

Test Summary	Value	Degree of Freedom	Probability
t-statistic	3.7964	137	0.0002
F-statistic	14.413	(1, 137)	0.0002
Likelihood ratio	14.2045	1	0.0002

From the Table-8.2, the adjusted R squared of the regression line of $dLnP_t$ on $dLnM_{1t}$ is 0.3806. The adjusted R squared has poorly represented the goodness of fit of model. However, the S.E. and D-W statistic show that equation (8.7) carries the property of goodness of fit of the model.

8.3.2 Wald Coefficient Restriction Test

With the help of Wald Coefficient Restriction Test, we can verify that whether or not M_1 money supply and price level are proportionally related. For this, we have the null hypothesis that the sum of the coefficients of independent variable equals one, i.e. $\beta_0 + \beta_1 + \beta_2 + \beta_3 = \sum_{i=0}^{3} \beta_i = 1$, where β_0, β_1, β_2 and β_3 stand for the coefficient of $dLnM_{1t}$, $dLnM_{1t-1}$ and $dLnM_{1t-2}$ and $dLnM_{1t-3}$ respectively. The null hypothesis is accepted or rejected on the basis of t-statistic F-statistic and Chi-square value. If null hypothesis is rejected, M_1 money supply and price level are not proportionally related but if alternative hypothesis is accepted, the variables under study are proportionally related.

Table-8.3 reveals the results from Wald Coefficient Restriction test of equation (8.7) with the null hypothesis $\beta_0 + \beta_1 + \beta_2 + \beta_3 = 1$. All the tests such as t-statistic, F-statistic and Chi-square value suggest that the null hypothesis of proportional relationship between the variables is strongly rejected. Thus, it can be concluded that there is no proportional relationship between M_1 money supply and price level.

Table-8.3: Wald Coefficient Restriction Test of Equation (8.7)

Test Statistic	Value	Degree of Freedom	Probability
t-statistic	-6.1946	81	0.0000
F-statistic	38.3742	(1, 81)	0.0000
Chi-square	38.3742	1	0.0000

8.3.3 Polynomial Distributed Lags ($dLnCPI_t$ Regressed on $dLnM_{1t}$)

The Polynomial Distributive Lags is also called Almon Lag Model. In the present study, this model is applied to find the total effect (current plus lagged) of M_1 money supply on price level. Under this model 3 distributed lags with third degree polynomial is used. Generally, second or third degree polynomial is suitable in Polynomial Distributed Lags model. And, the assumption under PDL model is that the degree of polynomial should not be more than the order of lags. Since, under our regression model, the appropriate lags are 3, we choose third degree polynomial.

The results from polynomials distributed lags have been presented through the following Table-8.4. From the table, it is observed that the sum of the coefficient (total effect of M_1 money supply on price level) is: $\beta_0 + \beta_1 + \beta_2 + \beta_3 =$0.2760, which is positive and statistically significant at 10 % level. This implies that there is positive relationship between change in M_1 money supply and price level. A 10 % rise of change in M_1 money supply has caused 2.76 % rise of change in price level.

Table-8.4: Results from Polynomial Distributed Lags ($dLnCPI_t$ Regressed on $dLnM_{1t}$)

Model: $dLnCPI_t$,C, PDL($dLnM_{1t}$,3,3)

Lag Distribution	Coefficient	Std. Error	t-Statistic
0	β_0 = -0.2008	0.0528	-3.7964
1	β_1 = 0.2210	0.0528	4.1862
2	β_2 = 0.1481	0.0527	2.8082
3	β_3 = 0.1076	0.0528	2.0366
Sum of Lags	$\beta_0 + \beta_1 + \beta_2 + \beta_3$ =0.2760	0.1440	1.9164

8.4 Residuals Diagnostic of Distributed Lag Models ($dLnCPI_t$ Regressed on $dLnM_{1t}$)

In order to examine the consistency of fitted regression of equation (8.7), we have tested Residual Diagnostic through Correlogram Squared Residuals, Serial Correlation LM Test and Heteroscedasticity Test. With the help of these tests, we can conclude whether or not estimated regression equation (8.7) is consistent.

8.4.1 Correlogram of Squared Residuals

The Correlogram-Q-statistic of the squared residuals of estimated regression equation (8.7) is presented through Table-8.5. The ACFs and PACFs of correlogram of the residual squared are nearly zero at all lags and the Q-statistics at all lags are not significant with large p-values. This indicates that there is no evidence of rejecting the null hypothesis of no serial correlation. This implies that the residuals of the fitted regression equation (8.7) are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of regression equation (8.7).

Table-8.5: Correlogram of Squared Residuals of Equation (8.7)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.003	-0.003	0.0012	0.973	9	-0.049	-0.037	4.6369	0.865
2	-0.094	-0.094	1.3029	0.521	10	-0.068	-0.073	5.3544	0.866
3	-0.046	-0.047	1.6209	0.655	11	-0.075	-0.092	6.2422	0.857
4	0.024	0.015	1.7052	0.790	12	-0.051	-0.094	6.6571	0.879
5	0.104	0.097	3.3293	0.649	13	0.037	0.014	6.8774	0.908
6	-0.002	0.001	3.3301	0.766	14	0.044	0.033	7.1906	0.927
7	0.079	0.101	4.2715	0.748	15	-0.101	-0.082	8.8185	0.887
8	0.002	0.012	4.2724	0.832	16	-0.022	0.017	8.8948	0.918

8.4.2 Breusch-Godfrey Lagrange Multiplier Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation have been presented through Table-8.6. As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test of Table-7.8, the null hypothesis of no autocorrelation cannot be rejected. The B-G LM test implies that residuals are not serially correlated. Due to the non-presence of serial correlation, the estimated regression equation (8.7) is considered as the consistent model for representing the relationship between M_1 money supply and price level.

Table-8.6: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.1500	Prob. F(2,135)	0.8608
$T \times R^2$	0.3148	Prob. Chi-Square(2)	0.8543

8.4.3 Residuals Heteroscedasticity Test

The null hypothesis of White's (1980) is: there is homoscedasticity in the residuals. The null hypothesis is not rejected if the F-statistic and χ^2 statistic are not significant. No rejection of null hypothesis confirms that residuals of estimated regression do not suffer the heteroscedasticity problem and estimated regression is claimed to be consistent. Table-8.7 presents the Residual Heteroscedasticity test of regression equation (8.7).

From the Table-8.7, it is observed that F-statistic and $T \times R^2$ value are not significant as reported by the probability values of the fourth column. There is no evidence of rejecting the null hypothesis that residuals are homoscedastic. It means, the residuals of estimated regression equation (8.7) do not suffer heteroscedastic problem. Hence, it is claimed that the estimated regression equation (8.7) representing the relationship between narrow money supply and price level is consistent model.

Table-8.7: White Heteroscedasticity of Residuals of Equation (8.7)

Test Summary	Value	Degree of Freedom	Probability
F-statistic	1.3452	Prob. F(14,127)	0.1903
$T \times R^2$	18.3386	Prob. Chi-Square(14)	0.1918

8.5 Stability Test of Estimated Distributed Lag Models ($dLnCPI_t$ Regressed on $dLnM_{1t}$)

To examine the stability of the estimated regression equation (8.7), we apply some test such as Ramsey's RESET test, Recursive Residual test, CUSUM test, CUSUM Squares test etc.

8.5.1 Ramsey's RESET Test

Table-8.8 demonstrates the results from Ramsey's RESET test of regression equation of equation (8.7). In the upper part of the Table, F-statistic, t-statistic and likelihood ratio are significant at 5% level as reported by the corresponding probability values. The null hypothesis 'correct specification is linear' is rejected when the variable $Fitted^2$ term is included in to the regression equation (8.7). It means the estimated distributed lag model of equation (8.7) is not linear. Likewise, in lower part of Table-8.8, H_0: $\gamma = 0$, is rejected as reported by the t-statistic. Hence, the Ramsey's RESET test implies that the estimated regression equation (8.7) is not stable model not containing the properties of linearity and it is misspecified model.

Table-8.8: Ramsey's RESET Test of Regression Equation (8.7)

Test-statistic	Value	Degree of Freedom	Probability
t-statistic	2.1177	136	0.0360
F-statistic	4.4847	(1, 136)	0.0360
Likelihood ratio	4.6071	1	0.0318

Unrestricted Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	$\alpha = 0.0098$	0.0054	1.7948	0.0749
$dLnM_{1t}$	β_0 =-0.0877	0.0746	-1.1745	0.2422
$dLnM_{1t-1}$	$\beta_1 = 0.0891$	0.0812	1.0972	0.2745
$dLnM_{1t-2}$	$\beta_2 = 0.0891$	0.0655	0.9700	0.3337
$dLnM_{1t-3}$	$\beta_3 = 0.0180$	0.0672	0.2677	0.7893
$Fitted^2$	$\gamma = 11.6233$	5.4885	2.11773	0.0360

Estimated regression equation (8.7) lacks the property of linearity due to the reason that the coefficient of $dLnM_{1_t}$ is negative. This negative coefficient has puzzled the Quantity Theory of Money. The estimated regression equation (8.7) does not support the Ramsey's RESET test when $dLnM_{1_t}$ is included in regression. So, this variable$dLnM_{1_t}$ should be deleted from regression equation (8.7) and new distributed lag model becomes:

$$dLnCPI_t = \alpha + \beta_1 dLnM_{1t-1} + \beta_2 \, dLnM_{1t-2} + \beta_3 \, dLnM_{1t-3} + \varepsilon_t \quad (8.8)$$

Ramsey's RESET test of equation (8.8) is presented through Table-8.9.

Table-8.9: Ramsey's RESET Test of Regression Equation (8.8)

Test-statistic	Value	Degree of Freedom	Probability
t-statistic	0.2727	138	0.7854
F-statistic	0.0744	(1, 138)	0.7854
Likelihood ratio	0.0770	1	0.7813

Unrestricted Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	$\alpha =$ -0.0016	0.0056	-0.2921	0.7706
$dLnM_{1t-1}$	$\beta_1 =$ 0.2178	0.0974	2.2360	0.0270
$dLnM_{1t-2}$	$\beta_2 =$ 0.2617	0.0933	2.8035	0.0058
$dLnM_{1t-3}$	$\beta_3 =$ -0.0016	0.0745	1.5762	0.1173
$Fitted^2$	$\gamma =$ 1.7351	6.3611	0.2727	0.7854

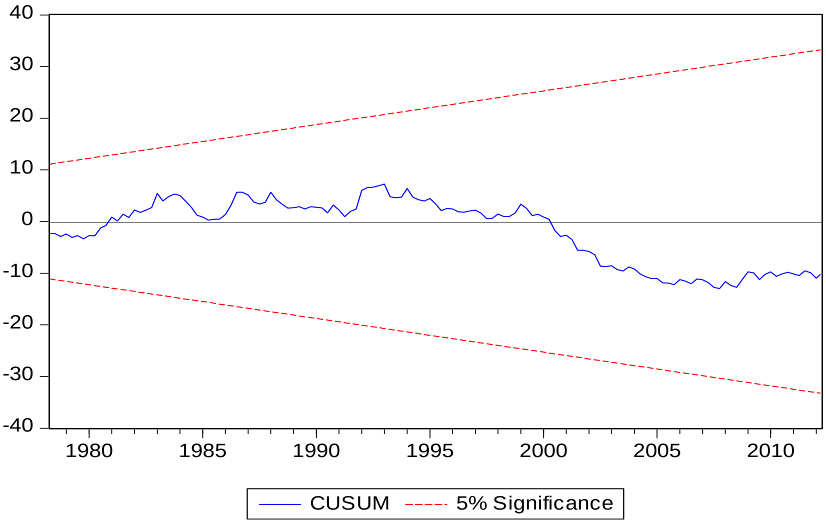
Table-8.9 demonstrates the results from Ramsey's RESET test of regression equation of equation (8.8). In the upper part of the Table, F-statistic, t-statistic and likelihood ratio are not significant. The null hypothesis 'correct specification is linear' is not rejected even if the variable $Fitted^2$ term is included in to the regression equation (8.8). It means the estimated distributed lag model of equation (8.8) is linear. Likewise, in lower part of Table-8.9, H_0: $\gamma = 0$ is not rejected as reported by the t-statistic. Hence, the Ramsey's RESET test implies that the estimated regression equation (8.8) is stable model containing the properties of linearity and it is not misspecified model.

Thus, Ramsey's RESET test bears the property of linearity and model is non-misspecified only when the variable $dLnM_{1_t}$ is omitted from the distributed lag model of equation (8.7). The reason of omitting the $dLnM_{1_t}$ term from equation (8.7) is that the term stood as the obstacle of applicability of the Quantity Theory of Money.

8.5.2 CUSUM Test

In Graph 8.1, W_t line lies within the critical lines. This clearly confirms the stability of coefficient of estimated regression equation (8.7).

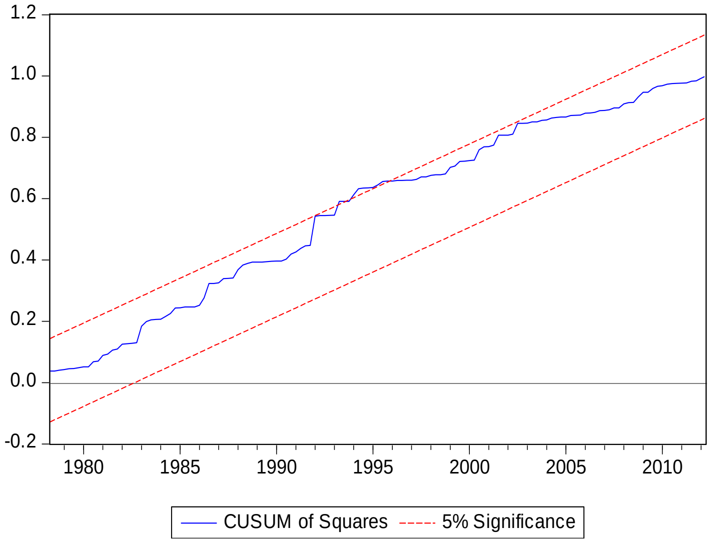
Figure-8.1: Graphical Presentation of CUSUM Test



8.5.3 CUSUM of Squared Test

Figure-7.2 shows the graphical presentation of CUSUM of squared test. In the graph, since S_t line lies within the critical lines except the period 1993-1998, the estimated regression equation (8.7) more or less fulfills the stability condition of parameter and variance.

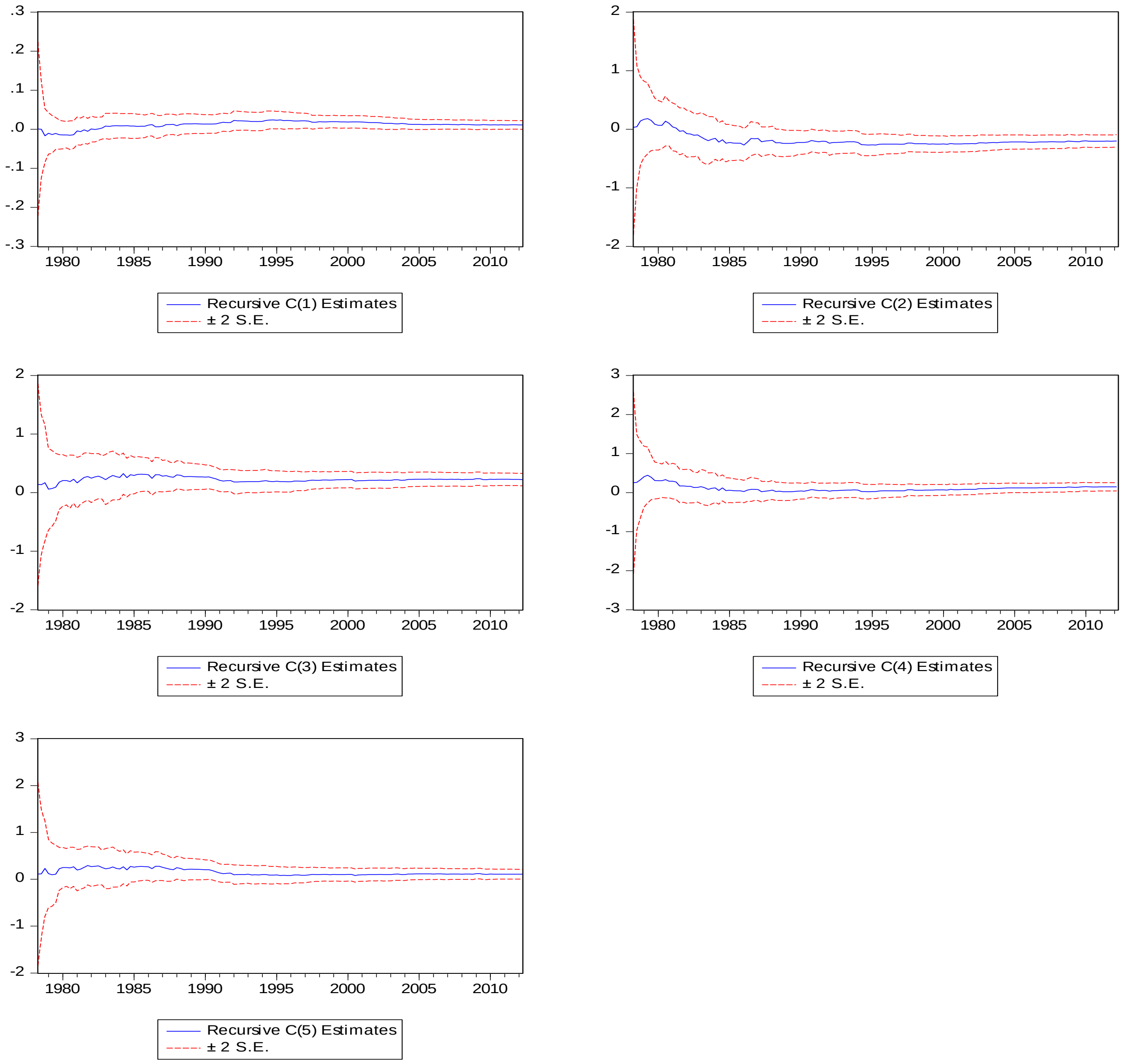
Figure-8.2: Graphical Presentation of CUSUM of Square Test



8.5.4 Recursive Coefficient Test

Figure/Graph-8.3 represents the Recursive Coefficient test of estimated regression (8.7). The graph of all coefficients represents no variation with respect to change in time. Thus, the Recursive Coefficient test also represents the stability of coefficients of estimated regression equation (8.7).

Figure-8.3 Recursive Coefficient Test of Regression Equation (8.8)



8.6 Distributed Lag Models: Price Level and Broad Money Supply

To find the magnitude of change in price level due to change in broad money supply (M_2), OLS regression should be run taking price level as dependent and broad money supply as independent variable. For this purpose, the distributed lag models are applied. Here, the stationary series ($dLnCPI_t$ on $dLnM_{2t}$) are taken in regression, where $dLnCPI_t$ and $dLnM_{2t}$ are logarithmic form of price level and M_2 money supply in their first differences. The stationary series are taken in the regression for consistent and meaningful results.

As in the regression equation (8.10) of $dLnP_t$ on $dLnM_{2t}$, the Ad Hoc lag selection procedure has been adopted. Applying this procedure, lags 2 are suitable for the independent variable $dLnM_{2t}$. The distributed lag model with $dLnP_t$ as dependent variable and $dLnM_{2t}$ as independent variable at lags 2 is given by equation (8.9).

The regression results of equation (8.9) are presented through Table-8.10.

$$dLnCPI_t = \alpha + dLnM_{2t} + \beta_1 dLnM_{2t-1} + \beta_2\, dLnM_{2t-2} + \varepsilon_t \qquad (8.9)$$

Table-8.10: Regression of $dLnCPI_t$ on Lagged $dLnM_{2t}$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	α = 0.0133	0.0054	2.4302	0.0164
$dLnM_{2t}$	$\beta_0 =$ -0.1609	0.0691	-2.3263	0.0214
$dLnM_{2t-1}$	$\beta_1 =$ 0.1457	0.0669	2.1767	0.0312
$dLnM_{2t-2}$	$\beta_2 =$ 0.1893	0.0674	2.8087	0.0057

R^2 =0.1410, $\bar{R}^2$=0.1224,S.E.of Regression=0.0241, D- W statistic=2.1380

From the Table-8.10, it is observed that the coefficients of dLnM_{2t-1} and dLnM_{2t-2} have positive sign and these are statistically significant 5% and 1% level respectively. However, the coefficient dLnM_{2t} has theoretically opposite sign even if it is statistically significant. The independent variable dLnM_{2t} has the negative coefficient, which is not in the line of Quantity Theory of Money. So the independent variable dLnM_{2t} should be avoided from our regression equation (8.9). However, the decision to avoid this variable from the regression equation or not depends on the Redundant test.

8.6.1Redundant Test

The redundant test allows testing for the statistical significance of a subset of included variables in the equation. More formally, the test is for whether a subset of variables in an equation all have zero coefficients and might thus be deleted from the equation. Under Redundant test, the null hypothesis is that the regression of $dLnCPI_t$ on $dLnM_{2t}$ has the redundant variable $dLnM_{2t}$. The variable $dLnM_{2t}$ will be deleted only when the null hypothesis is not rejected. (Eviews 7: User's Guide II)

When the redundant test is applied to the regression model (8.9), the null hypothesis is strongly rejected as reported by t-statistic F-statistic and Log Likelihood Ratio in

Table-8.11, and it can be concluded that $dLnM_{2t}$ is not redundant that should not be withdrawn from the above regression model.

Table- 8.11: Redundant Test of Equation (8.9)

Redundant Variables: $dLnM_{2t}$

Test Summary	Value	Degree of Freedom	Probability
t-statistic	2.3263	139	0.0214
F-statistic	5.4117	(1, 139)	0.0214
Likelihood ratio	5.4618	1	0.0194

From the Table-8.10, the adjusted R squared of the regression line of $dLnP_t$ on $dLnM_{2t}$ is 0.122. The adjusted R squared has poorly represented the goodness of fit of model. However, the S.E. and D-W statistic show that equation (8.9) has the property of little goodness of fit of the model.

8.6.2 Wald Coefficient Restriction Test

With the help of Wald coefficient Restriction Test, we can verify that whether or not M_2 money supply and price level are proportionally related. For this, we have the null hypothesis that the sum of the coefficients of independent variable equals one, i.e. $\beta_0 + \beta_1 + \beta_2 = \sum_{i=0}^{2} \beta_i = 1$, where β_0, β_1 *and* β_2 stand for the coefficient of $dLnM_{2t}$, $dLnM_{1t-1}$ and $dLnM_{2t-2}$ respectively. The null hypothesis is accepted or rejected on the basis of t-statistic F-statistic and Chi-square value. If null hypothesis is rejected, M_2 money supply and price level are not proportionally related but if alternative hypothesis is accepted, the variables under study are proportionally related.

Table-8.12 reveals the results from Wald Coefficient Restriction test of equation (8.9) with the null hypothesis of $\beta_0 + \beta_1 + \beta_2 = 1$. All the tests such as t-statistic, F-statistic and Chi-square value suggest that the null hypothesis of proportional relationship between the variables is strongly rejected. Thus, it can be concluded that there is no proportional relationship between M_2 money supply and price level.

Table-8.12: Wald Coefficient Restriction Test of Equation (8.9)

Test Statistic	Value	Degree of Freedom	Probability
t-statistic	-11.7569	139	0.0000
F-statistic	138.2257	(1, 139)	0.0000
Chi-square	138.2257	1	0.0000

8.6.3 Polynomial Distributed Lags ($dLnCPI_t$ Regressed on $dLnM_{2t}$)

The Polynomial Distributive Lags is also called Almon Lag Model. In the present study, this model is applied to find the total effect (current plus lagged) of M_2 money supply on price level. Under this model 2 distributed lags with first degree polynomial is used. The results from polynomials distributive lags have been presented through Table-8.13. From Table-8.13, it is observed that the sum of the coefficient (total effect of M_2 money supply on price level) is: $\beta_0 + \beta_1 + \beta_2 = 0.2047$, which is positive and statistically significant at 10 % level. This implies that there is positive relationship between change in M_2 money supply and price level. A 10 % rise of change in M_2 money supply has caused 2.04 % rise of change in price level.

Table-8.13: Results from Polynomial Distributed Lags: $dLnCPI_t$ Regressed on $dLnM_{2t}$

Model: $dLnCPI_t$,C, PDL($dLnM_{2t}$,2,1)

Lag Distribution	Coefficient	Std. Error	t-Stat
0	$\beta_0 =$ -0.1052	0.0571	-1.8424
1	$\beta_1 =$ 0.0682	0.0387	1.7624
2	$\beta_2 =$ 0.2417	0.0565	4.2767
Sum of Lags	$\beta_0 + \beta_1 + \beta_2 =$0.2047	0.1161	1.7624

8.7 Residuals Diagnostic of Distributed Lag Models ($dLnCPI_t$ Regressed on $dLnM_{2t}$)

In order to examine the consistency of estimated regression of equation (8.9), we have tested Residual Diagnostic through Correlogram Squared Residuals, Serial Correlation LM Test and Heteroscedasticity Test. With the help of these tests, we can conclude whether or not estimated regression equation (8.9) is consistent.

8.7.1 Correlogram of Squared Residuals

The Correlogram-Q-statistic of the residuals squared of estimated regression equation (8.9) is presented through Table-8.14. The ACFs and PACFs of correlogram of the residual squared tend to zero at all lags and the Q-statistics at all lags are not significant with large p-values. This indicates that there is no evidence of rejecting the null hypothesis of no serial correlation. This implies that the residuals of the fitted regression equation (8.9) are not serially correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of regression equation (8.9).

Table-8.14: Correlogram of Squared Residuals of Equation (8.9)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.031	-0.031	0.1415	0.707	9	0.039	0.034	11.329	0.254
2	-0.152	-0.153	3.5264	0.171	10	-0.091	-0.049	12.610	0.246
3	-0.090	-0.103	4.7316	0.193	11	-0.139	-0.104	15.663	0.154
4	0.049	0.018	5.0857	0.279	12	-0.028	-0.063	15.786	0.201
5	0.065	0.040	5.7240	0.334	13	-0.053	-0.138	16.239	0.236
6	-0.049	-0.044	6.0879	0.413	14	0.019	-0.020	16.299	0.295
7	-0.048	-0.031	6.4380	0.490	15	-0.035	-0.045	16.499	0.350
8	0.174	0.172	11.098	0.196	16	0.115	0.092	18.674	0.286

8.7.2 Breusch-Godfrey LM Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation have been presented through Table-8.15. As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test in Table-7.15, the null hypothesis of no autocorrelation cannot be rejected. The B-G LM test implies that residuals are not serially correlated. Due to the non-presence of serial correlation, the estimated regression equation (8.9) is considered as the consistent model for representing the relationship between M_2 money supply and price level.

Table-8.15: Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.2135	Prob. F(2,137)	0.3003
$T \times R^2$	2.4893	Prob. Chi-Square(2)	0.2880

8.7.3 Residuals Heteroscedasticity Test

The null hypothesis of White's (1980) is: there is homoscedasticity in the residuals. The null hypothesis is not rejected if the F-statistic and χ^2 statistic are not significant. No rejection of null hypothesis confirms that residuals of estimated regression do not suffer from heteroscedasticity problem and estimated regression is claimed to be consistent. Table-8.16 presents the Residual Heteroscedasticity test of regression equation (8.9).

From the Table-8.16, it is observed that F-statistic and $T \times R^2$ value are not significant as reported by the probability values of the fourth column. There is no evidence of rejecting the null hypothesis that residuals are homoscedastic. It means, the residuals of estimated regression equation (8.9) do not suffer from heteroscedastic problem. Hence, it is claimed that the estimated regression equation (8.9) representing the relationship between narrow money supply and price level is consistent model.

Table-8.16: White Heteroscedasticity Test of Residuals of Equation (8.9)

Test Summary	Value	Degree of Freedom	Probability
F-statistic	0.8295	Prob. F(9,133)	0.5901
$T \times R^2$	7.6002	Prob. Chi-Square(9)	0.5749

8.8 Stability Test of Estimated Distributed Lag Models ($dLnCPI_t$ Regressed on $dLnM_{2t}$)

To examine the stability of the estimated regression equation (8.9), we apply some test such as Ramsey's RESET test, CUSUM test, CUSUM Squares test and Recursive Residual test.

8.8.1 Ramsey's RESET Test

Table-8.17 demonstrates the results from Ramsey's RESET test of regression equation of equation (8.9). In the upper part of the Table, F-statistic, t-statistic and likelihood ratio are not significant as reported by the corresponding probability values. The null hypothesis 'correct specification is linear' is not rejected even if the variable $Fitted^2$ term is included in to the regression equation (8.9). It means the estimated distributed lag model of equation (8.9) does not avoid the property of linearity. Likewise, in lower part of Table-8.8, H_0: $\gamma = 0$, is not rejected as reported by the t-statistic. Hence, the Ramsey's RESET test implies that the estimated regression equation (8.9) is stable model containing the properties of linearity and it is not misspecified model.

Table-8.17: Ramsey's RESET Test of Regression Equation (8.9)

Test-statistic	Value	Degree of Freedom	Probability
t-statistic	0.0446	138	0.9645
F-statistic	0.0019	(1, 138)	0.9645
Likelihood ratio	0.0020	1	0.9638

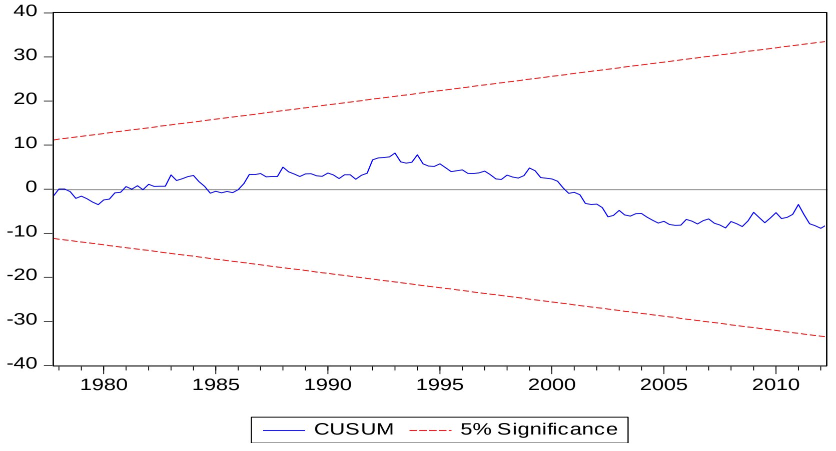
Unrestricted Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	$\alpha = 0.0132$	0.0063	2.0935	0.0381
$dLnM_{2t}$	β_0 = -0.1614	0.0703	-2.2941	0.0233
$dLnM_{2t-1}$	$\beta_1 = 0.1488$	0.0956	1.5557	0.1220
$dLnM_{2t-2}$	$\beta_2 = 0.1949$	0.1427	1.3656	0.1743
$Fitted^2$	γ = -0.4070	9.1247	-0.0446	0.9645

8.8.2 CUSUM Test

In Figure-8.4, W_t line lies within the critical lines. This clearly confirms the stability of coefficient of estimated regression equation (8.9).

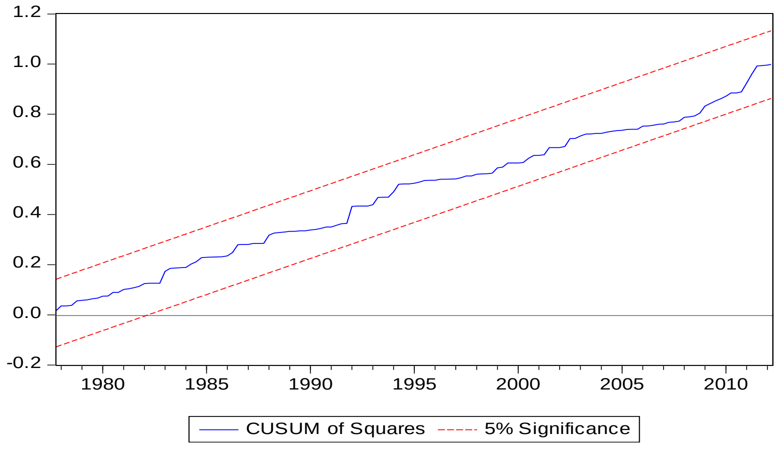
Figure-8.4: Graphical Presentation of CUSUM Test



8.8.3 CUSUM of Squared Test

Figure-8.5 shows the graphical presentation of CUSUM of squared test. In the graph, since S_t line lies within the critical lines, the estimated regression equation (8.5) fulfills the stability condition parameter and variance.

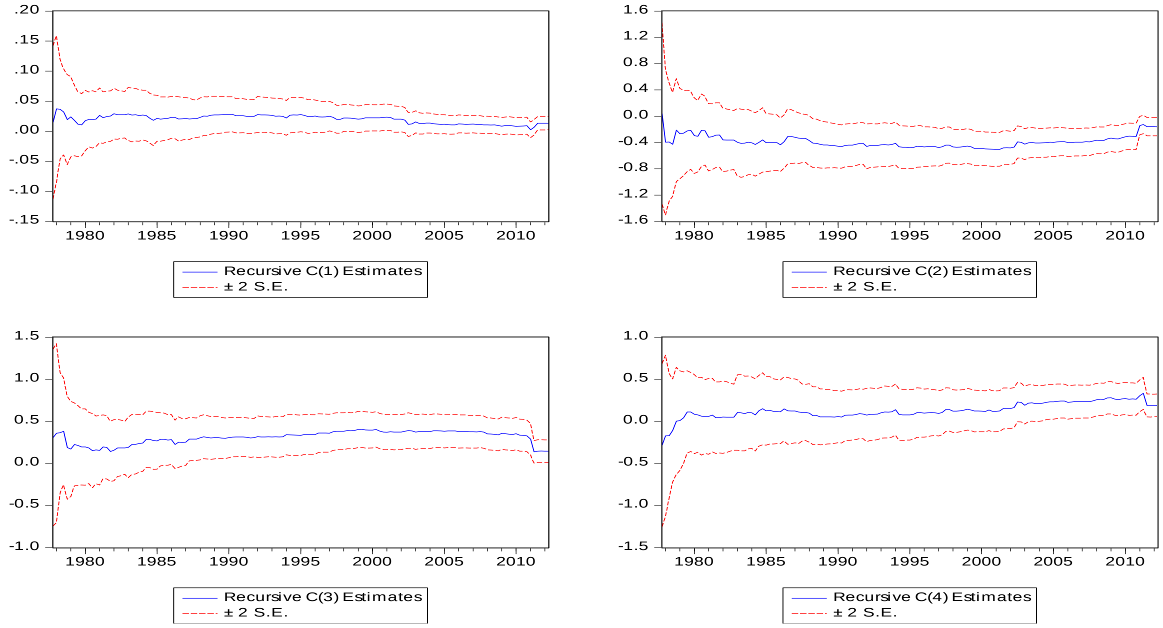
Figure-8.5: Graphical Presentation Squared of CUSUM Test



8.8.4 Recursive Coefficient Test

Figure/Graph-8.6 represents the Recursive Coefficient test of estimated regression (8.9). The graph of all coefficients represents more or less no variation with respect to change in time. Thus, the Recursive Coefficient test also represents the stability of coefficients of estimated regression equation (8.9).

Figure-8.6 Recursive Coefficient Test of Regression Equation (8.9)



8.9 Impact of Indian Inflation on Nepalese Inflation

Foreign price shocks are a major contributing factor to the inflation of Nepal. Changes in prices of goods and services in the international markets, especially in India widely affect the price in Nepal, with a coefficient equal to unity (Pant, 1988). In a study conducted by Nepal Rastra Bank in 2007, it was found that Indian inflation is a dominating factor in determining inflation in Nepal.

More recently a different trend is emerging on the factors contributing to Nepal's inflation. The Finding is that inflation in Nepal is more responsive to international oil prices and nominal effective exchange rate than to India's inflation. (Source: Nepal--Selected Issues, IMF, Nov 2011) These factors account for more than one-third of the variability in domestic inflation.

The close relation of Nepalese and Indian price level and inflation is consistent with absolute and Relative purchasing power parity holding between both countries. Nepal has high concentration of trade with India which is attributed to the open and contiguous border shared by both countries. In the review period of mid-December 2012, imports from India increased by 28.6%, compared to an increase of 8.1% in the previous period. The main items of import from India were petroleum products, vehicles and spare parts, cement, chemical fertilizer and rice. The trade deficit with

India increased by 33.7% during the review period compared to 6.7% previous period. (NIBL Capital, 2013).

This section tries to analyze the impact of Indian inflation along with the Nepalese money supply on Nepalese inflation. Indian inflation is augmented with autoregressive distributed lag models of Nepalese inflation on money supply both M_1 and M_2. The first difference of Indian Wholesale Price Index in logarithmic form (IWPI)[36] represents Indian inflation. Now, regression model of equation (8.7) augmented with Indian inflation is given by:

$$dLnCPI_t = \alpha + \beta_0 dLnM_{1t} + \beta_1 dLnM_{1t-1} + \beta_2\, dLnM_{1t-2} + \beta_3\, dLnM_{1t-3} + \gamma dLnIWPI_t + \varepsilon_t \qquad (8.10)$$

The regression results from equation (8.10) are presented through Table-8.18.

Table-8.18: Regression of $dLnCPI_t$ on Lagged $dLnM_{1t}$ Augmented with $dLnIWPI_t$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	α = 0.0091	0.0055	1.6568	0.0998
$dLnM_{1t}$	β_0= -0.1286	0.0604	-2.1275	0.0352
$dLnM_{1t-1}$	β_1 = 0.2012	0.0526	3.8228	0.0002
$dLnM_{1t-2}$	β_2 = 0.1040	0.0552	1.8844	0.0616
$dLnM_{1t-3}$	β_3 = 0.0970	0.0522	1.8581	0.0653
$dLnIWPI_t$	γ = 0.2061	0.0880	2.3398	0.0207

R^2=0.4214 $\bar{R}^2$=0.4002 S.E.of Regression=0.0199 D-W statistic=1.9313

From Table-8.10, it is observed that the coefficient of $dLnIWPI$, γ=0.2061 is positive and significant at 5% level. This implies that of the total inflation of Nepalese economy, 20.6% is caused (one-fifth) by Indian inflation. The values of $\bar{R}^2$ and S.E. of regression are improved in equation (8.10) than in equation (8.7).

Next, we analyze the impact of Indian inflation on Nepalese inflation. For this, we regress $dLnCPI_t$ on $dLnIWPI_t$ to capture the impact of Indian inflation on Nepalese inflation. Here, we do not use lagged $dLnIWPI_t$ in our regression because as inflation

[36] $LnIWPI$ is non-stationary and $dLnIWPI$ is stationary series.

arises in India, it immediately affects Nepalese price without delay. Table-8.19 presents the regression results of $dLnCPI_t$ on $dLnIWPI_t$.

In the Table-8.19, the coefficient of $dLnIWPI_t$, γ=0.4894 is positive and significant at less than 1% level. This implies that a ten percent rise in Indian wholesale price causes Nepalese price to rise by 4.8%. The regression results are robust due to the non-presence of serial correlation in residuals and heteroscedasticity. Thus, it can be concluded that Indian inflation plays vital role to cause inflationary pressure in the economy of Nepal in addition to other factors.

Table-8.19: Regression of $dLnCPI_t$ on $dLnIWPI_t$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	α = 0.0091	0.0606	8.0735	0.0000
$dLnIWPI_t$	γ=0.4894	0.0606	8.0735	0.0000

Finally, we regress $dLnCPI_t$ on lagged $dLnM_{2t}$ augmented with $dLnIWPI_t$. When equation (8.9) is augmented with $dLnIWPI_t$, we have new model given as:

$$dLnCPI_t = \alpha + dLnM_{2t} + \beta_1 dLnM_{2t-1} + \beta_2\, dLnM_{2t-2} + dLnIWPI_t + \varepsilon_t \qquad (8.11)$$

Table-8.20 demonstrates the results from regression equation (8.11). In the Table, the coefficient of $dLnIWPI_t$, γ=0.4260 is positive and significant at less than 1% level. The value of $\overline{\mathrm{R}}^2 = 0.3254$, which is more than in case of equation (8.9). The regression result is improved when regression equation (8.9) is augmented with $dLnIWPI_t$. The coefficient of $dLnIWPI_t$ implies that a ten percent rise in Indian wholesale price causes Nepalese price to rise by 4.26% when broad money supply M_2 is taken in to account.

Table-8.20: Regression of $dLnCPI_t$ on Lagged $dLnM_{2t}$ Augmented with$dLnIWPI_t$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	α = 0.0094	0.0048	1.9445	0.0539
$dLnM_{2t}$	$\beta_0 =$ -0.0435	0.0632	-0.6883	0.4924
$dLnM_{2t-1}$	$\beta_1 = 0.1297$	0.0587	2.2075	0.0289
$dLnM_{2t-2}$	$\beta_2 = 0.0822$	0.0613	1.3413	0.1820
$dLnIWPI_t$	γ = 0.4260	0.0651	6.5441	0.0000

R^2=0.3444 $\bar{R}^2$=0.3254 S.E. of Regression=0.0211 D-statistic=1.9347

8.10 Conclusion of Chapter Eight

Following conclusions are drawn from chapter Eight.

- This chapter has basically employed Autoregressive Distributed Lag Models to examine the relationship between price level and money supply along with Indian price.
- Ad Hoc approach has been applied to find the appropriate lag/s to use in independent variable/s.
- Lags 3 are the appropriate lags of the Autoregressive Distributed Lag Model for the relationship between $dLnCPI_t$ and $dLnM_{1t}$. Whereas, lags 2 are suitable in case regression of $dLnCPI_t$on $dLnM_{2t}$ under Autoregressive Distributed Lag Model.
- The regression of $dLnCPI_t$ on lagged $dLnM_{1t}$ implies that there is direct relationship between money M_1 money supply and price level.
- $dLnM_{1t}$ at lag 1, 2 and 3 is found to be causing $dLnCPI_t$ directly. However, $dLnM_{1t}$ at lag 1 did not cause $dLnCPI_t$ directly.
- The redundant test showed that the independent variable $dLnM_{1t}$ at lag could not be deleted from the regression of $dLnCPI_t$ on lagged $dLnM_{1t}$.
- The Wald Coefficient Restriction test implies that there is no proportional relationship between M_1 money supply and price level.

- In general, there is direct but non-proportional relationship between M_1 money supply and price level. The Keynesian view on the relationship between money supply and price level holds in case of narrow money supply.
- As reported by Polynomial Distributed Lags ($dLnCPI_t$ Regressed on $dLnM_{1t}$), a ten percent rise in M_1 money supply has caused price level to rise by 2.76%.
- As suggested by residuals Diagnostic test such as Correlogram of Residuals Squared, Breusch-Godfrey Lagrange Multiplier Test for Serial Correlation and Residual Heteroscedasticity test, there is no serial correlation and heteroscedasticity problems in the residuals of the Autoregressive Distributed Lag Model of the regression of $dLnCPI_t$ on lagged $dLnM_{1t}$. Hence, the ARDL model on the relationship between $dLnCPI_t$ and $dLnM_{1t}$ is claimed to be robust.
- The Ramsey RESET test for Stability test of $dLnCPI_t$ on lagged $dLnM_{1t}$ implies that the estimated regression equation is not linear until the independent variable $dLnM_{1t}$ at lag 1 is deleted from the equation. After deleting this term, the Ramsey RESET test implies that the estimated regression equation of $dLnCPI_t$ on lagged $dLnM_{1t}$ bears the property of linearity.
- The CUSUM test, CUSUM of Square and Recursive coefficient tests imply that the estimated regression equation (8.7) fulfills the stability condition of coefficients/parameters and variance and hence the estimated regression equation of $dLnCPI_t$ on lagged $dLnM_{1t}$ is stable.
- The regression of $dLnCPI_t$ on lagged $dLnM_{2t}$ implies that there is direct relationship between money M_2 money supply and price level.
- $dLnM_{2t}$ at lag 1 and 2 is found to be causing $dLnCPI_t$ directly. However, $dLnM_{2t}$ at lag 1 did not cause $dLnCPI_t$ directly.
- The redundant test showed that the independent variable $dLnM_{2t}$ at lag could not be deleted from the regression of $dLnCPI_t$ on lagged $dLnM_{2t}$.
- The Wald Coefficient Restriction test implies that there is no proportional relationship between M_2 money supply and price level.

- In general, there is direct but not proportional relationship between M_2 money supply and price level. The Keynesian view on the relationship between money supply and price level holds in case of broad money supply.
- As reported by Polynomial Distributed Lags ($dLnCPI_t$ Regressed on $dLnM_{2t}$), a ten percent rise in M_2 money supply has caused price level to rise by 2.04%.
- As suggested by residuals Diagnostic test such as Correlogram of Residuals Squared, Breusch-Godfrey Lagrange Multiplier Test for Serial Correlation and Residual Heteroscedasticity test, there is no serial correlation and heteroscedasticity problems in the residuals of the Autoregressive Distributed Lag Model of the regression of $dLnCPI_t$ on lagged $dLnM_{2t}$. Hence, the ARDL model on the relationship between $dLnCPI_t$ and $dLnM_{2t}$ is claimed to be robust.
- The Ramsey RESET test for Stability test of $dLnCPI_t$ on lagged $dLnM_{2t}$ implies that the estimated regression equation bears the property of linearity.
- The CUSUM test, CUSUM of Square and Recursive coefficient tests imply that the estimated regression equation (8.9) fulfills the stability condition of coefficients/parameters and variance and hence the estimated regression equation of $dLnCPI_t$ on lagged $dLnM_{2t}$ is stable.
- The regression equation of $dLnCPI_t$ on $dLnM_{1t}$ augmented with $dIWPI_t$(Indian Inflation) implies that a ten percent rise in Indian inflation causes the Nepalese price to rise by 2.06%, where as The regression equation of $dLnCPI_t$ on $dLnM_{2t}$ augmented with $dIWPI_t$ implies that a ten percent rise in Indian inflation causes Nepalese price to rise by 4.26%.
- The regression equation of Nepalese inflation on Indian inflation (without including money supply) implies that a ten percent rise in price in India causes price to rise by 4.9% in Nepal.