CHAPTER V

ESTIMATION AND ANALYSIS OF INFLATION

This chapter attempts to estimate and analyze various models of inflation in Nepal. Various tests are applied for the stability and robustness of the inflation model.

1. ESTIMATION OF INFLATION MODEL

The first section of this chapter includes an estimation and analysis of the different inflation models. The Monetarist and non-monetarist hypotheses of inflation are examined to explain the inflation trend in Nepal. The Monetarist hypothesis of the determination of inflation is coined with the classical and neo-classical quantity theory of money. Therefore, the application of classical, neo-classical and monetarist approaches to inflation is examined under the single section 'Monetarists' Model of Inflation'. The non-monetarists' model includes Keynesian and structural model of inflation, and are examined subsequently. As mentioned in earlier chapter, estimated results relate to annual data and quarterly data.

(A) Estimation Based on Annual Data

The reason for using two frequencies of data for the analysis is to identify the relative contribution of explanatory variables to the dependent variable. The estimation of inflation models based on annual data frequency is followed by the estimation based on quarterly data frequency.

(i) Monetarists' Model of Inflation

The difference between the equation of exchange of quantity theory of money (i.e. $MV = PY$) propounded by Fisher (1922), and neo-classical reinterpretation of the classical quantity theory of money (i.e. $M^d = \bar{k}PY$), is in terms of the velocity of money and the demand for money. However, according to Neo-classical and Monetrist models, inverse relationship holds true between demand for money and inflation, since there is a reciprocal relationship between the velocity of money and the demand for money. In other words, Fisher assumed money as 'having wings' and the faster it flies, velocity increases and hence inflation also rises. However, the Neo-classical and Monetarist models assumed that money is 'sitting money', and the longer it sits, velocity declines and hence inflation falls. Therefore, both schools of thought describe money supply as the root cause of inflation but interpretation is different, that is, the former focuses on velocity of money and the latter on demand for money.

In order to explain inflation in the short-run, velocity is assumed fixed because it is determined by institutional developments in the monetary sector or by the financial habits of the public. The demand for money is also fixed because it is assumed to be a stable function of transaction demand for money and some return variables. Similarly, the volume of output is fixed from the supply side and is also fixed in the short run (Froyen, 2003). Inflation takes place when increase is in money supply in excess of the transaction purpose of output. If an effect of money supply is not reflected in inflation, then velocity cannot be considered fixed, and its effect is reflected in output changes. Therefore, there is a direct and proportionate relationship between money supply and inflation. Inflation is primarily a monetary phenomenon only when it continues mounting because of the continuous increase in money supply growth (Laidler and Parkin, 1975). An analysis of the dynamics of inflation explains the monetarist claim of inflation as being "always and everywhere a monetary phenomenon" (Friedman, 1970b). Monetarists tend to concentrate on the long-run phenomenon of money-price relationship.

The argument of inflation as a monetary phenomenon has a direct implication on the quantity theory of money. It relates the levels of the nominal money supply *(M)*, the income velocity of money *(v)*, the general price level *(P)* and real output *(y)* as: $Mv = Py$. Taking logarithm and solving for '*P*' to apply Ordinary Least Square (OLS) method, the relationship holds as:

$$\ln P_t = \alpha_0 + \beta_1 \ln M_t - \beta_2 \ln y_t + u_t \quad \text{..........} \quad (1)$$

The coefficients of the double-log model like equation (1) are interpreted as elasticity coefficients. This is because, if we plot the log of one variable against the log of another variable, we found a linear relationship between the two variables. The ordinary least square model can be used, if and only if, they (variables) show a linear relationship between them. Equation (1) can be used to test the monetarist proposition that accounts for the sources of inflation, that is, to ascertain relative contribution of sources like money growth, real output and velocity. Inflation goes up when an increase in money supply in excess of the demand for money for transaction of output of an economy. In this context, the monetarist proposition states that inflation is predominately a monetary phenomenon. It implies that while real output changes should be accounted for, velocity changes are not significant and can be largely ignored.

The expected signs of the coefficients of equation (1) are as identified therein in the model itself. The null hypothesis (Ho) of the model is that the elasticity coefficients are not significantly different from zero so inflation in Nepal is not a monetary phenomenon and, is not determined by the growth of monetary aggregates and income. This hypothesis is tested against the alternative hypothesis (H1) of the model that inflation is a monetary phenomenon. According to monetarists, inflation is essentially a monetary phenomenon in the sense that a continuous increase in the general price level is due to the rate of expansion in money supply far in excess of the amount of money actually demanded by the economic units. However, this link between inflation and changes in money supply may not be instantaneous. Studies have shown that the lag between the two is significant. Therefore, the long-run impact of a 1 percent change in the money supply on inflation is about 1, whereas short-run impact coefficients are not necessarily equal to 1. The effects of contemporaneous and lag changes in $M1_t$ and Y_t on inflation are presented in Table 5.1.

Table 5.1
The Effect of $M1_t$ and Y_t on inflation
(1975 to 2003)

Specification	Intercept	M_1	$M1_{t-1}$	Y_t	Y_{t-1}	P_{t-1}	R^2	DW	F
1st	-1.63* (-20.50)	0.60* (71.24)	–	–	–	–	0.99	0 66	5074
2rd	-1.67* (-16.34)	0.68* (2.93)	-0.08 (-0.35)	–	–	–	0.99	0.64	2184
3nd	-1.72 (-0.52)	0.59* (5.88)	–	0.01 (0.03)	–	–	0.99	0.67	2443
4th	2.49 (0.80)	0.73* (7.49)	–	–	-0.45*** (-1.33)	–	0.99	0.74	2330
5th	-0.50* (-11.01)	0.59* (36.66)	–	–	–	–	0.98	1.52	2256
6th	0.03 (0.08)	0.04 (0.36)				0.92* (5.34)	0.99	1.48	4670
7th	0.14 (3.51)*					0 99 (98.31)*	0.99	1.56	9664

Where, M1= monetary aggregate consisting currency held by the public and demand deposit of the commercial banks, Subscripts- t-1, t-2 and t-3 indicate first, second and third quarter lag values of M1 monetary aggregates. Y_t = real GDP at the base year price of 1994/95. Figures in the parenthesis, given below the coefficients, are t values. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signify coefficient significant at 10% level.

The elasticity of inflation with respect to M1 is found to be 0.60. It suggest that if total M1 goes up by 1 percent, on an average, the inflation goes up by about 0.60 percent, as shown in 1st specification of Table 5.1. This result shows that inflation is M1- inelastic or inflation is relatively less responsive to changes in M1. The positive sign of M1 elasticity of inflation is according to the theoretical expected sign as hypothesized by the monetarists'.

However, if we strictly follow the Fisherian assumption and set null hypothesis that the estimated ($\hat{\beta}_1$) coefficient is not significantly different from true population parameter (β_1) of unity, we cannot reject the null hypothesis. Since, coefficient $\hat{\beta}_1$ is not sufficiently closer to unity, (that is, 0.60 is not sufficiently closer to unity), the hypothesis that there is a direct and proportionate (one-to-one) relationship between money supply and inflation does not hold true.

In order to examine inflation in Nepal as an "always and everywhere monetary phenomenon", one period lag M1 is introduced in 2^{nd} specification[2]. The summation of short-run elasticities of various lags does not exceed the coefficient of 0.60 (as examined contemporaneously). Therefore, inflation in Nepal is a monetary phenomenon as hypothesized by monetarists but does not confirm to Fisher's assumption. This conclusion is also satisfied by the application of adaptive expectation model as shown in 6^{th} specification, where 0.04 is the short-run price elasticity of M1, and if it is increased, the long-run elasticity will be 0.50 [i.e.0.04/(1-0.92)]. In other words, 1 percent change in M1, inflation contributes to variation in about 0.50 percent over the period.

Similarly, the coefficient of Y_t, as an additional variable combined with $M1_t$, is not found to be statistically significant as shown in 3^{rd} specification. It does not follow the expected theoretical sign too. Therefore, variation in current output has no impact on the variation in current inflation. Since the R^2 is very high and DW test statistics are low in every specification showing problem of first order autocorrelation except 5^{th} specification, where use is made up of Cochrane-Orcutt (C-O)[3] iterative method to overcome the autocorrelation problem. Though (C-O) method is thought to overcome the problem of autocorrelation, the coefficients derived in this way may not give long-run relationship between the variables because of its application of first difference specification of the model. The expectation coefficient of 0.08 (i.e.1-0.92) as found by using adaptive expectation method, as shown in 6^{th} specification, signifies that about

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[2] In the present study, only one lag of independent variables is considered because of two reasons. first, the sign of elasticity coefficient is changed; second, additional lags did not significantly improve the sum of elasticity coefficients β_i in the specification: $\ln P_t = \alpha_0 + \sum_{i=0}^{n} \beta_i \ln M_{t-i}$.

[3] Conversion in Generalized Least Square (GLS) model: $\ln P_t = \beta_0^* + \beta_1^* \ln M_t^* + \varepsilon_t$, Where, $\ln P_t^* = ((\ln P_t - \rho \ln P_{t-1})$, $\beta_0^* = \beta_0(1-\rho)$, $\ln M_t^* = (\ln M_t - \rho \ln M_{t-1})$, $\beta_1^* = \beta_1$

8 percent of the discrepancy between actual and expected inflation is eliminated within a year, which is considered to be quite a long period of time of adjustment. The expected inflation explains the current inflation.

In summing up, the elasticity coefficient of inflation with respect to M1 is positive and significantly different from zero, rejecting the null hypothesis that there is no impact of M1 on inflation. This implies that inflation in Nepal is a monetary phenomenon. The coefficient of Y_{t-1}, combined with M1, in 4^{th} specification, seems better than contemporaneous Y_t. Though coefficient of Y_{t-1} is significant at 10 percent level, according to F statistic, 4^{th} specification is statistically significant. Similarly, expected rate of inflation (P_{t-1}) as proxied by previous years of inflation has also significant impact on inflation as shown in 7^{th} specification.

Table 5.2

The Effect of changes in $M2_t$[4] and Y_t on inflation
(1975 to 2003)

Spec.	Intercept	$M2_t$	$M2_{t-1}$	Y_t	Y_{t-1}	P_{t-1}	R^2	DW	F
1^{st}	-1.40* (-17.82)	0.53* (69.10)	–	–	–	–	0.99	0.56	4774
2^{rd}	-1.55* (-13.88)	0.93* (3.43)	- 0.39*** (-1.47)	–	–	–	0.99	0.73	2305
3^{nd}	-2.44 (-0.52)	0.50* (5.88)	–	0.11 (0.03)	–	–	0.99	0.55	2307
4^{th}	2.97 (0.92)	0.65* (7.38)	–	–	- 0.47*** (-1.37)	–	0.99	0.74	2330
5^{th}	0.10 (0.37)	0.01 (0.12)	–	–	–	0.96* (5.44)	0.99	1.53	4649
6^{th}	0.14 (3.51)*					0.99 (98.31)*	0.99	1.56	9664

Figures in the parenthesis, given below the coefficients, are t values. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signify coefficient significant at 10% level.

The M2 elasticity of inflation found to be 0.53. This suggests that inflation in Nepal is relatively less responsive to changes in M2. The elasticity coefficient

[4] M2 is M1 monetary aggregate plus fixed deposits of commercial banks

is positive but significantly different from zero, rejecting the null hypothesis that there is no impact of M2 on inflation. The total sum of coefficients of various lags of M2, as shown in 2nd specification, is not found exceed the coefficient of contemporaneous M2 and inflation, as shown in 1st specification. This result supports the monetrist hypothesis that inflation in Nepal is a monetary phenomenon but it is not found to be proportionate relationship between inflation and M2 as hypothesized by Fisher. The expectation coefficient, as shown in 5th specification, signifies that about 4 percent of the discrepancy between actual and expected inflation is eliminated within a year which is quite a long period of time[5].

In summing up, the null hypothesis that there is an impact of expected rate of inflation, as proxied by one period lagged rate of inflation, on current rate of inflaton is rejected as shown in 6th specification. Similarly, the elasticity coefficient of inflation with respect to M2 is found to be positive and significantly different from zero. It implies that the null hypothesis that there is no impact of M2 on inflation is rejected.

A decision of holding money for the future is determined by the expected rate of inflation (π_t^*) over some time-horizon. A rise in the expected rate of inflation motivates financial asset holders to substitute consumer durables. The higher demand for consumer durables leads to a rise in inflation. Therefore, there is a positive relationship between the rate of inflation and the expected rate of inflation. However, rate of inflation will vary in proportion to the rate of monetary expansion if the expected rate of inflation is constant (Laidler and Parkin, 1975).

The monetarist model is reformulated into dynamic model incorporating price expectations as an additional variable to find the short-run effect of money supply on output and inflation. One version of expectation of a variable is the

[5] (1-0.96)=0.04 as generated by the adaptive expectations mechanism

adaptive expectations model (Frisch, 1983). The adaptive expectation model of inflation assumes that the current rate of inflation is not only a function of excess demand but also of the expected rate of inflation, where, expected rate of inflation is a function of past rates of inflation. Therefore, the adaptive expectation model is backward-looking. This model assumes that money supply is neutral in the long-run, but not in the short-run. The results of the extended monetarist model including expected rate of inflation (π_t^*)[6] is given in Table 5.3.

Table 5.3

The Effect of changes in $M1_t$, $M2_t$, Y_t P_t^e on inflation

(1975 to 2003)

Spec.	Intercept	$M1_t$	$M2_t$	Y_t	Y_{t-1}	π_t^*	R^2	DW	F
1st	-1.61* (-26.64)	0.59* (76.61)	–	–	–	0.010* (3.27)	0.99	1.01	3451
2nd	-1.39* (-19.65)	–	0.52* (70.95)	–	–	0.010* (2.73)	0.99	0.77	2960
3rd	-9.77* (-3.19)	0.33* (3.46)	–	0.87* (2.66)	–	0.013* (4.50)	0.99	1.56	2843
4th	-7.25* (-2.23)	0.41* (4.04)	–	–	0.60** (1.71)	0.015* (4.36)	0.99	1.52	2681
5th	-10.98* (-3.35)	–	0.26* (2.87)	1.02* (2.93)	–	0.014* (4.25)	0.99	1.55	2552
6th	-7.45* (-2.04)	–	0.36* (3.56)	–	0.64*** (1.64)	0.015* (4.0)	0 99	1.37	2437

Figures in the parenthesis, given below the coefficients, are t values. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signify coefficient significant at 10% level.

The elasticity coefficient of π_t^* is statistically significant at 1 percent level. However, an introduction of π_t^* in the monetarist equation of inflation leads the explanatory power M1 as well as M2 to decline. However, the explanatory

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[6] Expected rate of inflation (π_t^*) series is derived as $\pi_t^* = \theta\pi_{t-1} + (1-\theta)\pi_{t-1}^*$. The greater the weight assigned to recent events in the determination of expectations, the hgiehr will be the value of is θ The alternative values of the adjustment coefficient θ, were used above equation in order to yield the most appropriate formulation of expected inflation. In such a grid search, the optimal value of θ is the which minimizes $Min\sum_{t=1}^{b}[\pi_t - \theta\pi_{t-1} + (1-\theta)\pi_{t-1}^*]^2$. Where, repeated trial of θ=0.4 and (θ-1)=0.6 minimized the function. On the basis of θ=0.4, estimated series of expected rate of inflation has been used as expected rate of inflation in the monetarists' model.

power of Y_t increased with contrary to expected sign. The coefficients of the expected rate of inflation range between 0.010 and 0.015 for entire specifications of Table 5.3. It implies that one percent increase in the expected rate of inflation leads to one unit increase in consumer price index (antilog of 0.014=1). The DW test statistic is significantly increased after the introduction of the expected rate of inflation, resulting into less effect of autocorrelation.

In summing up the contribution of M1 and M2 in accelerating inflation in Nepal, M1 is found to be a better explanatory variable to inflation as compared to M2. Lagged effect of both the M1 and M2 does not significantly improve the long-run impact of money supply to inflation, implying that inflation in Nepal is determined by current money supply. An introduction of Y_{t-1} in the pure monetary model somehow increases the explanatory power of the model with the expected theoretical sign. If we consider one period lagged inflation as a proxy of expected rate of inflation, it is found statistically significant with almost unitary elasticity of inflation with respect to expected rate of inflation.

(ii) Keynesian Model of Inflation

The basic difference between the Monetarists approach to demand for money from Keynes is that for the Monetarists, demand for money is a stable function of some return variables; while for Keynes, demand for money function is unstable because of it being highly sensitive to the rate of interest that works through its speculative role (Mankiw 2004). Therefore, any changes in the supply of money as well as government deficit do not have a predictable impact on the level of economic activity. Keeping this in view, it is relevant to examine the effect of rate of interest and government budget deficit on the determination of inflation in Nepal.

$$\pi_t = \alpha_0 + \beta_1 D_t + \beta_2 R_t + \varepsilon_t \qquad \text{-------------- (2)}$$

D_t = budget deficit, R_t = rate of interest; and ε_t = disturbance term with zero mean and constant variance.

Since budget deficit is one of the basic sources of rise in money supply, it can be used as a proxy for money supply. An increase in the rate of interest leads to decline in a holding of money balances, and hence increase in velocity of money. There is a positive relationship between inflation and velocity. Therefore, theoretical expected sign of β_2>0 hypothesized to be positive, that is, there is a positive relationship between inflation and rate of interest[7].

Table 5.4

The Effects of changes in D_t, R_t $M1_t$, $M2_t$, Y_t and (P_t^e) on inflation

(1975 to 2003)

Spec	Intercept	Dt	Dt-1	Rt	$M1_t$	$M2_t$	Y_t	π_t^*	R^2	DW	F
1st	-0.94* (-3.60)	0.57* (18.86)		–	–	–	–	–	0.93	0.44	355
2nd	-0.83 (-3.20)*	0.11 (0.70)	0.45 (2 95)*	-	-	-	-	-	0.95	0.31	214
3rd	-0.96* (-3.55)	0.57* (18.50)		0.003 (0.33)	–	–	–	–	0.93	0.48	171
4th	-1.62* (-21.50)	–		-0.005* (-2.09)	0.60* (75.50)	–	–	–	0.99	0.50	2855
5th	-1.39* (-18.69)	–		-0.005* (-2.11)	–	0 53* (73 37)	–	–	0.99	0.47	2696
6th	-16.61* (-23.60)	0.14* (7.02)		-0.006* (-2.80)	–	–	1 61* (22 31)	–	0.99	1.72	2556
7th	-1.22* (-5.43)	0.64* (20.81)		–	–	–	–	-0.04* (-3.79)	0.95	1.06	276
8th	-16.27* (-20.79)	0.16* (6.87)					1 57* (19 65)		0.99	1.62	3006

Figures in the parenthesis, given below the coefficients, are t values. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signify coefficient significant at 10% level.

The elasticity of inflation with respect to budget deficit is found to be 0.57. This suggests that inflation is relatively less responsive to changes in budget deficit, as shown in 1st specification. The coefficient has the expected theoretical sign which is statistically significant at 1 percent level. Budget deficit can be considered to be a proxy of money supply because the government adopting monetization of deficit, resorts to the central bank funding finance its deficit. The effect of rate of the interest on inflation is

[7] One year bond real rate of interest is taken as proxy of rate of interest (Rt) for the analysis.

insignificant as show in 3rd specification. This shows that inflation in Nepal is not found to be sensitive to rate of interest. In developing countries, interest rate may not found sensitive to other variables because of the imperfection in the lonable fund market and the underdeveloped capital market. In a capital constrained economy like Nepal, rates of interest of informal sector are substantially higher than those in the formal sector, and the formal financial sector can fulfill only a small portion of the overall credit demand, the availability rather than the cost of capital determines investment decision. Due to the prevalence of underdeveloped secondary financial markets in Nepal, people hold financial assets in the form of currency and bank deposits. Therefore, the wealth effect working through changes in the interest rate does not substantial affect aggregate expenditure.

To sum up the Keynesian hypothesis of inflation in the context of Nepal, deficit budget is one of important factors determining inflation. The null hypothesis that there is no effect of budget deficit on inflation is rejected. Change in the monetary policy of the central bank is not the only factor responsible for the acceleration of inflation; the fiscal policy of the government to finance budget deficit is another such factor. The change in budget deficit contributes to the changes in rate of inflation. This effect is almost equal in magnitude to that of M1 monetary aggregate. Therefore, government actions are equally responsible in generating inflation. However, inflation is not found to be elastic with respect to the real rate of interest.

(iii) Structuralists' Model of Inflation

Structuralists argue that rise in inflation can be attributed to the basic structural constraints experienced in the process of industrialization and development. In such a situation, demand management policies are inoperative and inflation is determined independent of market forces.

In order to examine the structuralist argument in case of Nepal, this study sets null hypothesis (Ho) that inflation in Nepal is not determined by structural factors-such as import price, agricultural non-agricultural GDP ratio, food price, and export and export to GDP ratio, against the alternative hypothesis (H1) that inflation in Nepal is determined by various structural factors.

$$\pi_t = \alpha_a + \beta_1 IP_t - \beta_2 (\frac{IM}{GDP})_t - \beta_3 (\frac{AG}{NAG})_t + \beta_4 FP_t + \beta_5 (\frac{EX}{GDP})_t + \varepsilon_t \text{--------------} (3)$$

$IWPI_t$=Indian Wholesale Price Index, $(IM/GDPR)_t$ is import/GDPR ratio, $(AGDPR/NAGDPR)_t$ is agriculture/non-agriculture GDPR ratio, FP_t is food price relative, $(EX/GDPR)_t$ is export/GDPR ratio and ε_t= disturbance term with zero mean and constant variance.

Table 5.5

The Effect of changes in Structural Factors on Inflation

(1975 to 2003)

Spec	Intercept	$IWPI_t$	$IM_t/GDPR_t$	$AGDPR_t/NAGDP_tR_t$	FP_t	$EX_t/GDPR_t$	R^2	DW	F
1st	-1.14* (-16.09)	1.21* (72.28)	_	_	_	_	0.99	0.68	5223
2nd	5.52* (179.13)	_	0.72* (55.88)	_	_	_	0.99	0 70	3123
3rd	3.59* (86.30)	_	_	-2.74* (-19.99)	_	_	0.93	0.90	399
4th	4.34* (26.41)	_	_	_	18.84* (3.37)	_	0.30	0.32	11.35
5th	6.21* (60.29)	_	_	_	_	0.70* (22.86)	0.95	0.59	522
6th									

Figures in the parenthesis, given below the coefficients, are t values. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signify coefficient significant at 10% level.

Indian Wholesale Price Index ($IWPI_t$) has a positive impact on inflation in Nepal, as shown in 1st specification of Table 5.5. The elasticity of inflation with respect to $IWPI_t$ is 1.21 suggesting that when total $IWPI_t$ goes up by 1 percent, on an average, the inflation goes up by about 1.21 percent. Thus inflation is very responsive to changes in $IWPI_t$. The coefficient is also found to be statistically significant at 1 percent level with theoretical expected sign. Most of the commodities transacted with India are practiced on a wholesale price basis. Therefore, $IWPI_t$ can be proxied as import price of Nepal.

Similarly, the coefficient of the ratio of total import to real GDP is found to be positive as per the hypothesis of the study. The elasticity coefficient is statistically significant at 1 percent level. Success in rejecting the null hypothesis signifies that the degree of openness (represented by increase in the ratio of import to real GDP) reduces domestic inflation. This is because domestic demand shocks spill over into the balance of payment. As explained in the Purchasing Power Parity (PPP) theory of exchange rate determination, an increase in BoP deficit of the home country leads to depreciation of domestic currency. It results into import substitution of goods and services and hence into less inflation in the home country.

The coefficient of ratio of agricultural to non-agricultural real GDP has possessed the expected theoretical sign. The inverse relationship between the ratio of $AGDPR_t/NAGDPR_t$ and inflation holds true when the ratio of $AGDPR_t/NAGDPR_t$ decreases as a result of rise in agricultural produce, and hence rise in aggregate price level. The result shows that there is 2.74 percent decrease in inflation to a 1 percent increase in the $AGDPR_t/NAGDPR_t$ with elasticity coefficient statistically significant at 1 percent level.

Similarly, food price elasticity of inflation is found to be very responsive as shown in 4th specification. The rise in inflation by 18 percent for a 1 percent increase in the food price relative reveals that inflation in Nepal is highly sensitive to changes in food prices. However, the goodness of fit of the model seems poor represented by the value of R^2 equals to 0.30 percent. Very low DW statistic shows autocorrelation problem. The theoretical reason for the positive expected sign of food price relative is that the pressure of fixed agricultural food by the continuous rising population and development of non-agriculture sector results into an increase in the relative price of foods and hence increase in general price level. Being food index a major component of overall index, variation in it has ultimate effect on the overall index.

It is hypothesized that inflation and export to real GDP ratio (EX/GDPR) are positively related. An increase in this ratio implies a large foreign exchange reserve in the economy, causing the supply of money to increase, and hence there is a rise in price of goods and services. The elasticity coefficient of inflation with respect to EX/GDPR is found to be 0.70 suggesting inflation as relatively less responsive to the changes in EX/GDPR. Elasticity coefficient is statistically significant at 1 percent level with R^2 of 0.95 percent implying good fit.

In summing up, each structural variable individually has a significant impact on inflation. Therefore, inflation in Nepal is highly responsive to the structural variables. Almost elasticity coefficients of structural variables are found to be statistically significant at 1 percent level. The elasticity coefficient of inflation to food price, as shown in 4^{th} specification, is very high compared to other structural variables combined with very low R2 and DW statistic.

Structuralists concede that structural variables play only a partial role in generating inflation. Therefore, a combination of monetarist as well as structural variables gives a true representation of inflation behaviour, particularly in the context of developing countries. Keeping this argument in view, the structuralist hypothesis is also examined without completely negating the structuralist claim in this study. Therefore, regression results of structural variables combined with monetary variables are shown in Table 5.6.

Table 5.6

The Effect of changes in money supply and structural variables on Inflation[8]

(1975 to 2003)

Spec	Intercept	$M1_t$	BD_t	EP_t	$IWPI_t$	$IM_t/GDPR_t$	$AGDPR_t/NAGDPR_t$	FP_t	$EX_t/GDPR_t$	R^2	DW	F
1st	-1.41* (-15.04)	0.30* (3.66)	–	–	0 61* (3 73)	–	–	–	–	0.99	0.81	3860
2nd	1 25* (3 59)		0 29* (6.75)	–	–	–	-1.44* (-7.03)	–	–	0 97	1.05	534
3rd	1.20** (2 06)	0 36* (7.38)	–	–	–	0 29* (4 87)	–	–	–	0 99	0 93	4679
4th	2.84* (7 88)		0 28* (9.40)		–	–	–	–	0 40* (11.1)	0.30	0.32	11.35
5th	- 39* (-23.93)	0.58* (99 0)	–	–	–	–	–	2.34* (6 98)	–	0 95	0 59	522
6th	-1 44* (-16 13)	0 35* (4.31)	–	0 005* (3 10)	0 50** (2.07)	–	–	–	–	0 99	0 98	2913

Figures in the parenthesis, given below the coefficients, are t values. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signify coefficient significant at 10% level.

Each specification is the combination of variables, each from monetarists' and structuralists'[9]. The model's explanatory power of monetary-cum-structural is improved, confirming the structuralist hypothesis. However, structural variables combined with monetary variables have a significant impact on inflation in Nepal, if it is examined by taking one variable from each model.

(B) Estimation Based on Quarterly Data

Keeping in view the availability of data, the quarterly data is used to examine the monetarist hypothesis only in this section. The relationship between inflation and different monetary aggregates including various lags is examined. Two important aspects, which were not addressed in the monetarist hypothesis by using annual data frequency in preceding sections, are addressed in this section. The first is the measurement problem of data, and the second is the examination of the short-run effect of money supply on inflation. Because of the measurement problem, the estimated elasticity coefficients, which were found by using annual data frequency, may be underestimated or

[8] Only statistically significant coefficients of elasticity of monetarists' and structuralists' variables are presented in Table 6 after repeated trial.

[9] The elasticity coefficients of more than two independent variables combined with monetarists' and structuralists' are not presented in the analysis because of results being statistically insignificant.

overestimated. This problem is addressed by examining the results of the monetarist model using quarterly data frequency, and comparing the results with those estimated by using annual data frequency in previous section. This attempt will help to find the appropriate data frequency that shows the stronger relationship between the variables and recommendation accordingly.

The effect of independent variables on dependent variable using annual data frequency may, sometimes, mislead the short-term relationship between the variables because of the use of insufficient information. If variables are more sensitive to the changes in policy regime during the short-run, disaggregated data frequency is useful for the analysis, so that, the magnitude of the short-term impact can be found. Therefore, the advantage of quarterly data frequency over annual data frequency is that the effect of current quarter changes in one variable to the other is possible by using quarterly data frequency only.

The monetary policy affects the macroeconomic variables with varying lags. Therefore, one-to-one relationship between changes in money supply and inflation is difficult to find. Monetary policy's effectiveness depends, in part, on the ability to anticipate business trends so that current policy actions will be appropriate for dealing with future conditions. Alternatively, the current rate of inflation is determined by the monetary policy action taken in the last period as well as periods of the past. Therefore, the peak level of monetary growth may appear before the peak level of inflation. Similarly, the easing of policy to counteract recession would help to produce an upturn in the rate of monetary growth in advance of troughs in business activity (Davis, 1968). The longer the lag in the effects of the policy, the greater the risk that policy actions will prove to be ineffective.

The monetarist explanation of inflation is guided by the fundamental assumption that only monetary policy actions have a causal effect on the determination of prices in the economy. Inflation is, in essence, a monetary phenomenon (Laidler and Parkin, 1975). Friedman argues that inflation is always and everywhere a monetary phenomenon (Friedman, 1970b). This hypothesis is also examined in the context of Nepal in this study.

Table 5.7
Effects of M1 including Lags[10] on Inflation
(1975:I to 2003:IV)

Spec	Intercept	M1	M1t-1	M1 t-2	M1 t-3	R^2	Adj R^2	DW	F
1st	-1 58* (-32 49)	0.59* (115 2)	–	–	–	0 99	–	0 86	13277
2nd	-1.58* (-33 45)	0.29* (3.31)	0 30* (3 44)	–	–	–	0 99	0.64	7161
3rd	-1.57* (-34 42)	0.24* (2.81)	0 04 (0 40)	0.31* (3 69)	–	–	0.99	0 40	5217
4th	-1 57* (-32 58)	0.25* (2.42)	0 04 (0 37)	0.32* (2 88)	-0.01 (-0 17)	–	0.99	0.40	3748
5th	-1 56* (-31.94)	–	0 59* (114 68)	–	–	0 99	–	0.72	13153
6th	-1.53* (-32.38)	–	–	0 59* (117 87)	–	0.99	–	0 44	13893
7th	-1.54* (-31 91)	–	0 34* (5 04)	–	0 25* (3 60)	–	0 99	0.44	6892
8th	-1 49* (-28 58)	–	–	–	0 59* (106.21)	–	0 99	–	0 54
9th	-1 56* (-30.83)	0.36* (4 53)	–	–	0.23* (2.98)	–	–	0 99	0 53

Where, M1= monetary aggregate consisting currency held by the public and demand deposit of the commercial banks, Subscripts- t-1, t-2 and t-3 indicate first, second and third quarter lag values of M1 and M2 monetary aggregates. Figures in the parenthesis, given below the coefficients, are t values. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signify coefficient significant at 10% level.

The elasticity coefficient of inflation with respect to $M1_t$ is found to be 0.59, and it is statistically significant at 1 percent level as show in 1st specification of Table 5.7. The rejection of null hypothesis that there is no impact of M1 on inflation signifies that there is an impact of M1 on inflation. According to monetarists, inflation is essentially a monetary phenomenon in the sense that a continuous increase in the general price level is due to the rate of expansion in money supply in excess of the amount of money actually demanded by the economic units. In order to examine this hypothesis, M1 with three quarters lag elasticity coefficients are presented in 4th specification. The elasticity

[10] A finite lag model up to four quarters for both the monetary aggregates have been selected on the ground that the coefficients beyond these quarters turned either into contrary to theoretical sign or insignificant at 10 percent level because of the problem of multicollinearity.

coefficient of inflation to $M1_t$ at 0.24 signifies a 1 percent increase in the money supply will increase inflation by 0.24 percent in the short-run. The long-term elasticity coefficient of 0.59 implies that a 1 percent increase in the money supply increases inflation by 0.59 percent in the long-run. The sum of short-term elasticity coefficients does not exceed the coefficient of contemporaneous M1, even if regression includes around 20 quarters lags[11]. Inflation in Nepal found to be monetary phenomenon but there is no one-to-one relationship between inflation and M1. Further, $M1_t$ and $M1_{t-2}$ are found to be dominating explanatory variables of M1 that contribute of inflation.

In summing up, the elasticity coefficient of inflation to $M1_t$, measured contemporaneously, in the case of quarterly data frequency, is not found to be exceeding the coefficient found applying annual data in previous section. Further, an introduction of sufficient lags (quarters) in regression does not increase the long-term elasticity of inflation with respect to $M1_t$. $M1_t$ and $M1_{t-2}$ are found to be dominating variables in explaining inflation as comparison to other lags. Therefore, the impact of only six months or two quarters lag M1 is felt on the current quarter inflation.

Table 5.8

Effects of $M2_t$ including Lags on Inflation (1975:I to 2003:IV)

Spec	Intercept	M2	M2t-1	M2 t-2	M2 t-3	R^2	Adj R^2	DW	F
1st	-1 37* (-32.65)	0 52* (129 1)	–	–	–	0 99	–	0.50	16651
2nd	-1 38* (-31.16)	0.53* (2.72)	-0 008 (-0 04)	–	–	–	0.99	0.52	8326
3rd	-1.39* (-29 49)	0 53* (2.74)	-0.08 (-0 30)	0.07 (0 39)	–	–	0.99	0 50	5495
4th	-1 48* (-28.90)	0 87* (4 17)	-0 35*** (-1 32)	0 76* (2 86)	-0 75* (-3.69)	–	0 99	0.74	4441
5th	-1.34* (-31 26)	–	0.52* (125 49)	–	–	0.99	–	0 42	15748
6th	-1 31* (-30 12)	–	–	0.52* (122 96)		0 99	–	0.29	15118
7th	-1.34* (-29.50)	–	0 41** (2 10)	0 11 (0 55)	–	–	0.99	0 38	7784
8th	-1 37* (-32 65)	0 52* (129 1)	–	–	–	0.99	–	0.50	16651
9th	-1 38* (-31 16)	0.53* (2 72)	-0 008 (-0.04)	–	–	–	0.99	0 52	8326
10th	-1.39* (-29.49)	0 53* (2.74)	-0 08 (-0 30)	0.07 (0.39)	–	–	0 99	0 50	5495

[11] The result of only four quarter lags M1 is presented in this analysis because of no increase in sum of elasticity coefficients after including sufficient lags.

M2= M1 monetary aggregate plus fixed deposits of commercial banks. Subscripts- t-1, t-2 and t-3 indicate first, second and third quarter lag values of M2 monetary aggregates. Figures given below the coefficients in the parenthesis are t values. Asterisks (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signifies coefficient significant at 10% level.

The elasticity coefficient of inflation with respect to M2 is found to be 0.52. It is statistically significant at 1 percent level with theoretically expected sign. The sum of short-term elasticity coefficients is not found to exceed the coefficient of contemporaneous M2. This does not support the hypothesis of inflation in Nepal is found to be one-to-one relationship. Though the short-term individual elasticity coefficients in different lags are smaller than the 1^{st} specification, the total sum coefficients of sufficient lags does not exceed 0.52 as coefficient found regressing current inflation to M2. The effect of M2 to inflation, in the case of quarterly data, does not improve as compared to the estimation result found by using annual data in the previous section. In the case of M2 monetary aggregate, $M2_t$ and $M2_{t-2}$ are dominating explanatory variables of inflation in Nepal. The impact of only contemporaneous ($M2_t$) is felt on the current month's inflation.

There are two major components of the overall price index in Nepal. The first is, food and beverage index (weight: 51.53%) and the second is non-food and services index (weight: 48.47%). The dominant effect of monetary aggregates on inflation is attributable to food and beverage index or non-food and services index is an important topic for investigation. A study of the variation of food and non-food indices with the variation of M1 and M2 helps policymakers to identify the desired inflation variable that needs to be controlled while formulating monetary policy.

Table 5.9
Effect of M1 and M2 on Food and Beverage Price Index
(1975:I to 2003:IV)

Intercept	M1t	M1t-1	M1 t-2	M1 t-3	M2	M2 t-1	M2 t-2	M2 t-3	R^2	Adj R^2	DW	F
-1 68* (-28 66)	0 60* (97 1)	–	–	–	–	–	–	–	0 98	–	0 66	9429
-1 46* (-27 49)	–	–	–	–	0 53* (103 12)	–	–	–	0 98		0 40	10633
-1 68* (-28 65)	0 36* (3 29)	0 24** (2 22)				–	–	–	0 98		0 53	4777
-1 49* (-26 45)	–	–	–	–	0 79* (3 17)	-0 24 (-1 02)	–	–	0 98		0 47	5284
-1 51 (-25 12)	–	–	–	–	0 79 (3 20)	-0 20 (-0 61)	-0 06 (-0 22)			0 98	0 49	3461
-1 68* (-28 68)	0 31* (2 90)	0 01 (0 09)	0 28* (2 55)	–	–	–	–	–		0 98	0 40	3277
-1 62 (-24 54)	–	–	–	–	1 20 (4 47)	-0 53 (-1 56)	0 76 (2 23)	-0 90 (-3 34)		0 99	0 70	2752
-1 68* (-27 40)	0 33* (2 54)	0 01 (0 04)	0 30** (2 08)	-0 03 (-0 25)	–	–	–	–		0 98	0 40	2355
-1 65* (-27 30)	–	0 60* (93 69)	–	–	–	–	–	–	0 98		0 60	8777
-1 63* (27 02)	–	–	0 60* (93 90)	–	–	–	–	–	0 98		0 42	8817
-1 59* (-24 94)	–	–	–	0 60* (88 4)	–	–	–	–	0 98		0 42	7798
-1 68* (-28 80)	0 32* (3 85)	–	0 28* (3 40)	–	–	–	–	–		0 98	0 40	4960
-1 68* (-27 56)	0 33* (3 38)	–	0 30* (2 70)	-0 03 (-0 27)	–	–	–	–		0 98	0 57	4320

Figures given below the coefficients in the parenthesis are t values. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signifies coefficient significant at 5% level, and asterisks (***) signifies coefficient significant at 10% level.

The food price is relatively highly elastic to M1 as compared to M2. The M1 elasticity of food price is found to be 0.60 whereas that of M2 monetary aggregate is 0.53. Both coefficients are statistically significant at 1% level with theoretical expected sign. Therefore, controlling M1 can have a higher desired consequence to control inflation. Theoretically, the changes in M1 monetary aggregate have a dominant effect on the transaction of food and beverage group of commodities. The effect of an increase in M1 is spread or distributed, over the $M1_{t-1}$ quarters, while in the case of M2 this is spread over the $M2_t$ quarter.

Table-5.10

Effect of M1 and M2 on Non-food and Services Price Index

(1975:I to 2003:IV)

Intercept	$M1_t$	$M1_{t-1}$	$M1_{t-2}$	$M1_{t-3}$	$M2_t$	$M2_{t-1}$	$M2_{t-2}$	$M2_{t-3}$	R^2	Adj R2	DW	F
-1.39* (-31.24)	0.58* (122.18)	–	–	–	–	–	–	–	0.99	–	1 34	1492 6
-1 19* (-33.88)	–	–	–	–	0.50* (149.95)	–	–	–	0 98		1.06	2248 5
-1.39* (-34.92)	0.14* (1.90)	0.44* (5.92)	–	–	–	–	–	–	0.99		1 1	9591
-1.17* (-32.92)	–	–	–	–	0.05 (0.35)	0.45* (2.91)	–	–		.999	0 90	1229 8
-1.37* (-38.65)	0 07 (1.10)	0 12*** (1 40)	0.39* (5.89)	–	–	–	–	–		0.98	0.64	8171
-1.16* (-31.28)	–	–	–	–	0.04 (0.27)	0.18 (0.88)	0.28** (1.86)	–		0 99	0 77	8144
-1.37* (-27 40)	0.08* (2.54)	0.11 (0.04)	0.40** (2.08)	-0 02 (-0 25)	–	–	–	–		0.98	0.65	5869
-1.23* (-31.0)	–	–	–	–	0.33** (2.0)	-0.04 (-0.20)	0.85* (4.16)	-0 63* (-3 89)		0 99	0 99	6936
-1.37* (-34.60)	–	0 58* (136 9)	–	–	–	–	–	–	0 99		1 10	1874 8
-1.35* (-37.87)	–	–	0.58* (152.10)	–	–	–	–	–	0 99		0 68	2313 5
-1.31* (-29.20)	–	–	–	0 57* (120 3)	–	–	–	–	0.99		1 07	1448 6
-1.37* (-38.49)	0.13* (2.57)	–	0.46* (8.79)	–	–	–	–	–		0 99	0.71	1215 0
-1.37* (-36.86)	0.15* (2.47)	–	0.47* (6.92)	-0 05 (-0 59)	–	–	–	–		0 99	0 75	7776

Where, M1= monetary aggregate consisting currency held by the public and demand deposit of the commercial banks, M2= M1 monetary aggregate plus fixed deposits of commercial banks. Subscripts- t-1, t-2 and t-3 indicate first, second and third quarter lag values of M1 and M2 monetary aggregates. Figures given below the coefficients in the parenthesis are t values. Asterisks (*) signifies coefficients significant at 1% level, asterisks (**) signifies coefficients significant at 5% level, and asterisks (***) signifies coefficients significant at 10% level.

The effect of M1 and M2 on non-food and services price index is presented in Table 10. The elasticity of non-food price with respect to M1 is higher than that of M2. The M1 elasticity of non-food price is found to be 0.58 whereas it is 0.50 in the case of M2t. The effect of an increase in M1 is spread over the $M1_{t-1}$ quarters, while in the case of M2 it is spread over the $M2_t$ quarter.

Within food and beverage and non-food and services components, there are 22 components of goods and services. Out of the total components of the overall price index, some components within the food and non-food are found to be more important. An analysis of the major commodities, in terms of higher weight assigned to such commodities, the desired price indices can be found, which can be better explained by the variation of money supply.

Table-5.11
Effect of M1 on Major Components of Overall Price Index
1975:I to 2003:IV

Food and Beverages Group	Wight	Intercept	M1t	M1t-1	R^2	DW
Restaurant	6 91	-3.10* (-43.10)	0.74* (97.38)	_	0.89	0.93
Vegetables	7.89	-2.18* (-20.22)	65 0* (56 75)	_	0.96	1.13
Meat	5.21	-2.12* (-31.31)	0.64* (90.10)	_	0.98	0.93
Meat	"	-3.11* (-47.48)	0.17** (1.40)	0 57* (4.70)	0.99	0.71
Non-Food and Services Group						
Fuel	5.92	-2.70* (-35 54)	0.71* (88.21)	_	0.98	0.90
Fuel	"	-2 67* (-36 11)	0.23** (1 64)	0.48* (3.50)	0.98	0.61
Education	7.09	-1.70* (-42.83)	0.61* (144.77)	_	0.99	0.82
House Rent	4 19	-2.56 (0.98)	0.68* (79.56)	_	0.98	1.1
Total of housing and furnishing	14.87	-2.10* (-28.25)	0.64* (82 1)	_	0.98	1 15
Medical	7.86	-0.52* (-12.39)	0.50* (112.49)	_	0.99	0.88
Transportation	4.21	-1.11* (-19.38)	0.55* (93.10)	_	0 98	1.40

The variation of major components of food and non-food prices is analyzed with the variation of M1 only in Table 5.11. The elasticities of restaurant, vegetable, meat price to M1 are found to be 0.74, 0.65 and 0.64 respectively. The coefficients show that a one percentage increase in M1 will have a higher desired impact from these components under food and beverage group. Similarly, in non-food and service group, the elasticity of fuel, education, house rent, housing and furnishing, medical services and transport to M1 found to be 0.71, 0.61, 0.68, 0.64, 0.50, 0.55 respectively. Summary of M1 and M2 elasticity of inflation, in the case of quarterly data, are presented in Table 5.12.

Table 5.12
Summary of the Elasticities of Inflation with respect to M1 and M2

Price Indices ↓	Monetary Aggregates				
	Interecept	M1t	M1t-1	M2t	M2t-1
Overall Price Index	-1 58* (-32.49)	0 59* (115 2)	–	–	–
	-1 58* (-33.45)	0 29* (3.31)	0.30* (3 44)	–	–
	-1.37* (-32.65)	–	–	0.52* (129.1)	–
	-1 38* (-31 16)	–	–	0 53* (2 72)	-0 008 (-0 04)
Food and Beverage Index	-1.68* (-28 66)	0 60* (97 10)	–	–	–
	-1 68* (-28 65)	0 36* (3.29)	0.24** (2 22)	–	–
	-1.46* (-27 49)	–	–	0 53* (103 12)	
	-1 49* (-26.45)	–	–	0 79* (3.17)	-0 24 (-1 02)
Non-food and Service Price Index	-1.39* (-31.24)	0.58* (122.18)	–	–	–
	-1.39* (-34.92)	0.14* (1.90)	0.44* (5.92)	–	–
	-1.19* (-33 88)	–	–	0.50* (149 95)	
	-1.17* (-32.92)	–	–	0.05 (0.35)	0.45* (2.91)

Sources: Table 5.7-5.11.

(C) Chow Test for Structural Stability of Model

A structural change in the relationship between the dependent and independent variables may occur in a regression model involving time series data. This implies that the coefficients of the model do not remain the same throughout the study period. Such structural changes may occur due to changes in government policies, such as, policy switching from a controlled regime to a liberalized one. Keeping these possibilities in view, a number of policies of the government of Nepal are found to be shifting from non-liberalized to liberalized since the FY1989/1990. Taking this year as the point of structural break, F test statistic suggested by Chow (1960) is applied to test whether there is equality between the coefficients obtained from different samples. The structural stability of bi-variate regression model (inflation as a function of M1) is examined in this study.

$\ln(P)_t = -1.83 + 0.62 \ln M1_t$ ......(1) Sample Period: (1975I-1989IV)

(-15.66)* (44.17)* R^2=0.97 RSS1=0.29 df=58

$\ln(P)_t = -0.83 + 0.52 \ln M1_t$ ....(2) Sample Period: (1990I-2003IV)

(-5.52)* (36.54)* R^2=0.96 RSS2=0.18 df=54

$\ln(P)_t = -1.58 + 0.59 \ln M1_t$ .... (3) Sample Period: (1975I-2003IV)

(-32.50)* (115.23)* R^2=0 99 RSS3=0.577 df=114

Where, (*) indicates coefficients are statistically significant at 1% level, RSS is residual sum of square.

The null hypothesis is that regression equations (1) and (2) are statistically the same (that is, no structural change or break) against the alternative hypothesis that these regressions equations are not the same (that is, there is a structural change or break). It follows the F distribution with K and (n1+n2=2k) degrees of freedom in the numerator and denominator respectively. The computed value of F statistic is found to be 13.1 whereas the tabulated value of F statistic with 2 and 112 degree of freedom at 5% level is 3.1. The rejection of the null hypothesis in our case implies that there is structural break and parametric instability in our regression.

(D) The Dummy Variable Test for Structural Stability of Models

The Chow test is used to test the stability of two regression models obtained by dividing the whole sample period into two. However, it does not tell us anything about the instability of the model on account of the intercepts, or the slopes, or both. In order to pinpoint the sources of difference in models between two sample period (that is, whether it is due to the intercept or the slope or both) the dummy variable model is considered superior to the Chow test. The Chow test tells us only about the significance or insignificance of the structures of the model but not the sources. For the dummy variable test to be applied, different dummies, such as, time dummies, policy dummies, political dummies, seasonal dummies, monthly dummies are to be used according to the hypothesis of the studies. The structural stability of inflation model in Nepal by using dummy variable technique is as follows:

$\ln(P)_t = -1.83 + 1.00DUM + 0.62\ln M1_t - 0.10\ln M1_t * DUM$; Sample (1975I-2003IV)

(-17.14)* (4.98)* (48.35)* (-4.88)* R^2=0.99 DW=1.07

According to the regression result shown above, both the differential intercept and slope coefficients are found to be statistically significant. This suggests that the two regression models of inflation on M1 are found to be significantly different in terms of intercept as well as slope after breaking the whole sample period by the FY1989/90 into two parts.

The dummy variable technique is an alternative to Chow test to test stability of the model. In order to confirm this argument, the results obtained by using the dummy variable technique and the Chow test techniques are presented below. Here, structural coefficients found by using the Chow test technique, for the pre-liberalization and post-liberalization sample periods, are derived from dummy variable technique as follows:

$\ln(P)_t = -1.83 + 0.62\ln M1_t$ .... (5) Sample Period: (1975I-1989IV)

$\ln(P)_t = (-1.83 + 1.00) + (0.62 - 0.10)\ln M1_t$ ..(6) Sample Period (1975I-2003IV)

$\ln(P)_t = -0.83 + 0.52\ln M1_t$ ... (7) Sample Period (1990I-2003IV)

The summation of two terms of dummy variable model as given in equation (4) gives the result of equation (7) confirming dummy variable technique as an alternative to the Chow test of stability.

(F) Test of Causality between inflation and money supply

Monetarists assume that the causality of money-price relationship runs from money supply to inflation but not the other way round. Money supply is only the cause of inflation in the long-run. Instability in the supply of money creates a business cycle in the economy. Therefore, monetary authorities should follow some monetary growth rule, that is, the rate of growth of money supply should be based on some rules. Regression analysis show the cause and effect relationship of dependent and independent variables, as specified by the researcher, by ignoring possible causal relationship from dependent variable to independent variable. In the present study, the regression model of inflation on monetary aggregates, as examined in previous sections, does not tell us anything about the direction of causality, that is, whether money supply causes inflation or vice versa. Therefore, in order to confirm the validity of the causal relation between variables, a test of causality is adopted in the present study.

A test statistic developed by Granger (1969) is used to test whether change in one variable is a cause of change in another, or whether both of them are endogenously determined. The null hypothesis (Ho) to test the causality is that there is no causal relation between the variable against the alternative hypothesis (H1) of there is causal-relation between the variables.

The test result of causality between some important components of money supply and inflation is shown in Table 5.13. Each variable is transformed to logarithm before estimating the result.

Table-5.13
Granger Pair-wise Causality between Inflation and Money Supply
1975:I to 2003:IV

Direction of Causality	Number of lags	F-Values	Decision at 5% significant level
Log(M1)→Log(P)	2	F(2,111) = 5.11	Accepted
Log(P)→Log(M1)	2	F(2,111) = 16.60	Accepted
Log(M2)→Log(P)	2	F(2,111) = 2.78	Rejected
Log(P)→Log(M2)	2	F(2,111) = 13.90	Accepted
Log(M1)→Log(PF)	2	F(2,111) = 4.43	Accepted
Log(PF)→Log(M1)	2	F(2,111) = 11.08	Accepted
Log(M2)→Log(PF)	2	F(2,111) = 3.38	Accepted
Log(PF)→Log(M2)	2	F(2,111) = 11.73	Accepted

Where, P is overall price index, PF is food price index, M1 and M2 are narrow and broad money aggregate respectively.

A bi-directional causality is found between the pairs of variables except to that of M2 and inflation (P). For the latter case, uni-directional causality is found where causality is running from M2 to P but not the other way round. If the computed value of F statistic is greater than the tabulated value of 3.11 with (2,111) degree of freedom in every pair of variables, it is decided as bi-directional causality. The reason for bi-directional causality between M1 money supply and overall consumer price is that the rate of growth of money supply causes inflation as well as inflation causes money supply. Initially, the increase in supply of money causes inflation, but later while inflation is increased, the real value of government revenue as well as supply of money declines. In order to overcome such a problem, the government is motivated to increase further money supply.

2. STABILITY AND ROBUSTNESS OF INFLATION MODEL

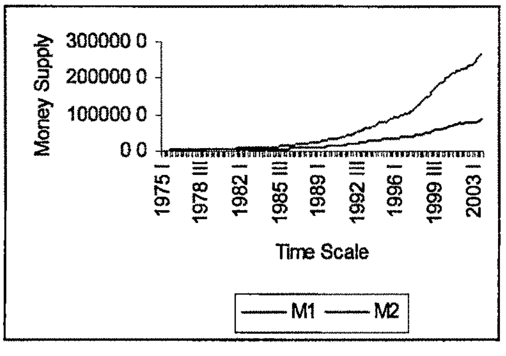
Due to various reasons like inertia in time series data, specification bias of model, lag and Cobweb relation between the variables, and manipulation and transformation of data, residual of an equation is correlated with its lagged values in different orders. This is called the problem of autocorrelation in an equation (Gujarati, 2004). In order to test whether the residual term in the regression equation is following first order autocorrelation, DW test statistic is adopted. There is a high possibility of such a problem found in time series data particularly. Not only that time series data, characterized by time trend, R^2 value of around 99 percent, show the model's perfect fit. Sometimes, very high R^2 in time series data is thought to be due to spurious relationships between the variables. Time series data, particularly in level form, show spurious regression because of the problem of data being non-stationary.

In order to overcome such a problem, the test of stationarity of time series data is examined before this data is applied for the analysis. Whether time series data used for analysis is found to be stationary in level form or first difference form or trend stationary form. This is examined applying Augmented Dickey Fuller (ADF) statistic.

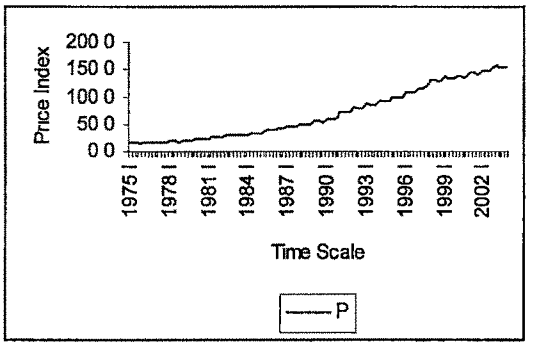
(A) Analysis Based on Quarterly Data Frequency

Financial and macroeconomic data series generally are found to be non-stationary or time trended or they are characterized by time variant in mean and variance in their level or absolute form. Plotting the absolute data of M1, M2 and price index show the following pattern.

(a) Time Trend of M1 and M2

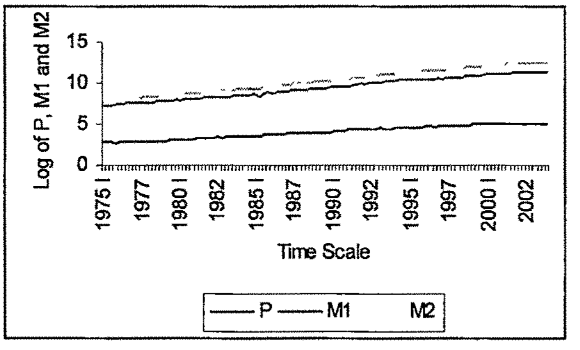


(b) Time Trend of Price Index



The data tendency of M1, M2 and CPIO, as shown in above diagrams, show an exponential pattern. Regression coefficients estimated by applying OLS method in such non-linear data trend can be biased and inconsistent. Therefore, it is required to transform data into logarithm before running regression. The logarithmic trends of the variable are shown in the diagram (c).

(c) Log Scale of M1,M2 and Price Index



However, log transformation data series may or may not characterize stationarity. Therefore, log transformed data series should be made stationary before analyzing. Data series transformed to logarithm also called level form data in the language of stationarity test.

(i) Stationary Test: Unit Root Test

If time series data follows random walk, then this data is said to be non-stationary. If data series follows a certain time trend then this is called random walk or non-stationary data. Time series data are considered following random walk when the subsequent observations of the recent past data are characterized summation of random components. Such a time series data generating process are assumed to follow infinite memory. Data series is characterized by difference stationary or trend stationary. Random Walk Model (RWM) without drift and with drift is mostly stationary after differencing, so that they are called difference stationary. However, a model consisting of a constant and time (t) variable is called a deterministic trend and the process of making them stationary is called trend stationary. Considering all the possibilities, if data are modeled as $\Delta Y_t = \delta Y_{t-1} + u_t$ it is called RWM without drift, if they are modeled as $\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$ is called RWM with drift, and if they are modeled as $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t$ is called RWM with drift around a stochastic trend.

A standard reduced form of random walk model with drift, trend and different lags of difference dependent variable is given below. This model is used to check unit root problem applying Augmented Dickey Fuller (ADF) fitting required variables to be tested for unit root in the present study.

$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha \Delta Y_{t-1} + \varepsilon_t$ --------- (1)

Unit root test is applied for the coefficient 'δ' on the above compact equation to find out whether the data is stationary or not. Null hypothesis of unit root or non-stationary of a time series is δ=0 against the alternative hypothesis $\delta \neq 0$. If δ=0, then there is unit root or non-stationary problem in time series data. Since $\delta = (\rho - 1)$, where, in order to get δ=0 the value of ρ=1 so that δ=0 and $\rho = 1$ are considered as equal. Therefore, unit root test is applied to test whether ρ value is significantly away from unity (or 1), so that, unit root problem or non-stationary problem is eliminated. Therefore, lower the value of "ρ" from unity, greater the possibility of a series becoming stationary because a value closer to unity or exactly unity shows the problem of unit root.

If the computed absolute value of the tau statistic $(/\tau/)$ given by Augmented Dickey Fuller (ADF) statistic exceeds the table MacKinnon critical tau values, we reject the null hypothesis δ=0 of unit root or accept time series as stationary. ADF test takes care of a possible serial correlation in the error terms by adding lagged difference terms of the dependent variable which is absent in Dickey Fulley (DF) test. Phillips and Perron (PP) test uses nonparametric statistical methods to take care of the serial correlation by introducing truncating lags. Since the asymptotic distribution of PP resembles ADF distribution only ADF test statistic is used to test the unit root in the present study. If the truncating lags asymptotic to zero in PP test, ADF and the PP test statistics become same.

The test results of stationarity of the level form data of M1, M2 and CPIO (Consumer Price Index, Overall) are given in Table 5.14. Statioanrity of data is tested on logarithmic data considered as level form data.

Table 5.14

Stationary Test –Unit Root Test- Test Statistics –ADF

(1975 I to 2003 IV)

Equation No.	Variables	Constant	Trend	One period lag of dep. Variables	ADF Statistics	MacKinnon Critical Value		
						1%	5%	10%
1	Ln(CPIO)	No	No	No	5.34	-2.58	-1.94	-1.62
2	,,	Yes	No	No	-0.82	-3.49	-2.89	-2 58
3	,,	Yes	Yes	No	-1.71	-4.04	-3.45	-3.15
4	,,	Yes	Yes	Yes	-0.17	-4.04	-3.45	-3.15
5	Ln(M1)	No	No	No	5.22	-2.58	-1.94	-1.62
6	,,	Yes	No	No	-0.74	-3.49	-2.89	-2.59
7	,,	Yes	Yes	No	-3 86	-4.04	-3.45	-3 15
8	,,	Yes	Yes	Yes	-1.24	-4.04	-3.45	-3.15
9	Ln(M2)	No	No	No	13.71	-2.58	-1 94	-1.62
10	,,	Yes	No	No	-1 75	-3.49	-2.89	-2.59
11	,,	Yes	Yes	No	-1.18	-4.04	-3.45	-3 15
12	,,	Yes	Yes	Yes	0.86	-4.04	-3.45	-3.15

Notes.

1. In a finite lag model, only one period lag has been considered in the present study which would expect to solve the problem of serial correlation
2. Model with absence of constant, trend and one period lag of dependent variable ('no', 'no', 'no') is called RWM without drift parameter. If null hypothesis is rejected in the case of RWM model without drift (i.e $\beta_1 = 0, \beta_2 = 0, \beta_3 = 1$) it signifies that Y_t is a stationary time series with zero mean,
3. Model with presence of constant and absence of trend and one period lag of dependent variable ('yes', 'no' 'no') is called RWM with drift parameter. If the null hypothesis is rejected in the case of RWM model with drift (i.e $\beta_1 \neq 0, \beta_2 = 0, \beta_3 = 1$), then it implies that Y_t is stationary time series with a non-zero mean $[\beta_1/(1-\rho)]$,
4. Model with presence of constant and trend but no one period lag of dependent variable ('yes', 'yes' 'no') is RWM with drift and trend parameter If the null hypothesis is rejected in the case of RWM model with drift around a stochastic trend ($\beta_1 \neq 0, \beta_2 \neq 0, \beta_3 < 1$), then it implies that Y_t is stationary around a deterministic trend.
5. Model with presence of constant and trend and one period lag of dependent variable ('yes', 'yes' 'yes') is RWM with drift and trend and one period lag dependent variable. The last term in the equation (1) is lagged values of the dependent variable "ΔY_t" which considers the problem of serial correlation making the ADF test applicable to DF test

RWM without drift, trend and difference term of dependent variable, as shown in equations (1) (5) and (9) and RWM with drift, trend and difference term dependent variable of equation (12) are ruled out because the estimated signs of 'δ' are found to positive. In order to get 'δ' positive, row 'ρ' value should be greater than unity, causing divergence of the series with respect to time. However, remaining equations, such as, (2),(3),(4),(6),(7),(8),(10), (11) and (12) show the non-stationary pattern. It is because of the ADF statistics of 'δ' being smaller than the MacKinnon critical value at 1 percent significant level accepting the null hypothesis of unit root. It implies that the 'δ' value is significantly closer to zero from negative tail showing problem of unit root or alternatively 'ρ' is significantly closer to unity. Therefore, the estimated relationship between variables (money-price) by using level form data shows spurious results.

Most of the time series data is expected to be found difference stationary. In order to test whether the first difference data are stationary, null hypothesis (Ho) is set that there is unit root problem in the first difference data, that is, $\delta = 0$ which is tested against the alternative hypothesis (H1) of there is no unit root problem in the first difference data i.e. $\delta \neq 0$. ADF statistics from first difference specifications of model and MacKinnon critical value for the rejection of null hypothesis of unit root for difference stationary are given in table 5.15.

Table 5.15

Test of Unit Root of First Difference and Trend Data

(1975 I to 2003 IV)

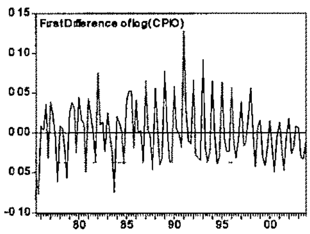
Variables	First Difference Stationary		ADF for First Difference Statioanry	Mackinnon Critical Value for First Difference Stationary Process		
	Constant	Trend		1%	5%	10%
Ln(CPIO)	Yes	No	-12.76	-3 49	-2 89	-2 58
Ln(M1)	Yes	No	-12.75	-3.49	-2.89	-2.58
Ln(M2)	Yes	No	-11.01	-3 49	-2.89	-2.58

Notes·

6 Unit root is tested on $\Delta\hat{Y}_t = \beta_1 + \delta Y_{t-1} + u_t$, for the first difference stationary, where $\hat{Y}_t = \Delta Y_t$ so, $\Delta\hat{Y}_t$ is Δ of ΔY_t

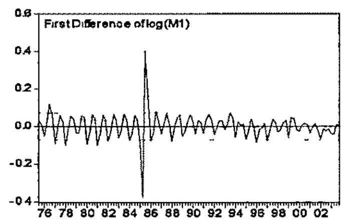
The test results show that ADF test statistics are significantly being lower in absolute value than MacKinnon critical values. It suggests the rejection of null hypothesis of unit root at 1 percent significant level for all the three variables. It implies that there is no unit root problem in the data, or they become stationary after first difference transformation. If we plot the first difference data in graph, it shows a constantly fluctuating pattern around the zero mean line over the long run.

(a)



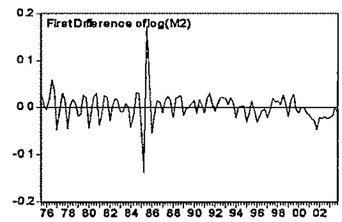
Time(quarterly)

(b)



Time (quarterly)

(c)



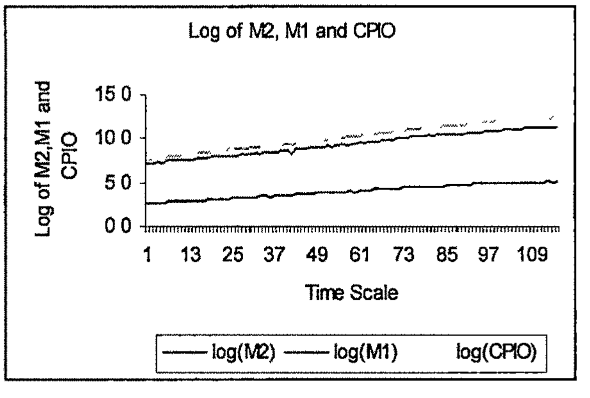
Time(quarterly)

In summing up, all the variables that were not stationary in level form data are found to be stationary in first difference. The ADF statistics of all the variables are greater than the MacKinnon critical value at 1 percent significant level as shown in Table 15. Therefore, the first difference data is stationary or considered to be integrated of order 1 or I(1).

(ii) Cointegration Test between Inflation and Money Supply

The tests of stationarity, as shown in the above sections, validate that the non-stationarity problem of level form data resulting to spurious relation between the variables, but the first difference data are considered as free from such problem. Any estimated results using differenced data may sometimes mislead the long-run relationship between the variables (Engle and Granger, 1987). The relationship between the variables computed under differenced data in different orders, show a short-term relationship which can be considered as disequilibrium relationship. The long-run relationship can be established by using level form data only when variables are co-integrated in same order; however, their linear relationship must be less than the co-integrating order. If the level form data of dependent and independent variables are waving at same length, then such data are found to be cointegrated in same order though they are individually found to be non-stationary.

Therefore, the properties of a cointegrating relationship is that: if $X_t \sim I(d)$ and $Y_t \sim I(d)$, then $Z_t = (aX_t + bY_t) \sim I(d^*)$ generally, but for the cointegration to be hold true $d^* < d$. In other words "two time series are said to be co-integrated of order (d, b) denoted CI (d, b) if (i) they are both integrated of order 'd' (ii) but there must be some linear combination between them (e.g. error term derived from cointegrated equation), that is, integrated of order 'b' which must be less than 'd' i.e. d>b". For example, if the residual series $(\hat{u}_t = Y_t - \hat{\beta}_1 - \hat{\beta}_2 X_t)$ from a cointegrating equation $(Y_t = \beta_1 + \beta_2 X_t + u_t)$ is stationary or I(0), the variables of cointegrating equation in their level form data are said to be cointegrated, though they individually are non-stationary or random walk. By satisfying this condition, cointegrating regression equation is considered to be meaningful, as it is not a spurious regression equation. A constant gap between the trends of M1, M2 and CPIO, as shown in the following diagram, shows variables being cointegrated with each other.



In order to derive the stable long-run relationship between the variables, a cointegration test should validate whether the variables are cointegrated in the same order. There is no cointegration between the variables as a null hypothesis (Ho) is tested against the alternative hypothesis (H1) of there is cointegration between the variables. Cointegrating relationship between CPIO, M1 and M2 is tested to find whether these variables are cointegrated in same order. Specification of dependent and independent variables in a cointegrated equation before the use of this test is a necessary condition. In this study, cointegrating relationship is tested on CPIO as a function of M1 as well as M2 as follows:

LOG(CPIO) = -1 582 + 0 591LOG(M1) (2)
(-32 50) (115 23) DW=0 86 R2=0.99
LOG(CPIO) = -1 365 + 0 522LOG(M2) (3)
(-32 65) (129 04) DW=0 50 R2=0 99

Equation (2) shows that CPIO increases by around 0.60 for a 1 percent increase in M1. A similar interpretation can be made in the case of equation (3). Taking estimated residual from the above cointegrated equations, unit root test is used to test the stationarity of residual term. If it is found to be stationary, variables are considered as cointegrated.

D(RESIDUAL) = -0 262RESIDUAL(-1) (4)
(-4.187) DW=2.06 R2=0.13
D(RESIDUAL) = -0 437RESIDUAL(-1) (5)
(-5 61) DW=1 90 R2=0 22

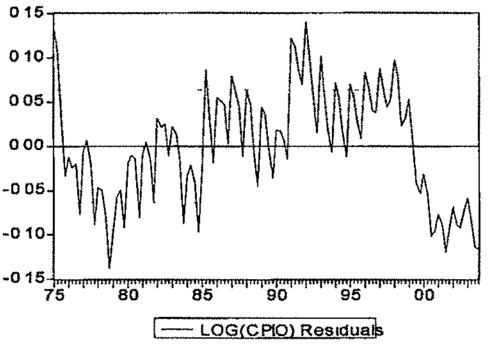
The test results of the unit root of the residual term and their corresponding MacKinnon critical value are presented in Table 5.16.

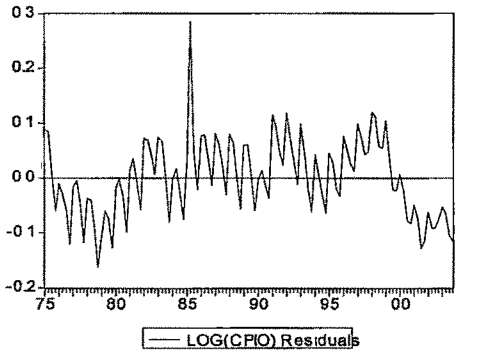
Table 5.16
Cointegration Test CPIO and M1 and M2
Sample: 1975 I to 2003 IV

Variables		ADF	Mackinnon Critical Value			Order of I(0)
Dependent	Explanatory	statistics	1%	5%	10%	Cointegration on $\hat{u}_t$
Log(CPIO)	Log(M1)	-5.61	-3.49	-2.89	-2.58	Cointegrated in I(0)
Log CPIO)	Log(M2)	-4.19	-3.49	-2.89	-2.58	Cointegrated in I(0)

The last column of Table 5.16 shows that the inflation and its determinant variables are found integrated of order 1, I(1) or first difference is I(0) at 1 percent significant level. A cointegrating relationship is confirmed between the variables by rejecting null hypothesis there is no cointegration in error term since the computed ADF statistics are greater than MacKinnon critical value, where ADF test statistic are estimated by applying unit root test on residual term of cointegrating equation. This implies that disequilibrium terms are fluctuated around zero mean as shown in following diagram.

(a) Residual Trend (regression CPIO on M1) (b) Residual Trend (from CPIO on M2)





The level form data of inflation and its determinants do not wander away from each other. The disequilibrium error (i.e. $Y_t - \hat{\beta}_1 - \hat{\beta}_2 X_t$), which measures the extent of departure from equilibrium, rarely drift too far from zero. Therefore, though there is short-run fluctuation in variable's trend path, such a fluctuation will no longer persist in the long-run. The findings of variables being cointegrated provide sufficient background to derive Error Correction Model (ECM), which shows both the short-run and long-run relationship.

(iii) Error Correction Model (ECM)

OLS estimation using non-stationary variables produces a spurious result while estimation using first difference loosens the long-run relationship between the variables. Hence, ECM is a modelling technique that captures both long-run relationship and short- run dynamics. A major advantage of the error-correction model is that the results estimated using first differenced are considered to be stationary. However, the model avoids the problem of losing long-run information of data. ECM reveals both short-term relationship and the adjustment toward the long run equilibrium.

If two variables are co-integrated, then the short-run "disequilibrium" relationship between the same can always be represented by an Error Correction Model (ECM), that is, $\Delta y_t = \alpha_0 + \alpha_1 \Delta x_t + u_{t-1} + \varepsilon_t$. This model states that changes in y depend on changes in x and one period lag residual. The residual is derived from cointegrating equation. The one period lag residual represents a disequilibrium error in the previous period, that is, $u_{t-1} = y_{t-1} - \gamma_1 - \gamma_2 x_{t-1}$. If no equilibrium relationship exists, short-run behavior should not be represented by ECM. According to the ECM argument both the level form data (long-run relationship) and their first differences (short-run relationship) are required in a single regression equation. Among cointegrated variables both the short-run as well as long-run relationship can be represented in Error Correction Model (ECM). Therefore, ECM reconciles the short-run behaviour of an economic variable with its long-run behavior.

On the basis of cointegrating equations found in equations (2) and (3), ECMs are estimated by introducing first difference in every variable of cointegrating equation (that is, 'D' in following equation- prior to LOG of each variables) and one period lag residual term from the cointegrating equation as found in equations (4) and (5). The ECMs of inflation as a function of two monetary aggregates (M1 and M2) of Nepal are as follows:

D(LOG(CPIO)) = 0 025 - 0 148D(LOG(M1)) - 0 069RESIDUAL$_{t-1}$ (6)

(6 67) (-2 83) (-1 28) DW=2 32 R^2=0 13

D(LOG(CPIO)) = 0 031 - 0 269D(LOG(M2)) - 0 096RESIDUAL$_{t-1}$ (7)

(5 13) (-2 22) (-1.62) DW=2 19 R^2=0 10

Where, D and LOG stands for Δ (change) and natural logarithm respectively. One period lag residual (RESIDUAL$_{t-1}$) is termed as Error Correction Term (ECT) and the model as a whole is termed as Error Correction Model (ECM).

The coefficients of constant, M1, and M2 are statistically significant at 1 percent level, but $RESIDUAL_{t-1}$ in both the equations is significant at 10 percent level. The coefficients show the short-run partial regression coefficients relating to the inflation and M1 and M2. Equations (6) and (7) show that any short-run changes in M1 and M2 have a negative impact on short-run changes in CPIO. However, in the long run, as shown in equations (2) and (3), both the coefficients are positive indicating that there is a positive relationship between inflation and money supply. Absolute value of the coefficient of $RESIDUAL_{t-1}$ decides how quickly the long-run equilibrium is restored. Statistically, the equilibrium errors are found to be zero, suggesting that CPIO adjusts to changes in M1 and M2 in the same time period.

To sum up results, CPIO and M1 and M2 are found to be non-stationary in level form while they are stationary in first difference. Studies based on level form create spurious results that can be biased and inconsistent, while first difference data, though stationary, gives only short-run relationship. However, if dependent and explanatory variables are cointegrated in the same order, only then can the, level form data be used for analytical purposes so that coefficients are not considered spurious. By the same reasoning, inflation as a function of both the M1and M2 is found to be cointegrated.

If variables are cointegrated, short-run relationships can be represented by Error Correction Model (ECM) which is considered to be unbiased and consistent. The Error Correction Term (ECT) in the ECM decides how quickly the long-run equilibrium will be restored. A statistically significant ECT coefficient of 0.096, as found in ECM of inflation on M1 and M2, suggests that inflation adjusts to changes in money supply rather fast. The negative sign of the coefficients of changes in money supply (M1 and M2) implies that there is short-run disequilibrium relationship between inflation and money supply (M1 and M2). However, in the long-run there is a positive relationship between inflation and money supply (M1 and M2), as depicted by the cointegrating equation.

(B) Analysis Based on Annual Data Frequency

Some of the macroeconomic variables that are supposed to explain inflation in Nepal are tested for stationarity. Due consideration has also been given to both the monetary-cum-structural variables. The inflation phenomenon of Nepal is found to be explained by structural variables as well as monetary variables.

(i) Stationary Test: Unit Root Test

RWM with drift and trend, and RWM with drift, trend and one period lag of dependent variable of each of the variables show non-stationarity in the level form data because the null hypothesis of unit root on the basis of the MacKinnon critical value has been accepted at 1 percent significant level as shown in Table 5.17. It implies that the "δ" value is significantly closer to zero, showing problem of unit root, or alternatively, "ρ" is significantly closer to unity. It shows random walk or time trend of macroeconomic data of Nepal or unit root problem in the level form data. Therefore, deriving relationship among variables under the level form data shows spurious results. The result of the test of stationarity is presented in Table 5.17.

Ln stands for natural logarithm, and Δ stands for change of the variable over the previous year. The variables included to test stationary are Consumer Price Index (CPI), M1 and M2, Real GDP (PRGDP), Indian Wholesale Price Index (IWPI), Real Agriculture GDP (APRGDP), Real Non-Agriculture GDP (NAPRGDP), High Powered Money (H), Ratio of Food Price/Total Price Index (FP/CPI).

Table 5.17

Test of Unit Root on "δ" in Level Form Data (1975-2003)

Variables	Constant β_1	Trend β_2	One period lag of dep. Variables[1] α_t	ADF Statistics	MacKinnon Critical Value 1%	5%	10%
Ln CPI[2]	No	No	No	8.83	-2.65	-1.95	-1.62
Ln CPI[3]	Yes	No	No	-0.27	-3.69	-2.97	-2.62
Ln CPI[4]	Yes	Yes	No	-1.72	-4.33	-3.58	-3.22
Δ Ln CPI[5]	Yes	Yes	Yes	1.12	-4.35	-3.59	-3.23
Ln M1	No	No	No	14 81	-2.65	-1.95	-1.62
Ln M1	Yes	No	No	0.01	-3.69	-2.97	-2.62
Ln M1	Yes	Yes	No	-1.70	-4.33	-3.58	-3.22
Δ Ln M1	Yes	Yes	Yes	-1.69	-4.35	-3.59	-3.23
Ln M2	No	No	No	18 45	-2.65	-1.95	-1.62
Ln M2	Yes	No	No	-1.02	-3.69	-2.97	-2.62
Ln M2	Yes	Yes	No	-1.95	-4.33	-3.58	-3.22
Δ Ln M2	Yes	Yes	Yes	-2.19	-4.35	-3.59	-3.23
Ln GDPR	No	No	No	7.81	-2.65	-1.95	-1.62
Ln GDPR	Yes	No	No	0.05	-3.69	-2.97	-2.62
Ln GDPR	Yes	Yes	No	-2.42	-4.33	-3.58	-3.22
Δ Ln GDPR	Yes	Yes	Yes	2.14	-4.35	-3.59	-3.23
Ln IWPI	No	No	No	8.35	-2.65	-1.95	-1.62
Ln IWPI	Yes	No	No	0.03	-3.69	-2.97	-2.62
Ln IWPI	Yes	Yes	No	2.32	-4.33	-3.58	-3.22
Δ Ln IWPI	Yes	Yes	Yes	2.57	-4.35	-3.59	-3.23
Ln AGDPR	No	No	No	3.18	-2.65	-1.95	-1.62
Ln AGDPR	Yes	No	No	0.59	-3.69	-2.97	-2.62
Ln AGDPR	Yes	Yes	No	-3.79	-4.33	-3.58	-3.22
Δ Ln AGDPR	Yes	Yes	Yes	-4.11	-4.35	-3.59	-3.23
Ln NAGDPR	No	No	No	6.51	-2.65	-1.95	-1.62
Ln NAGDPR	Yes	No	No	1.51	-3.69	-2.97	-2.62
Ln NAGDPR	Yes	Yes	No	2.35	-4.33	-3.58	-3.22
Δ Ln NAGDPR	Yes	Yes	Yes	3.28	-4.35	-3.59	-3.23
Ln H	No	No	No	15.55	-2.65	-1.95	-1.62
Ln H	Yes	No	No	0.39	-3.69	-2.97	-2.62
Ln H	Yes	Yes	No	-2.38	-4.33	-3.58	-3.22
Δ Ln H	Yes	Yes	Yes	3.28	-4.35	-3.59	-3.23
Ln(FP/CPI)	No	No	No	-1.92	-2.64	-1.95	-1.62
Ln (FP/CPI)	Yes	No	No	-2.81	-3.69	-2.97	-2.62
Ln (FP/CPI)	Yes	Yes	No	-3.59	-4.33	-3.58	-3.22
Δ Ln (FP/CPI)	Yes	Yes	Yes	-2.91	-4.35	-3.59	-3.23

Notes:

1. In a finite lag model, only one period lag has been considered in the present study, which would expect to solve the problem of serial correlation.
2. Model with absence of constant, trend and one period lag of dependent variable ('no', 'no', 'no') is called RWM without drift parameter If null hypothesis is rejected in the case of RWM model without drift (i e. $\beta_1 = 0, \beta_2 = 0, \beta_3 = 1$) it signifies that Y_t is a stationary time series with zero mean,
3. Model with presence of constant and absence of trend and one period lag of dependent variable ('yes', 'no' 'no') is called RWM with drift parameter. If the null hypothesis is rejected in the case of RWM model with drift (i.e. $\beta_1 \neq 0, \beta_2 = 0, \beta_3 = 1$), then it implies that Y_t is stationary time series with a non-zero mean $[\beta_1/(1-\rho)]$,
4. Model with presence of constant and trend but no one period lag of dependent variable ('yes', 'yes' 'no') is RWM with drift and trend parameter. If the null hypothesis is rejected in the case of RWM model with drift around a stochastic trend ($\beta_1 \neq 0, \beta_2 \neq 0, \beta_3 < 1$), then it implies that Y_t is stationary around a deterministic trend.

5 Model with presence of constant and trend and one period lag of dependent variable ('yes', 'yes' 'yes') is RWM with drift and trend and one period lag dependent variable. The last term in the equation (1) is lagged values of the dependent variable "ΔY_t" which considers the problem of serial correlation making the ADF test applicable to DF test

Most of the time series data, tested for unit root problem as shown above, are found to be non-stationary in their level form. These time series data are expected to be found first difference stationary or trend stationary. ADF statistics from first difference and trend specifications of model and MacKinnon critical value for the rejection of null hypothesis of unit root for difference and trend stationary are given in Table 5.18.

Table 5.18

Test of Unit Root in First Difference and Trend Data (1975-2003)

Variables	First Difference Stationary[6]		Trend Stationary[7]	ADF for First Difference Stationary	ADF for Trend Stationary	Mackinnon Critical Value for First Difference Stationary Process			Mackinnon Critical Value for Trend Stationary Process		
	Constant	Trend	Unit root on $\hat{u}_t$			1%	5%	10%	1%	5%	10%
Ln M1	Yes	No	Yes	-4.60	-4.69	-3.70	-2.97	-2.62	-2 65	-2.95	-1 62
Ln CPI	Yes	No	Yes	-4.10	-4 09	-3.70	-2.97	-2 62	-2 65	-2 95	-1 62
Ln M2	Yes	No	Yes	-4.20	-4.39	-3.70	-2 97	-2 62	-2.65	-2 95	-1 62
Ln GDPR	Yes	No	Yes	-6.36	-6-46	-3 70	-2 97	-2 62	-2 65	-2 95	-1 62
Ln IWPI	Yes	No	Yes	-3.59	-3.69	-3 70	-2.97	-2 62	-2 65	-2.95	-1 62
Ln AGDPR	Yes	No	Yes	-6.44	-6.56	-3 70	-2.97	-2 62	-2 65	-2 95	-1 62
Ln NAGDPR	Yes	No	Yes	-3.33	-3.43	-3 70	-2.97	-2 62	-2.65	-2 95	-1 62
Ln H	Yes	No	Yes	-4.92	-4.99	-3 70	-2 97	-2 62	-2 65	-2 95	-1 62
$LnGDPR_{t-1}$	Yes	No	Yes	-6.60	-5.15	-3.70	-2 97	-2.62	-2 65	-2.95	-1.62
$LnIWPI_{t-1}$	Yes	No	Yes	-3.63	-3.74	-3 70	-2 97	-2 62	-2 65	-2 95	-1 62
Ln CPI_{t-1}	Yes	No	Yes	-4.24	-4.86	-3 70	-2 97	-2 62	-2 65	-2 95	-1 62
Ln AGDPR/NAGDPR	Yes	No	Yes	-3.43	-3.53	-3 70	-2.97	-2 62	-2.65	-2 95	-1 62
Ln (FP/P)	Yes	No	Yes	-6.48	-3.63	-3.70	-2.97	-2 62	-2.65	-2 95	-1 62

Notes 6 Unit root is tested on $\Delta\hat{Y}_t = \beta_1 + \delta Y_{t-1} + u_t$, for the first difference stationary, where $\hat{Y}_t = \Delta Y_t$ so, $\Delta\hat{Y}_t$ is Δ of ΔY_t

7 Unit root is tested on $\hat{u}_t$ by using equation $\Delta\hat{u}_t = \delta u_{t-1}$ for trend stationary after obtaining $\hat{u}_t$ by regressing $Y_t = \beta_1 + \beta_2 t + u_t$

The IWPI, AGDPR and $IWPI_{t-1}$ AGDPR/NAGDPR are found to be first difference stationary at 5 percent significant level; the remaining variables at 1 percent significant level. Similarly, residual terms of the variables are trend stationary for all the variables. The ADF test statistic in absolute term for difference and trend data is larger than the MacKinnon critical value, rejecting the null hypothesis of unit root problem.

In summing up, almost all the variables that were not stationary in level form data (in Table 5.17) are shown to be stationary in first difference as well as trend stationary (in Table 5.18). The ADF statistics of most of the variables are greater than MacKinnon critical values at 1 percent significant level. Therefore, the first difference data are stationary, or they are integrated of order 1 or I(1). However, most macroeconomic time series variables are found to be Difference Stationary Process (DSP) rather than Trend Stationary Process (TSP) (Gujarati, 2004). Each variable of the macroeconomic time series (inflation and its determinants) in level form is considered as having varying mean and variance over time.

(ii) Cointegration Test between Inflation (log CPI) and its major Determinants

In order to derive the stable long-run relationship between inflation and its explanatory variables in Nepal, a cointegration test would validate whether the variables are cointegrated in the same order. The null hypothesis (Ho) that there no cointegration between the variables is tested against the alternative hypothesis (H1) that there is cointegration. The test results are given in Table 5.19.

Table 5.19
Cointegration Test between Inflation (Log CPI) and its Major Determinants
(1975-2003)

Variables		ADF statistics	Mackinnon Critical Value			Order of Cointe-gration on $\hat{u}_t$
Dependent	Explanatory		1%	5%	10%	
Log(CPI)	Log(M1)	2.62	-2.65	-1.95	-1.62	I(0) in 5% level
Log(CPI)	Log(M2)	-2.95	-2.65	-1.95	-1.62	I(0) in 1% level
Log(CPI)	Log(H)	-2.46	-2.65	-1.95	-1.62	I(0) in 5% level
Log(CPI)	Log(GDPR)	-2.39	-2.65	-1.95	-1.62	I(0) in 5% level
Log(CPI)	Log(IWPI)	-2.27	-2.65	-1.95	-1.62	I(0) in 5% level
Log(CPI)	Log(AGDPR)	-3.11	-2.65	-1.95	-1.62	I(0) in 1% level
Log(CPI)	Log(NAGDPR)	-3.44	-2.65	-1.95	-1.62	I(0) in 1% level
Log(CPI)	Log(P_{t-1})	-4.41	-2.65	-1.95	-1.62	I(0) in 1% level
Log(CPI)	Log(RLR)	-2.08	-2.65	-1.95	-1.62	I(0) in 5% level
Log(CPI)	Log(AGDPR/NAGDPR)	-3.10	-2.65	-1.95	-1.62	I(0) in 1% level
Log(CPI)	Log($IWPI_{t-1}$)	-2.38	-2.65	-1.95	-1.62	I(0) in 5% level
Log(CPI)	Log(FCPI/CPI)	-1.87	-2.65	-1.95	-1.62	I(0) in 10% level

The results shown in the last column of Table 5.19 confirm that inflation and its determinant variables are found to be integrated of order 1, I(1) or first difference is I(0) at either 1 percent or at 5 percent significant level. However, log(CPI) to Log(FCPI/CPI) is cointegrated at 10 percent significant level. This may be because of the test of cointegration using level form data with ratio data. Therefore, though there is short-run fluctuation in variable's trend path, such a fluctuation will no longer persist in the long run. Therefore, it can be concluded that all the explanatory variables shown in column (2) of Table 5.19 are found to be cointegrated. The cointegration result of macroeconomic variables provides sufficient background to derive Error Correction Model (ECM) which shows both the short-run and long-run relationship.

(iii) Error Correction Model (ECM)

The ECM of inflation has been estimated on the basis of coingegrated variables selected from the cointegration test given in Table 5.19. The macroeconomic variables for the cointegration test were selected on the basis of the robustness of the inflation equation following general to specific methodology. A coingetrating equation of inflation of Nepal is found on the basis of the statistical significance of the coefficients. The cointegrating relationship between the variables is as follows:

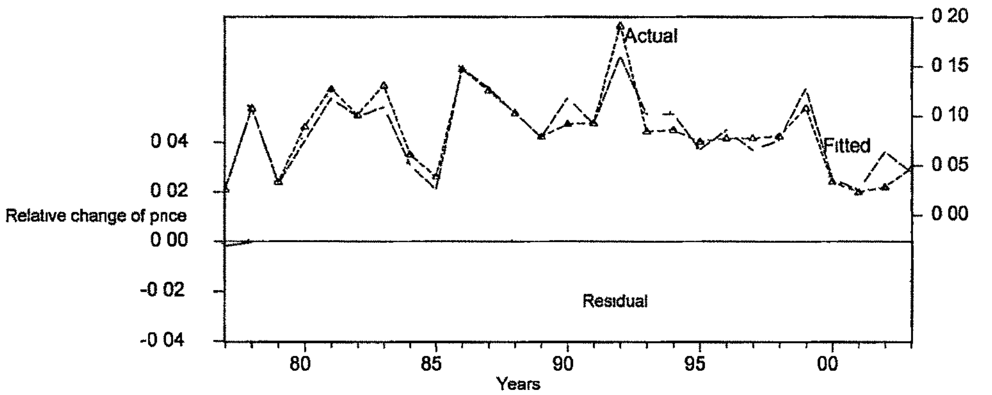
$$LOG(CPI)= 0\ 62 + 0\ 43LOG(M1) - 0\ 20LOG(GDPR_{t-1}) + 2\ 0LOG(FP/CPI)$$
$$(0\ 45)\ \ (8\ 73)\ \ \ \ (-1\ 36)\ \ \ \ (7\ 79)$$
$$+ 0\ 43LOG(IWPI_{t-1})\ \ \ \ .\ \ \ \ .\ (2)$$
$$(5\ 79)$$
$$\overline{R}^2 = 0\ 99\ \ \ DW=1\ 52\ \ \ F=7190\ 61$$

Inflation behaviour in Nepal is established as a function of monetary variable (M1) $PRGDP_{t-1}$ (as a real sector variable), the ratio of food index/total index (FP/CPI) (as a structural variable) and Indian Wholesale Price Index ($IWPI_{t-1}$) (as an international price variable. $GDPR_t$ and $IWPI_t$ have one period lag effect on inflation. All the coefficients, except constant term in the above cointegrating equation are having expected theoretical sign and statistically significant at 1 percent significant. The statistically significant value of F statistic confirms the model as a whole stable. The DW test statistic shows that there is no serious problem of autocorrelation in the model. A high adjusted R^2 shows a goodness of fit of the model. This model shows the long-run equilibrium relation between the variables. On the basis of the above cointegrating equation, ECM can be derived by introducing first difference in every variable of cointegrating equation (i.e.'D' in following equation- prior to LOG of each variables) and one period lag residual term from the cointegrating equation. The ECM of inflation in Nepal is found to be as:

$$DLOG(CPI)=0\ 04+0\ 14DLOG(M1)-0\ 19DLOG(GDPR_{t-1})+1\ 63DLOG(FP/CPI)+$$
$$(3\ 31)\ \ (2\ 03)\ \ \ \ (-1\ 60)\ \ \ \ (10\ 75)$$
$$0\ 39DLOG(IWPI_{t-1})+0\ 84(RESD_{t-1})\ \ ....\ \ .....\ \ ..\ (3)$$
$$(5\ 13)\ \ \ \ (5\ 17)$$
$$\overline{R}^2=0.87\ DW=2.01\ \ \ F=30.36$$

Where, D and LOG stands for Δ and natural logarithm respectively. One period lag residual ($RESD_{t-1}$) is termed as Error Correction Term (ECT) and the model as a whole is termed as Error Correction Model (ECM). The coefficients of constant, M1, FP/CPI, $IWPI_{t-1}$ and $RESD_{t-1}$ are statistically significant at 1 percent level, but $GDPR_{t-1}$ is significant at 5 percent level. On the basis of F statistic, the above model is significant. The coefficients are considered as short-run partial regression coefficients relating to the inflation and its determinants. However, the short-run coefficient estimates of equation (3) can be compared with the long-run coefficient given in equation (2). For example, coefficient of 0.14 of first difference Log(M1) in equation (3) is a disequilibrium or short-run coefficient, which after a certain time of adjustment, is converged into the long-run coefficient of 0.43 given in equnation (2). However, the absolute value of the coefficient of $RESD_{t-1}$ determines how quickly the long-run equilibrium is restored.

Diagram 1: Cyclical Nature of Price Movement

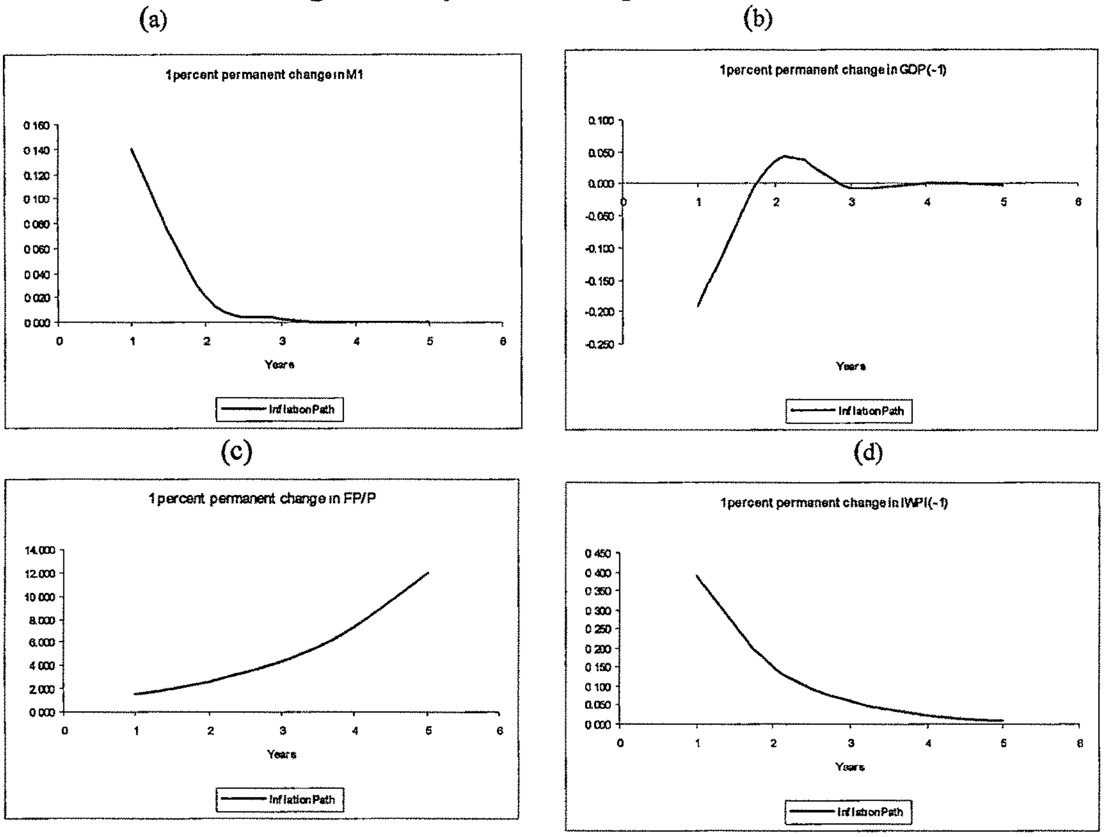


A statistically significant coefficient of ECT of 0.84, as found in the result, suggests that CPI adjusts to changes in explanatory variables in a relatively longer period of time. When the ECM was fitted against the actual rate of inflation data, it performed well in terms of tracking the cyclical nature of price movements in Nepal (Diagram 1).

(iv) Dynamic Multiplier of Inflation Path based on ECM

The impact of changes in the exogenous variables on the inflation path can be studied by using the dynamic multiplier of the ECM. The response of inflation (ΔCPI_t) over time to a permanent one percent increase in each of the right-hand-side variables in the ECM model are shown in the following dynamic inflation path. Inflation path is calculated on the basis of dynamic multiplier, that is, $\frac{\Delta \log(P_t)}{\Delta \log(M1)_t} = (1 + \alpha + \alpha^2 + \alpha^3 + \quad + \alpha^{n-1})$.

Diagram 2- Dynamic Multiplier of Inflation



The dynamic inflation path, as shown in diagram 'a' signifies the adjustment period of inflation, when there is a permanent 1 percent increase in the rate of M1. A permanent 1 percent increase in the rate of M1 would yield a 0.14 percent increase in CPI in the initial year, and moving towards long-run increase in inflation of 0.43 percent. The convergence trend of the inflation path signifies the time interval to realize the full effect of changes in one of the determinants of inflation in the long-run.

A one percent increase in $PRGDP_{t-1}$ would lead to a decrease of 0.19 percent in CPI in the next year, and a decrease of 0.20 percent in the long-run, as shown in diagram 'b'. The inflation time path shows oscillatory convergence to the long-run inflation path. The reason for oscillation is the negative sign of the impact multiplier.

The divergence nature of inflation path of ratio of FP/CPI is shown in diagram 'c'. The greater than unity coefficient of FP/CPI is the reason for this divergence. A one percent increase in the ratio would lead to an increase of 1.63 percent in inflation in the next year and a continuous increase in inflation in the long-run. It shows an unstable equilibrium relationship between the variables.

A permanent 1 percent increase in the rate of $IWPI_{t-1}$ would yield a 0.39 percent increase in inflation in the initial year, and move towards long-run increase in inflation of 0.43 percent as shown in diagram 'd'.

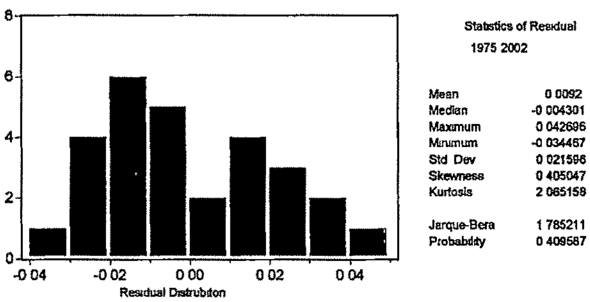
In summing up, the period of convergence of inflation path towards long-run equilibrium in the case M1 and $PRGDP_{t-1}$ ranges between 2 to 3 years, while in the case of $IWPI_{t-1}$ it is 4 years. The time period is indeterminate in the case of FP/CPI because of the divergence trend in inflation path. A relatively longer period of time taken to converge into long-run equilibrium by the variables like M1, $PRGDP_{t-1}$ and $IWPI_{t-1}$ is also supported by the high value of ECT in the previous section.

(v) Test of Serial correlation of ECM

The general form of autocorrelation was rejected on the basis of Brusch-Godfrey serial correlation LM (Lagrange Multiplier Principle) test for the inflation equation derived on the basis of ECM. Where the null hypothesis for no autocorrelation was $H_o : \rho_1 = \rho_2 = . = \rho_p = 0$ with $(n-p)R^2 \approx \chi^2_p$. For this test $\hat{u}_t$ is derived from the inflation equation of ECM and applying regression equation: $\hat{u}_t = \alpha_t + \alpha_2 X_{1t} + \alpha_2 X_{2t} ... \hat{\rho}_1 \hat{u}_{t-1} + \hat{\rho}_2 \hat{u}_{t-2} ... \hat{\rho}_p \hat{u}_{t-p}$.

The test of normality of disturbance term of the inflation equation is examined by Jarque-Bera (JB) test of normality based on the OLS residuals, that is, $JB = n\left[\frac{S^2}{6} + \frac{(K-3)^2}{24}\right]$ where, n=sample size, S=skewness coefficient, and K=kurtosis coefficient. The JB test of normality is a test of the joint hypothesis that S and K are 0 and 3 respectively. In that case, the value of the JB statistic is expected to be 0 to confirm normality. The Classical Linear Regression Model (CNLRM) assumes that the disturbance term is normally distributed, so that 't' and 'F' tests require that the error term should follow the normal distribution. JB test is based on skewness and kurtosis measures of the OLS residuals. For the present study, the null hypothesis of Jarque-Bera test statistic being equal to zero is accepted, confirming the normal distribution of residual term. The JB statistic of inflation equation is 1.78 as shown below. If we compare the tabulated value of χ^2 (5.99) with JB statistic with 2 degree of freedom, we cannot reject the null hypothesis, that the error terms are normally distributed. Therefore, residual term satisfies CNLRM. The following histogram shows an almost normal distribution of residual term satisfying normality condition.

Diagram: 3- Histogram of Residual Term

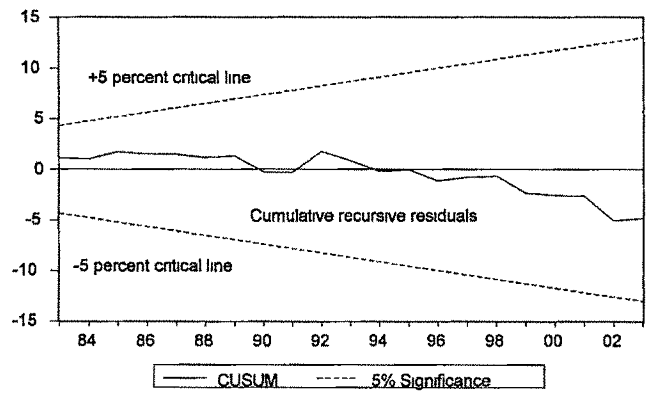


The presence of general specification error was rejected by the results of the Ramsey RESET (regression specification error test) test. Obtaining $\hat{Y}_i$ from inflation equation and introducing $\hat{Y}_i^2$ and $\hat{Y}_i^3$ as additional regressors are introduced in the same inflation equation. That is, $Y_i = \beta_1 + \beta_2 X_{1i} . X_{kn} + \hat{Y}_1^2 + \hat{Y}_1^3 + u_i$ where, a new R^2 can be derived. Ramsey RESET test is the test based on stability of old and new R^2 using F test statistic. If F value is highly significant, then the null hypothesis of no stability is rejected, implying that there is no general specification error in the model. It has been found that F value derived from Ramsey RESET test is not highly significant, so that, the null hypothesis of no stability in R^2 is rejected. This means that there is no general specification error in Nepal's inflation model.

(vi) Structural Stability of Price Equation (ECM equation)

The estimated inflation equation based on the error correction model (subject to fulfill the CUSUM recursive residual test) is used to test the structural stability of the model.

Diagram 4-Cumulative Recursive Residuals



The above figure plots the CUSUM cumulative recursive residuals. If there is deviation of residuals inside the 5 percent critical line, it implies structural stability in the model. This test validates the structural stability of the inflation equation, since the cumulative recursive residual is inside the 5 percent critical region. Similarly, the estimated inflation error correction model is found to be stable over the period studied. Chow F test was selected as a possible breakpoint in the year 1989 for structural reform or exogenous shocks. The null hypothesis of no structural stability is rejected.

To sum up, Nepal's macroeconomic time series data are non-stationary in level form while they are stationary in first difference. Studies based on level form create spurious results that can be biased and inconsistent while first difference data, though they are stationary, gives only short-run relationship and lacks theoretically plausibility. However, if dependent and explanatory variables are cointegrated in same order, then and then only, level form data can be used for analytical purpose so that coefficients are not considered spurious. By the same reasoning, the variables in inflation model of Nepal are found cointegrated.. Therefore, the price behavior in Nepal is a function of M1 (monetary variable), PRGDPt-1 (real sector variable), FP/CPI (structural variable) and IWPIt-1 (international price variable)..

Using errors from cointegrated inflation model, ECM has been derived which has given short-run coefficient estimates. By statistical as well as theoretical criteria, the ECM is found robust and stable, which confirms the explanatory variables of inflation of Nepal being true determinants of inflation phenomenon. The Error correction term (ECT) in the ECM decides how quickly the long-run equilibrium is restored. A statistically significant coefficient of ECT of 0.84, as estimated in the section 5, suggests that CPI adjusts to changes in explanatory variables in a relatively longer period of time. Dynamic multiplier of inflation path also supports the result of ECM. In case of variation in M1 and $PRGDP_{t-1,}$ the period of inflation convergence to equilibrium ranges from 2 to 3 years while that in the case of $IWPI_{t-1,}$ it is 4 years. These results are consistent given underdeveloped financial market, difficult geographical structure, subsistence economy, fragmented market structure, escalation of the conflict and lack of smooth supply of commodities in Nepal.

3. VOLATILITY CLUSTERING OF INFLATION: ARCH MODEL

Inflation rates sometimes exhibit the phenomenon of volatility clustering. The latter term signify periods in which prices show wide swings for an extended time period followed by periods of relative calm. The study of the variability of inflation is important because volatility in it creates uncertainty in financial planning, which is a bad thing. The measurement of volatility clustering is modeled as the ARCH phenomenon. This model was initially developed by R. Engle (1982). The ARCH model is used to find the autocorrelation in the variance σ^2 at time 't' with its values lagged one or more periods of time series variable[12]. As the name of the model (ARCH) suggests, autoregressive (AR) means here it is dealt on autoregressive model on order (p), conditional (C) means variance of error term that is conditional to its lag values, heteroscedasticity (H) means this model is related to variance of variable i.e. variance error term. If the error variance is related to the squared error term in the previous term, it is used as an ARCH criterion. If the error variance is related to squared error variance terms several periods past, in that case it is used as a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) criterion.

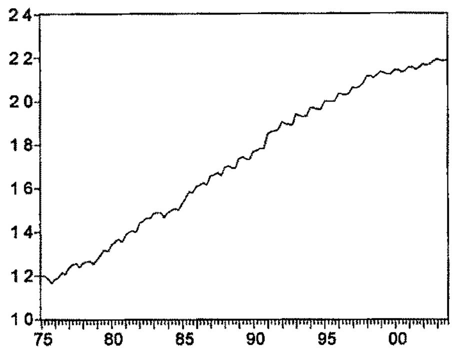
[12] Since σ^2 is not directly observable, it can be derived by calculating estimated variance residual $\text{var}(\hat{u}_t)$ applying OLS method to the regression as: $Y_t = \alpha_0 + \alpha_1 X_t + \alpha_2 X_t .. \alpha_k X_{kt} + u_t$. Under the assumption that $u_t = N[0(\alpha_o + \alpha_1 u_{t-1}^2)]$ that is, u_t is normally distributed with zero mean and $\text{var}(u_t) = \sigma_t^2 = (\alpha_o + \alpha_1 u_{t-1}^2)$ that, the variance follows an ARCH(1) process. The Estimable equation for ARCH effect is: $\hat{u}_t^2 = \hat{\alpha}_o + \hat{\alpha}_1 \hat{u}_{t-1}^2 + \hat{\alpha}_2 \hat{u}_{t-2}^2 ... + \hat{\alpha}_p \hat{u}_{t-p}^2$ where, If there is no autocorrelation in the error variance, we have null hypothesis $H_0 : \alpha_1 = \alpha_2 = ... = \alpha_p = 0$ in which case $\text{var}(u_t) = \alpha_0$, and it is not found the ARCH effect.

Understanding the volatility clustering of inflation in Nepal is important in the sense that high variance of a certain variable represents uncertainty and hence creates uncertainty in decision making of economic agents. For some decision makers, inflation in itself may not be bad, but its variability is bad because it makes financial planning difficult. The mean of a particular variable cannot be considered representative if its variance or standard deviation is high. On this background, an univariate model is built and tested to see whether the variable is highly volatile or not in order to understand inflation trend from the variance point of view. An empirical test of ARCH effect in Nepal's inflation data will validate whether inflation in Nepal is highly volatile or not, so that economic agents experience uncertainty in takeing financial decision. Is inflation volatility clustering creating problem of uncertainty in the economic activities of Nepal? In order to answer this question, the ARCH model is applied to examine the volatility clustering the inflation in this study.

For the analysis of the volatility clustering of inflation, quarterly data frequency of overall consumer price index (CPIO) from 1975 to 2003 is considered here. A reasonably large number of the sample observations studied here are thought to be representative of population variance. A characteristic of most of the financial time series is in their level form, are characterized as random walks; that is, they are nonstationary. On the other hand, in the first difference form, they are found generally to be stationary. Therefore, instead of modelling the levels form of financial time series, their first difference is modeled for volatility, suggesting that the variance of financial time series varies over time by ARCH model.

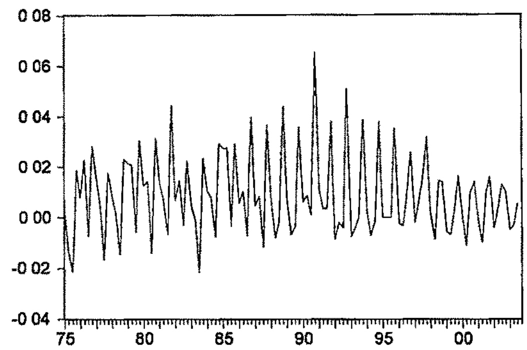
The trend of log (CPIO) and its relative change (showing percentage change) has been graphically presented in the following diagrams.

(a) Trend of Log (CPIO)



Time Scale (Quarterly)

(b) Trend of changes in the Log CPIO



Time Scale (Quarterly)

By visual inspection, log of CPIO in panel (a) shows random walk or is non-stationary in nature. Transforming the trend data into first difference form (relative change or percentage change form), it shows high volatility in the mid-eighties and early ninties in comparison to other periods of relative calm, as shown in panel (b). If higher variance of inflation is followed by higher variance for a some longer time, then volatility clustering exists.

As explained above, the squared residual term is considered to be a measure of volatility; residual can be derived by running following regression:

$Y_t = \beta_1 + u_t$ .... (1)

D(LOG(CPIO)) = 0 020

(5.66) DW=2.37

In the above equation, a regression has been run between changes in log of CPIO as dependent variable and constant as an independent variable. The coefficient is statistically significant at 1 percent level. The coefficient shows that over the long run, inflation increased by almost 2 percent. The estimated residual taking from equation no.(1) and squaring it yields the error variance. ARCH is tested under the coefficient of current error variance to error variance of different lags. ARCH effect is tested under the null hypothesis that there is no ARCH effect, that is $H_0 \cdot \alpha_1 = \alpha_2 = ... = \alpha_p = 0$, against there is ARCH effect, that is $H_1 : \alpha_1 = \alpha_2 = .. = \alpha_p \neq 0$.

$$\hat{u}_t^2 = 0.0016 - 0.124\,\hat{u}_{t-1}^2 \quad \text{-------- (1)}$$

(6 40) (-1 32) DW=2 04

$$\hat{u}_t^2 = 0.0023 - 0.197\,\hat{u}_{t-1}^2 - 0.232\,\hat{u}_{t-2}^2 - 0.209\,\hat{u}_{t-3}^2 \quad \text{------- (2)}$$

(6.82) (-2.10) (-2.52) (-2.24) DW=1.80

If we introduce only one lagged variance term as shown in equation (1), the null hypothesis of no ARCH(1) is accepted. However, if we introduce up to three lagged variance terms, the null hypothesis of no ARCH(3) effect is rejected. Here, the computed X^2 statistic of 11.008 (nR2=112(0.099) is found to be greater than the table value of 7.81 at 5 percent significant level implying null hypothesis being rejected. Therefore, volatility clustering is found to be existent in inflation series in Nepal.

4. BUSINESS CYCLES AND INFLATION

Understanding the phases and amplitudes of inflation business cycles is important for the formulation of macroeconomic polices in general and monetary policy in particular. The classicists emphasized supply (real) shocks that trigger business cycle. The supply shocks are caused by nature, the workers, firms, the government, and factors like wars and terrorism. Keynesians stress demand shocks that are dominant in generating business cycles. Demand shocks could emanate from the behaviour of the private sector, actions of the government and the foreign sector. The monetarists, in contrast to Keynesians, see changes in the supply of money, which originate from the actions of monetary authorities, as a primary factor causing business cycles (Levacic and Rebmann, 1982).

The experiences of the 1970s questioned the predominant idea that business cycles are driven mainly by changes in demand. Instead, the contemporary macroeconomic fluctuations are found to be originated largely from supply (technology) shocks, such as, the drastic oil price hikes during 1973-74 and in 1979 and the worldwide slowdown in productivity growth in the mid-Seventies. Kydland and Prescott (1982) found that technology shocks (that is, short-run variations are experienced around the positive growth trend due to technological changes) is one of the important factors contributing to output fluctuations. At present, supply shocks along with the demand shocks play an important role in formulating macroeconomic models. Therfore, Kydland and Prescott integrated business cycles (short-run fluctuations) theory and growth (long-run) theory on the ground that the long-run is a sequence of short-run.

If temporary movements of output resulted primarily from demand shocks, prices would be expected to be procyclical; if they result from supply shocks, prices would be expected to be countercyclical. Mankiw (2004) argues that in the absence of identifiable real shocks, such as the OPEC oil price changes, inflation may tend to rise in booms and fall in recession. Temporary movements of output are associated with shocks to demand, while longer-term movements are associated with shocks to supply (Blanchard and Quah, 1989). However, the countercyclical variation of prices suggests that even temporary movements in output may be due to supply disturbances. This is consistent with the view of supply-driven models of the business cycles, which is explained by the real business cycles model. This model is believed to be a more accurate representation of reality than conventional demand-driven models (Kydland and Prescott, 1982, and Smith, 1992).

Studies found inflation as being positively correlated with various measures of cyclical component of output. The cyclical component of output is defined as the difference between the current level of output and its predicted long-run value. Cooley and Prescott (1995) and Kydland and Prescott (1988) concluded that the conventional belief that prices are procyclical. But it is not supported by post war U.S. data. This study complements these studies of post-war data as well as Kydland's in their cross-country study of the historical properties of business cycles.

The positive correlation of inflation with the business cycles suggests that demand-driven models that were rejected by the business cycles model are not necessarily falsified by the countercyclical behaviour of the price level. Because, the quantitative results are affected by the choice of the detrending procedure but the hypothesis of countercyclical price behaviour is supported in most cases.

If business-cycle regularities are cyclical co-movements between macroeconomic variables, we can measure these movements using relevant statistics in the time domain. It has become a common practice in the real-business cycle literature to measure the co-movements by cross-correlation coefficients between different variables at different leads and lags (Jha, 2006). Keeping these in view, cyclical co-movements between inflation and major macroeconomic variables of Nepal are analyzed by using correlation coefficients between the variables as follows.

Table 5.20

Correlation Coefficient between Inflation and Macroeconomic Variables of Nepal (Sample 1975-2003)

Macroeconomic Variables	One period lag (t-1)	Contemporaneous (t)	One period lead (t+1)
Narrow Money Aggregate (M1)	0.377(1.83)**	0.464 (2.42)*	0.689 (4.35)*
Broad Money Aggregate (M2)	0.374 (1.85)**	0.543 (3.03)*	0.764 (5.43)*
Real Gross Domestic Product (GDP)	0.369 (1.82)**	0.403 (2.07)*	0.524 (2.82)*
Real Agriculture GDP	0.028 (0.12)	0.114 (0.54)	0.228 (1.07)
Aggregate Consumption	0.782 (5.75)*	0.684 (4.40)*	0.768 (5.50)*
Aggregate Investment	0.160 (0.74)	0.519 (2.85)*	0.379 (1.88)**
Budget Deficit of the Government	0.065 (0.30)	0.084 (0.39)	0.397 (1.98)**
Balance of Payment (BoP) Surplus	0.188 (0.88)	0.241 (1.16)	-0.219 (-1.03)

Values into the parenthesis are t statistics. Asterisk (*) signifies coefficient significant at 1% level, asterisks (**) signify coefficient significant at 5% level, and asterisks (***) signify coefficients significant at 10% level.

The cross correlation between inflation and major macroeconomic variables are presented in Table 5.20. All the data series are in first difference transformation. The variables are measured contemporaneously, as well as at one period (year) lag and lead. A variable is procyclical (counter cyclical) if it has predominantly positive (negative) and statistically significant correlation coefficients. Otherwise we will call it acyclical. A variable displays cyclical (non-cyclical) behaviour if the correlation coefficients display (do not display) a pronounced peak. If such a peak occurs when the variable has one period lead (lag) relative to inflation, we will refer to it as a lagging (leading) variable.

On the basis of the above arguments, almost all macroeconomic variables are positively correlated with inflation in Nepal. The correlation coefficients between inflation and M1, M2 and real GDP, in the case of contemporaneous and one period lead, are found to be statistically significant at 1 percent level, while these variables are statistically significant at 5 percent level in the case of one period lag. The correlation between inflation and aggregate consumption is positive with statistically significant at 1 percent level in both lead and lag. In the case of investment, it is significantly positively correlated with inflation in the case of contemporaneous and one period lead. However, government deficit is positively correlated with statistically significant in the case of lead only. However, real agricultural GDP and balance of payment surplus are not found to be statistically significant.

Aggregate consumption, monetary aggregates and real GDP are procyclical lagging variables to inflation. Among these variables, aggregate consumption is a strong procyclical variable. Budget deficit and investment are weakly procyclical, whereas agricultural real GDP and balance of payment are not procyclical because of the coefficients of correlation being statistically insignificant.