CHAPTER ELEVEN

STUDY WITH INVARIANCE PROPOSITION OF RATIONAL EXPECTATIONS

11.1 Introduction

The concept of Invariance Proposition of Rational Expectations, developed by Lucas, Sargent and Wallace in early seventies, presents the idea that the anticipated part of money supply affects price level. Since the present work is devoted to study the relationship between money supply and price level, the Invariance Proposition theory of rational expectation can be applied to examine the relationship between anticipated money supply and price level. In order to apply Invariance Proposition theory in examining the impact of anticipated money supply on price level, we need to estimate the anticipated money supply.

There are several procedures to estimate the anticipated money supply; the present study has applied ARIMA structures of narrow and broad money supply for the estimation of anticipated money supply. After identifying anticipated money supply, a regression equation has been performed taking price level as dependent variable and anticipated money supply as explanatory variable.

11.2 ARIMA Model for M_1 Money Supply

In order to quantify anticipated money supply, the ARIMA model has been applied. For this purpose equation (11.1) has been employed for ARIMA structure for M_1 money supply, on the basis of which the anticipated M_1 money supplies has been quantified.

$$dLnM_{1t} = \alpha + \beta_1 dLnM_{1t-1} + \beta_2 dLnM_{1t-2} + \cdots + \beta_k dLnM_{1t-k} + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \cdots + \theta_k u_{t-k} + \varepsilon_t \quad (11.1)$$[41]

Where, $dLnM_{1t}$, $dLnM_{1t-1} \ldots dLnM_{1t-k}$ are first difference of money supply in logarithmic form at different lags; $u_{t-1}, u_{t-2} \ldots . u_{t-k}$ are the error terms at different

[41] Same procedures can be applied for ARIMA of M_2 money supply as well.

lags after regressing money supply with its own past lags. The fitted part of the above model provides the quantity of anticipated part while the error term 'ε_t' depicts the unanticipated part of money supply. The estimations from the different alternative ARIMA models for narrow money supply (M_1) have been presented through the Table- 11.1.

Table-11.1 shows the estimations of ARIMA structure of M_1 from different four alternative models. Among these alternative models the ARIMA model (2, 1, 2) can be taken as more appropriate model because all the coefficients are significant at less than one percent level. With satisfactory values of R^2 and Adjusted R^2 as well as D-W statistic, the ARIMA (2,1,2) model can be claimed to be suitable model. The ARIMA model (1,1,1) has minimum AIC and SC but the coefficient of AR(1) is not significant. Likewise, the coefficients of AR and MA terms of other ARIMA models are not significant. Due to these reasons, ARIMA (2,1,2) model is suitable as compared to other ARIMA models. However, the suitability of this ARIMA(2,1,2) model needs residuals diagnostic tests. After residuals diagnostic tests, it can be claimed that whether or not the ARIMA (2,1,2) model for M_1 money supply is appropriate.

Table-11.1: Estimation of ARIMA Models for M_1

ARIMA (1, 1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant(α)	0.0244	0.0075	3.2336	0.0015
AR(1)	0.3297	0.2032	1.6222	0.1070
MA(1)	-0.6328	0.1667	-3.7955	0.0002
Akaike info criterion		-3.4526	R^2	0.0939
Schwarz criterion		-3.3907	Adj.R^2	0.0810
Durbin-Watson stat		1.7294	RSS	0.2560

ARIMA (1, 1, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant(α)	0.0383	0.0037	10.2848	0.0000
AR(1)	-0.0513	0.0844	-0.6082	0.5440
MA(2)	-0.3617	0.0788	-4.5871	0.0000
Akaike info criterion	-3.6235		R^2	0.2362
Schwarz criterion	-3.5617		Adj. R^2	0.2254
Durbin-Watson stat	2.0266		RSS	0.2158

ARIMA (2, 1, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant(α)	0.0729	0.0038	18.91815	0.0000
AR(2)	-0.9770	0.0029	-326.9132	0.0000
MA(2)	0.9862	0.0129	76.3938	0.0000
Akaike info criterion :-	-4.6273		R^2 :-	0.7218
Schwarz criterion :-	-4.5652		Adj. R^2:-	0.7178
Durbin-Watson stat:-	2.0939		RSS :-	0.0785

ARIMA (2, 1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant(α)	0.0617	0.0034	17.9473	0.0000
AR(2)	-0.6878	0.0613	-11.2191	0.0000
MA(1)	-0.0465	0.0845	-0.5506	0.5827
Akaike info criterion	-3.9917		R^2	0.4747
Schwarz criterion	-3.9296		Adj. R^2	0.4672
Durbin-Watson stat	2.0347		RSS	0.1482

11.2.1 Residuals Diagnostic Test of ARIMA(2,1,2) Model for M_1

The residuals diagnostic tests of ARIMA(2,1,2) model consists of the following different tests.

11.2.1.1 Correlogram of Squared Residuals

The Correlogram-Q-statistic of the squared residuals of estimated ARIMA (2,1,2) model of M_1 money supply is presented through Table-11.2. The ACFs and PACFs of correlogram of the squared residual are very small/nearly zero at all lags and the Q-statistics at all lags are not significant with large p-values. This indicates that there is no evidence of rejecting the null hypothesis of no serial correlation. This implies that the residuals of the estimated ARIMA (2,1,2) model of M_1 money supply are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of the ARIMA (2,1,2).

Table-11.2: Correlogram-Q-statistics of Squared Residual of ARIMA (2,1,2) for M_1

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	0.039	0.039	0.2214	-	7	-0.074	-0.042	7.0376	0.317
2	0.145	0.144	3.3327	0.068	8	-0.093	-0.103	8.3573	0.302
3	-0.091	-0.103	4.5459	0.103	9	-0.019	0.013	8.4116	0.394
4	0.064	0.053	5.1596	0.160	10	-0.023	-0.012	8.4967	0.485
5	-0.083	-0.062	6.1860	0.186	11	0.040	0.031	8.7506	0.556
6	-0.009	-0.029	6.1986	0.287	12	-0.001	0.004	8.7507	0.645

11.2.1.2 Breusch-Godfrey LM Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation of residuals of estimated ARIMA (2,1,1) have been presented through Table-11.3. As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test, the null hypothesis of no serial correlation cannot be rejected. The B-G LM test implies that residuals are not serially correlated. Due to the non-presence of serial correlation, the estimated ARIMA (2,1,1) for M_1 money supply is considered as the consistent model for forecasting.

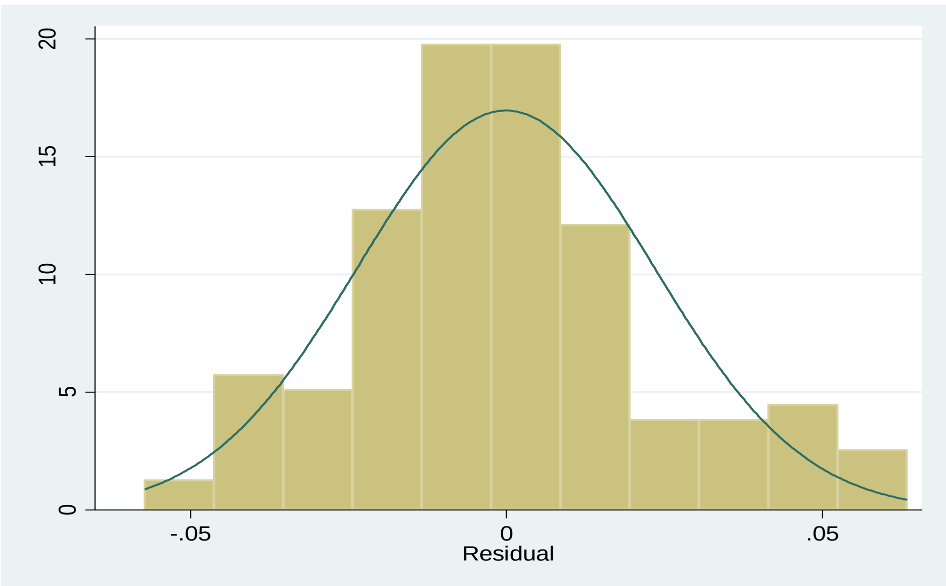
Table-11.3: Breusch-Godfrey Serial Correlation LM Test for M_1

F-statistic	1.380904	Prob. F(2,138)	0.2548
$T \times R^2$	2.804281	Prob. Chi-Square(2)	0.2461

11.2.1.3 Histogram Normality Test of Residuals

Figure-11.1 displays the Histogram Normality test of the residuals of estimated ARIMA (2,1,2) model for M_1 money supply. Bottom of the figure shows the various statistics. The coefficient of Kurtosis is 3.3, which is greater than 3. There is indication of leptokurtic. However, the Jarue-Bera statistic is 3.44, which is not significant as indicated by high value of probability. The null hypothesis of normality of residuals is not rejected. This implies that the residuals of estimated ARIMA (2,1,2) is normally distributed, representing the goodness of fit of the model.

Figure-11.1: Histogram Normality Test of Residuals of ARIMA (2,1,2) for M_1



Mean -7.51e-05 Median -0.0020 Maximum 0.0634 Minimum-0.057264

Standard Deviation 0.023515 Skewness 0.349376 Kurtosis 3.300

Jarque-Bera 3.44803 Probability 0.1783

11.3 ARIMA Model for M_2 Money Supply

Table-11.4 shows the estimations of ARIMA structure of M_1 from different four alternative models. Among these alternative models the ARIMA model (2, 1, 2) can be taken as more appropriate model because all the coefficients are significant at less than one percent level. Values of R^2 and Adjusted R^2 are improved in this model as compared to other ARIMA models. The ARIMA(2,1,1) has minimum AIC and SC as well as D-W statistic is nearly to 2, but the coefficient of MA(1) is significant at only10% level. Likewise, the values of R2 and Adjusted R2 are very less. The ARIMA(1,1,1) and ARIMA(1,1,2) show that the coefficients of AR(1) are not significant. So these two models are not comparable to ARIMA(2,1,2) and ARIMA(2,1,1). Between the ARIMA(2,1,2) and ARIMA(2,1,1), the ARIMA(2,1,2) can be taken as the suitable model for M_2 money supply of forecasting. However, the suitability of this ARIMA(2,1,2) model needs residuals diagnostic tests. After residuals diagnostic tests, it can be claimed that whether or not the ARIMA (2,1,2) model for M_2 money supply is appropriate.

Table-11.4: Estimation of ARIMA Models for M_2

ARIMA (1, 1, 1)

Variable	Coefficient	Std. rror	t-Statistic	Prob.
Constant(α)	0.0571	0.0112	5.0806	0.0000
AR(1)	-0.3238	0.2428	-1.3334	0.1845
MA(1)	0.5257	0.2245	2.3416	0.0206
Akaike info criterion	- 4.1533		R^2	0.0516
Schwarz criterion	-4.0915		Adj.R^2	0.0382
Durbin-Watson stat	2.0818		RSS	0.1270

ARIMA (1, 1, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant(α)	0.0375	0.0041	9.0298	0.0000
AR(1)	0.1278	0.0830	1.5407	0.1256
MA(2)	-0.1821	0.0840	-2.1671	0.0319
Akaike info criterion	-4.1581		R^2	0.0561
Schwarz criterion	-4.0962		Adj. R^2	0.0427
Durbin-Watson stat	1.9257		RSS	0.1264

ARIMA (2, 1, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant(α)	0.0854	0.0044	19.2896	0.0000
AR(2)	-0.9679	0.0224	-43.0250	0.0000
MA(2)	0.8928	0.0477	18.6996	0.0000
Akaike info criterion :-	-4.3398		R^2 :-	0.2111
Schwarz criterion :-	-4.2777		Adj. R^2:-	0.1998
Durbin-Watson stat:-	1.6857		RSS :-	0.1046

ARIMA (2, 1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant(α)	0.0540	0.0045	11.9785	0.0000
AR(2)	-0.2457	0.0803	-3.0578	0.0027
MA(1)	0.1499	0.0843	1.7775	0.0777
Akaike info criterion	-4.1919		R^2	0.0854
Schwarz criterion	-4.1298		Adj. R^2	0.0723
Durbin-Watson stat	1.9820		RSS	0.1213

11.3.1 Residuals Diagnostic Test of ARIMA(2,1,2) Model for M_2

The residuals diagnostic tests of ARIMA(2,1,2) model consists of the following different tests.

11.3.1.1 Correlogram of Squared Residuals

The Correlogram-Q-statistic of the squared residuals of estimated ARIMA (2,1,2) model of M_2 money supply is presented through Table-11.5. The ACFs and PACFs of correlogram of the squared residual are nearly zero at all lags and the Q-statistics at all lags are not significant with large p-values. This indicates that there is no evidence of rejecting the null hypothesis of no serial correlation. This implies that the residuals of the estimated ARIMA (2,1,2) model of M_1 money supply are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of the ARIMA (2,1,2).

Table-11.5: Correlogram-Q-statistics of Squared Residual of ARIMA (2,1,2) for M_2

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.011	-0.011	0.0163	-	7	-0.004	-0.004	0.0448	1.000
2	0.004	0.004	0.0184	0.892	8	0.002	0.002	0.0453	1.000
3	-0.008	-0.008	0.0279	0.986	9	0.010	0.010	0.0600	1.000
4	0.009	0.009	0.0397	0.998	10	-0.004	-0.004	0.0628	1.000
5	-0.000	-0.000	0.0397	1.000	11	-0.002	-0.002	0.0633	1.000
6	-0.004	-0.004	0.0425	1.000	12	-0.003	-0.003	0.0650	1.000

[42]

11.3.1.2 Breusch-Godfrey LM Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation of residuals of estimated ARIMA (2,1,1) have been presented through Table-11.6. As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test, the null hypothesis of no serial correlation cannot be rejected. The B-G LM test implies that residuals are not serially correlated. Due to the non-presence of serial correlation, the estimated ARIMA (2,1,1) for M_2 money supply is considered as the consistent model for forecasting.

Table-11.6: Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.7048	Prob. F(2,138)	0.1856
$T \times R^2$	3.4480	Prob. Chi-quare(2)	0.1783

11.4 Estimated ARIMA Models for M_1 and M_2 Money Supply

From Table-11.1, the suitable estimated ARIMA(2,1,2) mode for M_1 money supply can be recast as:

$$dLnM_{1t} = \alpha + \beta dLnM_{1t-2} + \theta u_{t-2} + \varepsilon_{1t} \quad (11.1)$$

Substituting the values of coefficient gives,

$$dLnM_{1t} = 0.0729 - 0.9770 dLnM_{1t-2} + 0.9862 u_{t-2} + \varepsilon_{1t} \quad (11.2)$$

[42] Since the Histogram Normality of Residuals test did not show the normality of residuals, it is not necessary to mention here. The serial correlation tests are sufficient by correlogram squared of residuals and B-G LM test.

Likewise, from Table-11.4, the suitable estimated ARIMA(2,1,2) mode for M_2 money supply can be recast as:

$$dLnM_{2t} = \gamma + \delta dLnM_{1t-2} + \pi u_{t-2} + \varepsilon_{2t}$$

After substituting the values of coefficient gives,

$$dLnM_{2t} = 0.0854 - 0.9679 dLnM_{1t-2} + 0.8928 u_{t-2} + \varepsilon_{2t} \tag{11.3}$$

Equations (11.2) and (11.3) can be used for forecasting of M_1 money supply and M_2 money supply respectively. Using these two equations we estimate the anticipated M_1 money supply and M_2 money supply.

11.5 Regression of Price Level on Anticipated M_1Money Supply

In order to find the magnitude of relationship between anticipated M_1 money supply and price Level, it is necessary to run the OLS regression with Price Level dependent variable and anticipated M_1 money supply independent variable. The present study has used $dLnCPI_t$ as dependent variable and anticipated part of $dlnM1_t$, represented by AM_{1t} as independent variable.

Now, the regression equation of $dLnCPI_t$ on AM_{1t} is given by:

$$dLnCPI_t = \alpha + \beta AM_{1t} \tag{11.4}$$

The results of the regression ($dLnCPI_t$ on AM_{1t}) have been presented through Table-11.7.

Table-11.7: Regression of $dLnCPI_t$ on AM_{1t}

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	α = 0.0049	0.0055	1.9987	0.0476
AM_{1t}	$\beta =$ 0.4117	0.0526	7.8249	0.0000

$R^2 = 0.2998$ $\bar{R}^2 = 0.2949$ S.E. of Regression $= 0.0221$ D − W statistic $= 2.02$

From the Table-11.7, it is observed that the coefficients of AM_{1t} has positive sign ($\beta =$ 0.4117) and statistically significant at less than 1% level. This clearly confirms that the anticipated part of M_1 money supply affects the price level. A ten percent rise in anticipated part of change in M_1 money supply causes price level to increase by

4.1%. When narrow money supply is expected to rise, the businessmen think that there would be more money at hands of public. Individuals, now are able spend more because of the expansion of money in the society. Thinking so, the businessmen will have the good opportunity to increase price of goods.

The estimated regression equation is robust in the sense that it does not suffer from autocorrelation problem as indicated by $D - W\ statistic\ =\ 2.02 \sim 2$, there is no positive or negative autocorrelation.

The residuals of the estimated regression equation (11.4) are not serially correlated as reported by B-G LM test shown by Table-11.8.

Table-11.8: Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.4184	Prob. F(2,141)	0.2455
$T \times R^2$	2.8597	Prob. Chi-square(2)	0.2393

The F-statistic and $T \times R^2$ value are not statistically significant as reported by corresponding probability and χ^2statistic. So there is no evidence of rejecting the null hypothesis of no serial correlation. Since the residuals are not serially correlated, the estimated regression of price level on anticipated part of M_1 money supply is robust.

Next, we augment anticipated part of M_1 money supply with the regression equation (8.7) in order to find the impact of anticipated part of M_1 money supply along with M_1 money supply on price level. After augmenting the anticipated part of M_1 money supply (AM_{1t}) in to equation (8.7), our new regression equation becomes,

$$dLnCPI_t = \alpha + \beta_0 dLnM_{1t} + \beta_1 dLnM_{1t-1} + \beta_2\, dLnM_{1t-2} + \beta_3\, dLnM_{1t-3} + \gamma AM_{1t} + \varepsilon_t \quad (11.5)$$

The results from regression equation (11.5) are presented through Table-11.9.

Table-11.9: Regression of $dLnCPI_t$ on Lagged $dLnM_{1t}$ Augmented with AM_{1t}

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	α = 0.0019	0.0072	0.2770	0.7821
$dLnM_{1t}$	$\beta_0 - 0.1057$	0.0717	-1.4744	0.1427
$dLnM_{1t-1}$	$\beta_1 = 0.2259$	0.0523	4.3176	0.0000
$dLnM_{1t-2}$	$\beta_2 = 0.0609$	0.0688	0.8856	0.3774
$dLnM_{1t-3}$	$\beta_3 = 0.1074$	0.0523	2.0532	0.0420
AM_{1t}	γ=0.2313	0.1191	1.9406	0.0544

$R^2 = 0.4144\ \overline{R}^2 = 0.3928$ S.E. of Regression $= 0.0200$ D − W statistic $= 2.0572$

From Table-11.9, it is observed that the coefficient of AM_{1t}, γ=0.2313 is positive and significant at 10% level. This implies that, of the total inflation of Nepalese economy, 23.1% is caused by anticipated part of M_1 money supply. The values of $\overline{R}^2$ and S.E. of regression are improved in equation (11.5) than in equation (11.4). The D-W statistic is 2.05$\sim$ 2, implying no autocorrelation problem. However, the impact of anticipated part of M_1 money supply on Nepalese inflation is not so strong due to the reason that the coefficient of AM_{1t} is significant only at 10% level.

Now, our next job is to examine the residuals diagnostic test of equation (11.5). the B-G LM test as the residuals diagnostic test has been performed check the serial correlation. The results from B-G LM test are presented through Table-11.10.

Table-11.10: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.2157	Prob. F(2,134)	0.8062
T×R^2	0.4558	Prob. Chi-Square(2)	0.7962

The F-statistic and T×R^2 value are not statistically significant as reported by corresponding probability and χ^2statistic. So there is no evidence of rejecting the null hypothesis of no serial correlation. Since the residuals are not serially correlated, the estimated regression of price level on anticipated part of M_1 money supply along with M_1 money supply and its lagged terms is robust though the impact of AM_{1t} on $dLnCPI_t$ is not so strong.

11.6 Regression of Price Level on Anticipated M_2 Money Supply

In order to find the magnitude of relationship between anticipated M_2 money supply and price Level, it is necessary to run the OLS regression with Price Level dependent variable and anticipated M_2 money supply independent variable. The present study has used $dLnCPI_t$ as dependent variable and anticipated part of $dlnM1_t$, represented by AM_{2t} as independent variable.

Now, the regression equation of $dLnCPI_t$ on AM_{2t} is given by:

$$dLnCPI_t = \alpha + \beta AM_{2t} \tag{11.6}$$

As we ran regression of $dLnCPI_t$ on AM_{2t} the coefficient of AM_{2t} was found to be negative, which did not hold the rational expectations. So, this regression result is disregarded. Likewise, as AM_{2t} was augmented with lagged $dLnM_{2t}$, again the coefficient of AM_{2t} was negative, which is also not necessary to mention here. Thus, it can be concluded that anticipated part of M_2 money supply has no effect on price level.

It is, therefore, like rational expectation the anticipated part of M_1 money supply has the positive effect on price level and unlike the rational expectation, the anticipated part of M_2 money supply has no positive effect on price level. In policy perspective, only the anticipated part of M_1 money supply should be taken into consideration for the price stability in Nepal.

11.7 Conclusion of Chapter Eleven

Chapter eleven give the following conclusions.

- For M_1 money supply, ARIMA (2,1,2) model is the suitable model for forecasting. As indicated by residuals diagnostic tests, this model does not suffer from autocorrelation and serial correlation problem. The residuals are normally distributed. Hence, this model bears the property of goodness of fit.
- For M_2 money supply also, ARIMA(2,1,2) is the suitable model for foresting. Under this model, although the residuals are not normally distributed, no serial

correlation problem emerges. Hence, this model bears the property of goodness of fit.

- The anticipated part of M_1 money supply causes price level to increase. A ten percent rise in anticipated part of M_1 money supply causes price level to increase by 4.1%, which holds rational expectationists.
- While augmenting the anticipated part of M_1 money supply into the regression of price level on M_1 money supply and its lagged terms, the anticipated part of M_1 money supply causes price level to increase. A ten percent rise in anticipated part of M_1 money supply has caused the price level to increase by 2.31%.
- The residuals of the regression equation with price level as dependent variable and anticipated part of M_1 money supply as regressor are free from serial correlation problem. Similarly, the residuals of regression equation with price level as dependent variable and M_1 money supply and its lagged terms augmented with anticipated part of M_1 money supply as regressor are also free from serial correlation. Hence, both of the regressions bear the property of goodness of fit.
- The anticipated part of M_2 money supply has no role to cause price level to increase.