RELATIONSHIP BETWEEN MONEY SUPPLY AND PRICE LEVEL IN NEPALESE ECONOMY

A Thesis Submitted to the University of North Bengal for the Award of Degree of ***Doctor of Philosophy*** *in* **Economics**

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DECLARATION

As a Ph.D. Scholar of University of North Bengal at Department of Economics, I declare that the thesis entitled ***"RELATIONSHIP BETWEEN MONEY SUPPLY AND PRICE LEVEL IN NEPALESE ECONOMY"*** *has been originally carried out under the supervision of* ***Dr Kanchan Datta (Associate Professor)****, Department of Economics, University of North Bengal; and under the co-supervision of* ***Professor C.K. Mukhopadhyay*** *(Retd) of NBU, India in fulfillment of the requirements for the degree of* ***DOCTOR OF PHILOSOPHY*** *in* ***Economics****. This work is the outcome of my own effort except the explicit references are made to the contributions of other researchers, and this work has not been submitted for any other degree in University of North Bengal and other institutions.*

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CERTIFICATE

This is to certify that the thesis entitled "RELATIONSHIP BETWEEN MONEY SUPPLY AND PRICE LEVEL IN NEPALESE ECONOMY" Submitted to the University Of North Bengal, India for the award of the Degree of Doctor of Philosophy in Economics is a bonafide record of the research work done by Mr. Rajendra Adhikari under my Supervision and Co-Supervision of Prof.(Retd.) C.K. Mukhopadhyay, Department of Economics, NBU. It is also certified that this work has not previously formed the basis for the award to candidate of any Degree, Diploma, Associateship, fellowship or any other similar title and the thesis is an independent and honest work of the candidate. He bears a good moral character.

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ACRONYMS

ACF = Auto Correlation Function

ADB = Asian Development Bank

ADF = Augmented Dickey Fuller

ADO = Asian Development Outlook

AIC = Akaike Information Criterion

AM = Anticipated Money

AR = Auto Regressive

ARCH = Auto Regressive Conditional Heteroscedasticity

ARIMA = Auto Regressive Integrated Moving Average

ARMA = Auto Regressive Moving Average

B-G = Breusch-Godfrey

BIC = Bayesian Information Criterion

BIMSTEC = Bay of Bengal Initiative for Multi-sectoral technical and Economic Cooperation

Cov = Covariance

CPI = Consumer Price Index

CUSUM = Cumulative Sum of Recursive Residuals

D = Differenced

DF = Dickey Fuller

D-W = Durbin-Watson

E = Expectation/Expected

ECT = Error Correction Term

ERS = Elliott, Rothenberg and Stock

FY = Fiscal/Financial year

GARCH = Generalized Auto Regressive Conditional Heteroscedasticity

GDP = Gross Domestic Product

GLS = Generalized Least Square

GNDI = Gross National Disposable Income\

H_0 = Null Hypothesis

H_1 = Alternative Hypothesis

HDR = Human Development Report

H-P = Hodric-Prescott

HQ = Hanan Quinn

I(1) = Integrated of Order One

IMF = International Monetary Fund

IWPI = Indian Wholesale Price Index

J-B – Jarque-Bera

KPSS = Kwiatkowski, Phillips, Schmidt and Shin

LM = Lagrange Multiplier

Ln = Logarithm

M_1 = Narrow Money Supply

M_2 = Broad Money Supply

MA = Moving Average

MW = Mega Watt

NRB = Nepal Rastra Bank

NRs = Nepali Rupees

OLS = Ordinary Least Square

PACF = Partial Auto Correlation Function

PP = Phillips-Perron

Q = Quarter of Year

QTM = Quantity Theory of Money

RBI = Reserve Bank of India

REH = Rational Expectation Hypothesis

RESET = Regression Specification Error Test

SAARC = South Asian Association for Regional Cooperation

SAFTA = South Asian Free Trade agreement

SC = Schwartz Criterion

UNDP = United Nations Development Program

UP = Uttar Pradesh

US $ = United States Dollar

Var = Variance

VAR = Vector Auto Regressive

VEC = Vector Error Correction

VECM = Vector Error Correction Modeling

WB = World Bank

WPI = Wholesale Price Index

CHAPTER ONE

INTRODUCTION

1.1 General Background of Nepalese Economy

Nepal is a small beautiful country with highest mountain, Mt. Everest and with third highest mountain, Kanchanganga in the world. Nepal has a scenic beauty with high prospects of tourism development. Besides, the country is very rich in water resources, mineral resources, and forest resources. It is a culturally and ethnically diverse country which is able to captivate a number of people in the world to visit Nepal for different purposes. Although Nepal is rich in natural resources, it is one of the poorest and least developed countries in the world with very low per-capita income less than $ 400 in 2012 and nearly one-fourth of the population is living below the poverty line[1].

Nepal is the agriculture dominated country, providing a livelihood for three-fourth (3/4) of the population and accounting for a little over one-third of GDP. However, the agriculture system of the country is primitive with rarely professionalized. The agro-industrial activity of Nepal mainly involves the processing of agricultural products like pulses, jute, sugarcane, tobacco, and grain. These agro-industrial activities are more labor intensive that cannot compete with the foreign products in quality as well as prices. Agriculture is the mainstay of the economy resulting little contribution to GDP growth of the economy.

Nepal has substantial potentiality of hydropower, with an estimated 42,000 MW of feasible capacity. However, the political instability of the country could not have attracted the foreign investment in a significant amount. Additional challenges to Nepal's growth include its landlocked geographical location, civil conflict and labor unrest, and its susceptibility to natural disaster[2]. Nepal extends for 500 miles along the Himalayas between 26^0 25’ and 30^0 27’ north latitudes and 80^0 4’ and 88^0 12’ east longitudes. Its northern boundary merges with the Tibet region of the People’s

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[1] World Bank. “World Fact Book (2013)”.

[2] World Bank. “World Fact Book (2013)”.

Republic of China. On the east, it borders with the state of Sikkim and the North Bengal division of India. It touches the Indian states of Uttar Pradesh (U.P.) and Bihar on the southern side and the state of Uttaranchal on the western side of Nepal.[3]

Nepal has very low per capita income as compared to Asian countries. Two giant countries China and India are the closest neighbors in the north and south who are becoming economically very strong and powerful, but Nepal is economically very weak in trade, tourism, industrialization, technology and other various economic spheres. In the current time, there is a great debate about how to restructure the country and make economically prosperous.

So far as the natural physical divisions of Nepal are concerned, these are divided into three parts as northern highlands, middle hills and lower plains. The northern highlands are by nature more isolated and less populated but very rich in scenic beauties. These highlands are extended towards Tibetan range of China. The middle hilly sides are more populated than northern highlands but consisting heterogeneous classes of people. These lands are more fertile as compared to northern highlands. The south plain area is connected with Bihar and UP of India with high density of population. In the point view of agricultural productivities, it is very important part of Nepal that yields more crops due to its fertile nature of land.

The Human Development Report 2013[4] has ranked Nepal 157th, just ahead of Afghanistan (175) among the South Asian countries. Sri Lanka, at the 92nd place, topped the region. However, there is something to cheer for Nepal. The portion of the Nepali population living under multidimensional poverty has come down to 44.2 percent in 2012 from 64.7 percent in 2010, according to the report prepared by the United Nation Development Program (UNDP). The main reasons of the reduction of multidimensional poverty are increased wage rate, remittance and government's efforts to reduce poverty.

Introduced in the HDR in 2010, the multidimensional poverty indicator consists of factors such as poor people's experience of deprivation, including poor health, lack of

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[3] Statistical Year Book of Nepal, various issues.

[4] UNDP, (2013). "Human Development Report, 2013". *United Nations Development Program*.

education, inadequate living standard, lack of income, disempowerment, and poor work quality. The report shows there has also been some improvement in the income Gini-coefficient. Nepal’s income Gini-coefficient in the latest report is 32.8. It was 47.3 two years ago. The HDR 2013 states that child labor is relatively high in Nepal, where more than a third of children in the age group 5-14 are economically active.

Nepal has achieved remarkable growth after it had adopted liberal economic policy since 1990s. There have been economic reforms in the heart areas of the country like industry, trade, foreign investment including foreign direct investment, financial markets and international transactions. This liberal economic policy has been proved successful to foster growth of private sector by minimizing the regulation of the state. The reform and restructuring process in the various economic sectors has been instrumental in making the economy more investment friendly, transparent, market oriented and efficient. As a result, the contribution from the non-agriculture sector reached almost 67 percent from its 49 percent share in early 1990s.

In order to promote its economy and trade further, Nepal presented itself as an active member in the international trade forums. Nepal became a member of the World Trade Organization (WTO) on 23 April 2004. It is a founding member of SAARC and is a party to the South Asian Free Trade Agreement (SAFTA). Similarly, Nepal is also a member of the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC). In 2011, Nepal signed Bilateral Investment Promotion and Protection Agreement (BIPPA) with India for the promotion and protection of investment to expand Indian investment in Nepal. These initiatives have contributed to further widening the country's trade and economic relations. The Trade Treaty between Nepal and India has permitted Nepalese manufactured products to enter the Indian market with no tariff and quantitative restriction, except four items like vegetable ghee, copper products, zinc oxide and acrylic yarn.

Nepal's total foreign trade reached Rs 814.14 billion in 2014/15. The share of export and import in total foreign trade are 11.2% and 88.8% respectively (MOF, 2015). Nepal has trade relations with more than ninety-three countries of the world. Kolkata and Haldia ports are the only sea ports available for Nepal with India for transit. The two countries have agreed to open Vishakapattanam as another point for transit.

However, this point is yet to be operationalized. Dry-port facilities are available in Biratnagar, Birgunj and Kakarbhitta customs[5].

Nepal is geographically as well as economically attached to India. Nepal is industrially backward even if required natural resources are available. The available natural resources are underutilized in the production of industrial goods. Nepalese economy is highly dependent on India for almost all imports and for little exports. Nepal's economic variables are subject to fluctuations resulting from changes its relation with India. Nepal has no direct access to abroad due to its landlockedness situation. The open boarder with India sometimes brings the complications in the relation between these two countries. Nepal has signed different agreement with India, for example BIPPA in 2011 to promote economic relations with India. However, Nepal has not been able to grasp satisfactory benefits economically due to the scarcity of export promotion. Firstly, Nepal has no sufficient industries for export, limited to vegetable fat (vanaspati ghee), noodles, foot wears and some others. Secondly, Nepalese imports are extremely higher than exports leading huge trade deficit every year.

In FY2014, GDP is now expected to exceed the ADO 2013 forecast and grow by 4.5% on the favorable monsoon, restored supplies of chemical fertilizers, and a timely budget. Remittances will sustain expansion in services, but growth in industry will remain constrained by persistent power shortage and long-standing structural bottlenecks, including a distorted labor market, deficient skills, investment lacking in research and development, inadequate infrastructure, and low productivity.

Prices in FY2014 will be under pressure from hikes in administered fuel prices, continued inflation in India transmitted through the currency peg, and higher import prices as the Nepal rupee depreciates. The ADO 2013 Update raises the inflation forecast to 10.5%. The current account balance forecast is greatly improved from the April projection as greater remittance inflows and tourism income offset rising imports. The increase in the number of migrants to the Gulf and higher incentives to remit money as the rupee weakens are expected to accelerate remittance growth greatly in FY2014

[5] http://www.nepalembassy.in/economyataglance.html.

The agricultural domination in Nepal has continued till the present time. Though Nepal is agriculture dominated country, the agricultural sector has no significant contribution to GDP growth due to the dependence of this profession on monsoon and lack of arable land. In FY 2011, the growth of agriculture productivity was 4.1 percent, which increased from 1.3 percent in 2010 as the favorable weather prevailed. The paddy production contributed 17 percent of agriculture value added in 2012 due to the improvement in weather. However, after 2012, the agricultural performance in the national economy remained weak. The reasons behind it are: heterogeneous rainfall, which caused floods in some parts and lack of rainfall in other parts; timely unavailable of fertilizer; and defective seeds (the defective seeds of maize had adverse impact on maize production).

Nepal Economic Update 2011 emphasized that the performance of industrial sector is found to be unsatisfactory, which is of great concern of the economy with reference to economic growth. The growth of industrial sector in FY 2011/12 was found to be 1.4 percent only as compared to overall average growth rate of 1.2 percent of the previous three FYs. In 2011/12, the contribution of industrial sector to GDP was found to be declining to 14 percent from 17 percent of previous ten years. This poor performance was mainly due to lethargic manufacturing sub-sectors that were found growing only by 0.3 percent during the last decade. Another reason of poor performance of the industrial sector was the negative growth of 0.3 percent. Additionally, the other responsible factors causing the poor industrial performance were the electricity, gas and water sub-sector which declined by 4 percent in FY 2010/11. The remittance inflow was softer; whereas there was tight credit situation and low budgetary spending. The new monetary policy to regulate the commercial banks to postpone investment in real estate also hampered the construction industries in the country.

Nepal has the great challenge of underdeveloped infrastructure facilities. This problem has weakened the public investment program of government and the administrative services on behalf of government have proven to be ineffective. Every economic plans of Nepal aim to improve the infrastructure but the improvement of it is not found to be satisfactory so as to accelerate economic growth. Nepalese economy is agriculture dominated economy with large number of unskilled labor force, yielding low level of GDP. This low level of GDP undoubtedly has caused low economic growth in the country. Government of Nepal is launching various developmental and economic programs via deficit financing. But this deficit financing has caused the deficit in current account bringing the adverse impact on balance of payment situation.

1.2 Nepalese Macroeconomic Scenario[6]

1.2.1 Performance of Nepalese Economy in Terms of Economic Growth

The growth rate of real GDP at basic price of 2000/01 was 3.8 % in 2002/03. It increased to 4.4 % in 2003/04, but declined to 3.2 % in 2004/05. There was little improvement in the economy and the real GDP was increased to 3.7 % in 2005/06. The fiscal year 2006/07 was not favorable with heavy decline in real GDP to 2.8 %. However, this growth stood up to 5.8 % in 2007/08, the highest growth rate after 2001/02. In 2008/09, it sharply declined to 3.9 % and increased to 4.3 % in 2009/10, but again declined to 3.9 % in 2010/11. In 2011/12, it increased to 4.6 % but again declined to 3.5 % in 2012/13. The growth rate of real GDP was estimated to increase to 5.2 % in 20013/14. These figures clearly indicate that Nepal’s real GDP growth rate is fluctuating and very low, unable to mitigate with various macroeconomic bottlenecks like high rate of inflation, high population, high rate of unemployment, low rate of capital formation etc.

There are three main contributing components of GDP: agriculture sector, industry and service sector. The growth rate of agriculture real GDP was 3.1 % in 2002/03. It declined to 1.0 % in 2006/07. However, in 2007/08, it sharply increased to 5.8 %. Thereafter, it declined to 3.0 % and 2.0 % in 2008/09 and 2009/10 respectively. However, in 2010/11 2011/12 it increased to 4.5 % and 4.6 % respectively. In the year 2012/13, the agricultural sector remained unfavorable causing growth rate to decline to 1.1 % due to unfavorable monsoon in Nepal.

The industrial sector also showed fluctuating and unsatisfactory growth in real GDP. The year 2008/09 was extremely unfavorable with negative growth – 0.6 %. It dramatically increased to 4.0 % and 4.3 % in 2009/10 and 2010/11 respectively. Thereafter, it continued to decline. The service sector showed relatively better

[6] The data used in the analysis are taken from Economic Survey, MOF, Nepal (Various Issues).

performance with highest growth rate 7.3 % in 2007/08. Fiscal Years 2003/04 and 2010/11 showed the lowest growth rate as 3.3 % and 3.4 % respectively.

The Per Capita National Income at constant price of 2000/01 are also fluctuated and remained very low during 2002/03-2012/13. FY 2006/07 represented the highest growth rate of PCI as 6.9 %. The succeeding fiscal years have proven the unsatisfactory growth rate of PCI; and it remained 2.9 % only in 2012/13 and it was estimated to remain 5.4 % in 2013/14. The per capita gross national income continued to increase from $ 261 to $ 713 from 2002/03 to 2012/13. The PCI was estimated to remain $ 717 in 2013/14. The real GDP at basic price of 2000/01 was 429.7 billion. It remained RS 565.8 billion in 2009/10 and increased to Rs 635.9 billion in 2012/13 and was estimated to remain Rs 668.7 billion in 2013/14. The per capita GNI at basic price of 2000/01 was Rs 24152 in 2009/10. It remained Rs 26326 in 2012/13 and was estimated to remain Rs 27762 in 2013/14.

1.2.2 Performance of Nepalese Economy in Terms of Consumption, Saving and Capital Formation with Population

The ratio of gross consumption to GDP was 91.4 % in 2002/03, reduced to 88.3 % in 2003/04 and 88.4 % in 2004/05. It increased to 91.0 %, 90.2 %, 90.2 %, and 90.6 % in 2005/06, 2006/07, 2007/08 and 2008/09 respectively. The ratio of gross consumption to GDP reduced to 88.6 %, 86.0 %, 89.0 % and 89.9 in 2009/0, 2010/11, 2011/12 and 2012/13 respectively. It was estimated to remain 91.1 % in 2013/14.

The ratio of gross saving to GDP was 8.6 % in 2002/03. It increased to 11.8 % and 11.6 % in 2003/04 and 2004/05 respectively. Thereafter, it reduced to 9.4 % in 2008/09. It increased to 11.4 %, 14.0 %, 11.0 % and 10.1 % in 2009/10, 2010/11, 2011/12 and 2012/13 respectively. It was estimated to remain 8.9 %in 2013/14.

The ratio of gross fixed capital to GDP was 19.9 % in 2002/03. Thereafter, it slightly fluctuated and increased to 22.2 % in 2009/10. It further increased to 22.6 % in 2012/13 and was estimated to remain 23.1 % in 2013/14. The ratio of gross capital formation to GDP was 21.4 % in 2002/03. It continued to increase and remained 38.3 % in 2009/10. It fluctuated and declined to 36.9 % in 2012/13 and was estimated to remain 37.1 % in 2013/14.

The gap between gross domestic saving and gross investment was -12.8 % and it continued to increase and remained -26.8 % in 2009/10. Thereafter, it reduced till 2011/12 and increased to -26.8 % in 2012/13 and was estimated to remain -28.2 % in 2013/14.

Total population of Nepal was 23.8 million in 2002/03 and continued to increase and remain 26.3 million in 2009/10. It again increased to 26.9 million in 2011/12 and 27.2 million in 2012/13. It was estimated to remain 27.6 million in 2013/14.

1.2.3 Inflation Scenario in Nepal

The inflation rate is measured by price index and GDP deflator. The growth rate of Consumer Price Index (CPI) was 4.7 % in 2002/03 and it jumped to 8.0 % 2005/06 and converted to double digit, 12.6 % in 2008/09. After this period, it remained around 10.0 % in 2012/13. It was estimated to reduce to 9.0 % in 2013/14. The GDP deflator continued to increase from 3.1 % to 7.3 % during 2002/03-2006/07. It reduced to 5.6 % in 2007/08 but increased by three-fold to 16.1 % in 2008/09. It remained double digit in 2009/10 and 2010/11 as 14.4 % and 11.0 % respectively. Thereafter, it reduced and remained 6.2 % in 2012/13 and estimated to remain 7.9 % in 2013/14. The wholesale price index continued to increase and remained 12.6 % in 2009/10. It declined to single digit and remained 9.0 % in 2012/13 and was estimated to remain 8.1 % in 2013/14. The salary and wage rate index was 3.9 % in 2005/06. It converted to double digit (15.3 %) in 2008/09. After this period, it continued to increase and remained 27.4 % in 2011/12, but declined to 9.3 % in 2012/13 and was estimated to remain 13.1 % in 2013/14.

1.2.4 Scenario of Public Finance in Nepal

Government revenue was increased by 11.5 % in 2002/03 and it reduced to 10.9 % in 2003/04, but increased to 12.5 % in 2004/05. In 2005/06, the annual growth rate of government revenue reduced to 3.0 %. After this, it continued to increase as 21.3 %, 22.7 % and 33.3 % in 2006/07, 2007/08 and 2008/09 respectively. After 2008/09, it reduced to 27.2 %, 11.4 %, 23.2 % and 21.1 % in 2009/10, 2010/11 and 2012/13 respectively. Government revenue was estimated to increase by 19.8 % only in 2013/14.

The annual growth rate of total government expenditure was 4.9 % in 2002/03 and increased to 6.5 % and 14.7 % in 2003/04 and 2004/05 respectively. However, it reduced to 8.1 % in 2005/06. Thereafter, it continued to increase and remained 36.1 % in 2008/09. After this period, it continued to decline and remained 5.7 % in 2012/13 and was estimated to remain 25.4 % in 2013/14.

The share of government revenue in GDP was 11.4 % in 2002/03. It continued to increase and remained 14.9 % in 2009/10 and 17.5 % in 2012/13. It was estimated to remain 18.4 % in 2013/14. The share of total government expenditure in GDP was 17.1 % in 2002/03. It slightly increased with fluctuation and remained 21.8 % in 2009/10. It remained 21.2 % in 2012/13 and was estimated to remain 23.3 % in 2013/14.

1.3 Monetary Background of Nepal with Reference to Banking and Financial Institutions

So far as the monetary system is concerned, Nepalese economy consists of rural area and urban area. Urban area is, no doubt, exercises monetized system. All the banking and financial institutions are concentrated in urban areas. The urban areas comprise large number of industries and trading agencies. So, in these areas there is well use and strong practice of money. On the other hand, the rural areas are deprived of banking, financial and trading agencies. Majority of the people of these areas are at subsistence level and they can save rarely from their agricultural occupation. Still, there is practice of barter system in many remote rural areas. But, even in rural areas, people with surplus in their agriculture exercise the monetary system.

Nepal Bank Limited, the first commercial bank of Nepal, was established in 1937 with 51% shares at government level and rest at public level. The operation system of this bank was solely controlled by government. With establishment of Nepal Bank Limited, some branches were also established in different parts of the country. Besides, other government banking institutions such as National Commercial Bank and Land Reform Savings Corporation owned by state were also established in 1966. The former was dealing banking services; whereas later was dealing finance related to land reforms in Nepal.

Two other specialized financial institutions such as Nepal Industrial Development Corporation and Co-operative Bank, which became the Agricultural Development Bank in 1967, were the state-owned development finance organizations. Nepal Industrial Development Corporations was established in 1959 with US assistance to offer financial and technical assistance to private industry. Nepal Industrial Development Corporation was controlled by Board of Directors formed including the private business sector. The Co-operative bank converted to Agricultural Development Bank in 1967, was the main source of finance to petty agribusiness and cooperatives, small farmers' group development projects supported by Asian Development Program

Three foreign commercial banks were established in Nepal in the mid-1980s. NABL bank was co-owned by Government of Nepal and Emirates Bank International Limited of Dubai and some Nepalese people. The second foreign bank was Nepal Indosuez Bank and it was jointly owned by French Banque Indosuez, National Commercial Bank of Nepal and Nepal Insurance Corporation and Nepalese people. The third foreign bank established during mid-1980s was Nepal Grindlays Bank which was co-owned by Grindlays Bank of Britain, local financial institutions of Nepal and Nepalese public.

Nepal Rastra Bank, the central bank of Nepal was established in 1956. It's the then functions were to supervise commercial banks and to guide the basic monetary policy required for the nation. Later on, its functions were increased in accordance with the major aims such as (1) regulating the issue of paper money (2) securing countrywide circulation of Nepalese currency and achieving stability in its exchange rates (3) mobilizing capital for economic development and for trade and industry growth (4) developing the banking system in the country and thereby (5) ensuring the existence of banking facilities and maintaining the economic interests of the general public in Nepal. Besides, Nepal Rastra Bank had also to supervise foreign exchange rates and maintain foreign exchange reserves.

Prior to the establishment of Nepal Rastra Bank, Indian currencies were the prevalent medium of exchange in the country. However, after the establishment of Nepal Rastra Bank, Nepalese currencies are being used all over the country as the medium of exchange.

Nepal Rastra Bank along with commercial banks and different financial institutions are now supplying the necessary money required to individuals and institutions in the country. Two types of money supply are in practice in Nepal: narrow money (M_1) and broad money (M_2). The narrow money (M_1) consists of currency in circulation plus demand deposits, where as broad money (M_2) includes M_1 money plus time deposits or quasi money.

As reported by Economic Survey 2012/13[7], the narrow money supply grew by 8.6% in FY 2002/03. It increased to 12.2% in 2003/04, but reduced to 6.6% in 2004/05. The growth rate of narrow money supply increased to 14.2% in FY 2005/06. In FY 2007/08, it increased to 21.6% and reached to 27.3% in 2008/09. Thereafter, it continued to fall and remained 18.5% in FY 2011/12.

Likewise, the annual growth rate of broad money supply was 9.8% and 12.8% in the FYs 2002/03 and 2003/04 respectively. In FY 2004/05, it reduced to 8.3%. However, it increased to 15.4% in 2005/06 and slightly reduced to 14% in 2006/07. In FY 2007/08, it increased to 25.2% and 27.3% in 2008/09. And it followed decreasing trend in 2009/10 and 2010/11. In FY 2011/12, the growth rate of broad money supply remained 22.7%. While comparing the growth figures between narrow money supply and broad money supply, the broad money supply is found to be relatively higher.

The ratio of narrow money supply to GDP was 17% in 2002/03 and slightly increased to 17.5% in 2003/04. It remained 17% in 2004/05. The FY 2005/06 experienced narrow money supply to GDP ratio as 17.3% and increased to 18.9% and 19.9% in 2007/08 and 2008/09 respectively. The FY 2009/10 and 2010/11 experienced narrow money supply to GDP ratio as 17.8% and 16.2% respectively and it remained 17.2% in 2011/12.

On the other hand, the ratio of broad money supply to GDP was 50% in 2002/03. It continued to rise to 53% in 2005/06; 54.3% in 2006/07; 60.7% in 2007/08; 63.8% in 2008/09; 68.8% in 2009/10 and it slightly reduced to 67.1% in 2010/11 and increased to 73.6% in 2011/12.

[7] Economic Survey of Nepal (2012/13)

1.4 Overview of Price and Inflationary Situation of Nepalese Economy[8]

Measurement of prices in Nepal began from 1973 using the expenditure weightage of the goods and services of the people obtained from first Household Budget Survey (HSB). Prior to that, equal weights were assigned for each and every commodity of the basket.

Economic Survey 2012/13 states that prior to fiscal year 2005/06 or between FY 2000/01 and 2004/05, the Consumer Price Index (CPI) based annual inflation rates were 2.5, 2.9, 4.7, 4.0 and 4.5 percent respectively while the CPI-based annual inflation rate stood at 8.7 percent between the FY 2005/06 and FY 2011/12. In the first eight months of the fiscal year 2012/13, the point to point based inflation rate of food and beverage group remained at 11.3 percent while that of non-food and service group stood at 9.3 percent. The price indices of these groups had increased by 4.2 percent and 9.4 percent during the same period of the previous year.

For the last few years both internal and external factors have been influencing the price rise. Internal factors that have adverse impact on productive activities and supply situation are low agricultural production and productivity, higher imports of agricultural commodities, frequent closures, strikes, load shedding and political instability while price hike in petroleum products and the effect of high food price inflation observed in India are the major external factors. Additionally, open border between Nepal and India, pegging of Nepal's foreign exchange rate with Indian currency, and almost two third shares of Nepal’s total trade transactions with India can be mainly attributed to the direct impact of Indian inflation on Nepal (Economic Survey, 2012/13).

The inflation rate in Nepal was recorded at 9.47 percent in April of 2014. Inflation Rate in Nepal averaged 8.38 Percent from 1964 until 2014, reaching an all time high of 30.42 Percent in May of 1966 and a record low of -11.54 Percent in May of 1967. Inflation Rate in Nepal is reported by the Nepal Rastra Bank.

[8] The presented data are taken from Economic Survey and Nepal Rastra Bank (Economic Bulletin: Various Issues)

[9]*Nepalese inflation was moderate to 8.3% in FY 2012, which was reducing from 9.6% in 2011. However, it climbed to 9.9% in 2013, higher than targeted 9.5% by monetary policy 2013. The CPI inflation remained above 10% till December 2012 and declined to 9.8% in January 2013. Overall inflation was found to be higher in all months of 2013. These all data represent that Nepalese inflation is not tolerable as compared with low economic growth. This high inflation rate had adverse impact on all economic activities during these periods.*

Overall food and non-food inflation was found to be increased in 2013. The food and beverages inflation rate was 7.7% in 2012, and it increased to 9.7% in 2013. On the other hand, the non-food inflation in 2012 was 9% in 2012, and it increased to 10.1% in 2013 (same inflation was 5.4% in 2011). The rise in food price was caused by the factors like low agricultural harvest, rise in transportation cost of food, and higher import prices of agriculture products along with increased price of fertilizer, seeds and insecticides imported from India. The high non-food prices were due to increase in import prices and domestic currency depreciation in relation to US dollars. Not only these factors are responsible for high inflation in Nepal, but also other factors like domestic structural bottlenecks and supply-side constraints. Under structural bottlenecks, the factors like lack of skilled human resources, weak backward and forward linkage, lack of research and development, deficiency in investment, pressures of trade unions to increase wage without increasing labor productivity, policy inconsistencies and so on are found playing dominant role. Supply side constraints include the factors like transportation constraints, electricity deficiency, shortage of raw materials, high import price of inputs, political movements (strikes and agitations) and others.

1.5 Statement of the Problem

Nepalese economy has been bearing the problem of more or less double digit inflation since 2007. Other neighboring countries like India and China are enjoying double digit economic growth. However, Nepal is suffering from the problem of double digit

[9] ADB, 2013 (Posted by Chandan Sapkota): http://sapkotac.blogspot.com/2013/09/nepalese-economy-in-fy2013-monetary.html

inflation, which has made economy severe ill. This high growth of inflation has caused the economy adversely from different spheres.

Due to the higher inflation, there is rapid fall in value of Nepalese currency. Central bank of Nepal, Nepal Rastra Bank is compelled to pay very high price to gain foreign currency like US dollar, Euro dollar, Pound Sterling and other foreign currencies. Interests for foreign loans are increasing day by day. The per capita amount of loans for Nepalese people has reached to nearly NRs 19,000. By the similar fashion, the balance of payments situation for the economy of Nepal is also adverse that imports are extremely higher than exports.

Nepal is to depend on India for petroleum products. The price of petroleum product is mounting in the international market. As price of oil in international market increases, a higher amount of money should be paid to Indian Oil Corporation with decreasing value of currency due to the inflationary pressure in Nepal. The increases in price of petroleum products have multiple effects on Nepalese economy adversely at micro and macro level. The rise in price of oil automatically causes transportation costs to rise, which in turn, causes price of food and non-food items to increase.

The inflation in Nepal has invited artificial as well as natural scarcity of commodities. Majority of the intellectuals have accused that corruption has been institutionalized from government side as a result of inflation. Additionally, different types of criminal activities and social crimes like murdering for money, theft and dacoit, involuntary and forceful donation, kidnapping etc have become common and uncontrolled in Nepal.

Besides, income inequality in Nepalese society has become widespread due to the higher inflation. Minorities of the people are getting rich, but majority of the people are getting economically worse and they are deprived of even basic needs. These all social and economic evils are claimed to be the outcomes of rapidly rising price level in the economy of Nepal.

In Nepal, different factors are responsible to cause inflation. Excess money supply, political instability, growing population, increasing remittance, shortage of commodities, lack of good governance, rise in oil price, lack of sufficient electricity, slow pace of industrialization, less investment and capital formation, unfavorable balance of payment situations, increasing expenditure in unproductive activities etc are the dominant factors causing inflationary pressure in Nepalese economy. Broadly speaking, Nepalese inflation is caused mainly by two factors: monetary factors and non-monetary/institutional factors. Over money supply along with the increasing remittance are monetary factors and other factors mentioned above are institutional factors.

Nepal was suffering a long spell of double digit inflation during 2008-2012 periods despite the decline in consumer prices across the globe. Even at present time, Nepalese inflation is nearly double digit. The Financial Stability Report of NRB (2014)[10] highlights that the year-on-year inflation, as measured by the consumer price index (CPI), increased by 9.7 percent in mid-Jan 2014 compared to 9.8 percent in the corresponding month of the previous year. The price index of food and beverages group increased by 12.9 percent whereas the index of non-food and services group increased by 6.9 percent. The indices of food and beverages and non food and services had increased by 9.6 percent and 10.2 percent in the same period of respectively in 2012/13.

Nepal's economic growth is slow and, unlike the global trend, inflation has reduced from double digit to single digit but the inflation in food items is still of double digit. The GDP growth of Nepalese economy in 2012/13 was below 4%, where as the neighboring countries like India and China were enjoying above 8% economic growth. There are different reasons for slow economic growth of Nepal like stoppage of vehicular movements, closures of business, industries coupled with the power shortage. These activities have caused falling output and rising prices in Nepal.

Furthermore, the political transition and the policy instability along with the disturbance in implementation of policies have made the economic development process very slow, inefficient and ineffective. The less priority to the concerned output generators relating to economic management have also increased the weaknesses and vulnerabilities in the economy. With unsatisfactory socio-economic development indicators, including very low level of per capita income and highly

[10] Nepal Rastra Bank (2014). "Financial Stability Report".

skewed distribution of income and access to opportunities have caused very slow economic development in Nepal.

Macroeconomic management in a situation of slower economic growth and higher inflation remains a challenging task. Raising the aggregate demand would be an important policy option to address the slow economic development. However, due to high inflation, any attempt at raising the output via increasing aggregate demand could put further pressure on prices.

Likewise, the monetary measures aimed at controlling the over money supply could reduce the inflation. So there is a need for improving monetary policy with the help of credit contraction, increasing reserve ratio of commercial banks, increasing bank rates, open market operation and other monetary measures.

The government's potential role in improving the supply management and ensuring price stability should be transformed into meaningful outcomes. The government and political parties should support and escort in a sound policy environment, encourage the smooth flow of economic activities, discourage non-competitive market behavior and refrain from adding unnecessary costs to the economy, thereby ceasing to act as a watchdog of inflation and slow output in Nepal.

The present study is mainly associated with the exploration of the relationship between money supply and price level in the economy of Nepal aiming at giving the answer the following main research questions.

- Which model for forecasting of Nepalese inflation is suitable?
- Is Nepalese inflation caused by inflow of remittance along with the population growth and political instability?
- Do the money supplies affect price level in Nepal? If yes, then at what extent money supplies affect Nepalese price level?
- Does the relationship between money supply and price level hold *Quantity Theory of Money* in Nepal?
- Is there any short run or long run relationship between money supply and price level in Nepal?
- Is the relationship between money supply and price level robust and stable?

1.6 Importance of the Study

From the national data of inflation, it is observed that Nepalese general price level is rising at a higher rate in every month without delay. Due to the higher inflation, the economy is affected adversely at micro as well as macro level. The rise in price arises by different factors, of which the present study is confined in analyzing the role of money supply to cause inflation in the economy of Nepal. The present study is the empirical analysis on the relationship between money supply and price level in the spirit of *Quantity Theory of Money*. The present study aims at providing the guidelines to policy makers to formulate suitable policy in stabilizing the price in Nepal.

From the policy makers point of view two important aspects are of particular interest. The first aspect is the time it takes for changes in the rate of money growth to work through to the rate of inflation which is long and variable. The second aspect is the market short-run impact of changes in money growth on real variables such as income and employment. These two aspects have important implications for monetary policy.

Since the monetary policy of Nepal has the single objective of price stability in the country. If there is quick response of inflation to a monetary change, it will be fruitful to take a short time anti-inflationary monetary policy to mitigate with the inflation. The monetarists can formulate the policies accordingly so as to control inflation immediately. On the other hand, if there is a slow response of inflation to a monetary change, it is necessary to take a long-time anti-inflationary monetary policy to formulate. In such a situation, quick monetary remedies for inflation do not exist.

According to quantity theorists, the appropriate way for the monetary authority to achieve price stability and avoid economic disturbances is that discretionary policy should be abandoned in favor of a rigid rule whereby the money supply grows at steady figure roughly corresponding to the long-term growth of real output.

The empirical issue of the relationship between money supply and price level is very important for Nepalese monetary authority. The monetary authority can formulate the short-time or long-time monetary policy as an anti-inflationary policy to mitigate with the inflationary pressure in accordance with the findings of the present study. Additionally, the present study would be fruitful to amend the current NRB act setting new objectives to facilitate in formulating further strong monetary policy to stabilize the price in accordance with the findings of the present study.

Next, if the present study bears of strong association between money supply and price level, then the price stability can be taken as the most important tool for monetary policy objectives. Finally, the present study becomes fruitful to the monetary authority to bring the long-term monetary vision, mission and goal since the present study has used the long-term quarterly data on money supply and price level.

The present study would be fruitful in the sense that it would bridge the research gaps associated with the relationship between money supply and price level in the economy of Nepal on the following grounds.

- The present study examines the impact of remittance along with population growth and political instability on price level. The impact of remittance on price is rarely found in economic literature. In this context, the present study bridges the research gap of dependence of price on remittance.
- Observing the economic literature on the relationship between money supply and price level in international context, the present study is not new one. However, it is a cornerstone to Nepalese context that this study analyzes the empirical relationship between money supply and price level intensively applying modern econometric tools. The tools used in the present study bear the robust relationship between the variables under study.
- Many researchers have explored the relationship between money supply and price level applying the econometric tools, but these studies do not include the diagnostic tests of the employed tools. Without diagnostic tests, the relationship between the variables may or may not be robust. However, the present study confirms the robustness of the relationship between money supply and price level through diagnostic test.
- No generalization is made on the basis of single test, but the association between money supply and price level is generalized with the help of different tests.

1.7 Objectives of the Study

The present study tries to empirically test the *Quantity Theory of Money* developed by different economists ranging from classical period to modern era and verify that which theory is applicable in developing countries like Nepal. The effectiveness of the relationship between money supply and price level is tested applying various modern econometric tools and models. The general objective of this study is to explore and examine the state of relationship between money supply and price level in the economy of Nepal in the line of *Quantity Theory of Money*. In order to achieve the general objective, the present study has set the following specific objectives.

The specific objectives of the present study are to:

(i) Identify the suitable model of inflation forecasting in Nepal.

(ii) Examine the impact of remittance on inflation.

(iii) Examine the relationship between money supply and price level and extent of relationship employing the autoregressive distributed lag models.

(iv) Analyze the relationship between money supply and price level in short run and long run employing cointegration test, vector error correction models

(v) Examine the Granger causality between the variables.

(vi) Explore the relationship between the variables using the technique of VAR, IRF and variance decomposition.

(vii) Examine the robustness of the relationship between the variables through diagnostic and stability tests.

(viii) Examine the impact anticipated money supply on price level.

1.8 Hypothesis

The following hypotheses have been set in order to study the relationship between money supply and price level in the economy of Nepal.

(a) Remittance affects inflation to occur in Nepal.

(b) Money supply affects inflation in Nepal.

(c) There is direct but non-proportional relationship between money supply and price level.

1.9 Limitations of the Study

The following are the limitations of the present study.

(a) Present study does not study the relationship between money supply and price level prior to 1976.

(b) Due to the non-availability of quarterly data on remittance, the present study analyzes the relationship between remittance and inflation using the annual data sets.

(c) This study analyzes only the relationship between money supply and price level as well as remittance along with population growth and political instability and price level. Study of other determinants of inflation except aforementioned variables is left for future research.

1.10 Scope for Future Research

A number of factors are responsible to cause inflation in Nepal. However, the present study is confined to analyzing the role of money supply, remittance along with population growth and political instability; and anticipated money supply causing inflation. The present study would be beneficial to the interested researchers in the future to identify other factors causing inflation in Nepal as well as other economies. Very new and sophisticated econometric tools are being developed to analyze the relationship between and among the variables. The present study would be fruitful to utilize those econometric tools that are not employed by the present study. Additionally, the present study would be helpful to identify the limitations of the tools used in the present study.

Besides, the future researchers would be benefitted to bridge the research gaps associated with money-price relationship as well as the relationship between and among other variables in micro and macro levels. The future researchers of different fields like economics, commerce and science would understand the tools and techniques used in the present study and employ in their research works within short time.

1.11 Plan of the Study

The present study consists of altogether twelve chapters. CHAPTER TWO is devoted to Literature Review incorporating some theoretical and empirical analysis of previous studies. CHAPTER THREE endeavors Research Methodology adopted in the present work. CHAPTER FOUR analyzes the Forecasting of Inflation in Nepal employing the methodology of ARMA/ARIMA models and ARCH/GARCH models. While, CHAPTER FIVE analyzes the Impact of Remittance along with Population Growth and Political Instability on Inflation of Nepalese economy. CHAPTER SIX is devoted to Unit Root Test of money supply and price level. CHAPTER SEVEN seeks to analyze the relationship between money supply and price level using the techniques of Johansen's Cointegration Test, VECM and Granger Causality Test.

CHAPTER EIGHT utilizes the Distributed lag Models to analyze the relationship between money Supply and price level. CHAPTER NINE employs the technique of VAR of forecasting to examine the money-price relationship. CHAPTER TEN analyzes the money supply and price relationship using the techniques of Impulse Response Function and Variance Decomposition. CHAPTER ELEVEN studies the money supply with Invariance Proposition of Rational Expectations. And, CHAPTER TWELVE is devoted to Conclusions, Recommendations and Policy Implications based on the present study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The relationship between money supply and price level is very influential topic in the field of macroeconomic literature, which has received greater attention among government agencies, policy makers and researchers. This topic has been continuously discussed in the economic society since 16th century. The general price level of every economy is being continuously reported to be high from 16th century to present 21st century except some years. These higher price levels compelled the economists to carry out the study on whether over money supply are responsible to cause inflation or there are any other reasons responsible for high price or inflation. The economists have spent a lot of time in finding the causes of higher prices in the economy and reached the conclusion that higher prices are caused by different factors like over money supply, higher income, high wage rate, scarcity of commodities, increase in cost of production, international reasons, institutional factors etc. However, unnecessary and over money supply has been taken as the influential factor responsible to cause inflation or higher price in the economy by most of the economists in the world.

Any economy should bear the high social and economic cost of inflation as there is no price stability. Over the past two decades, the policy makers are much worried with the instability of prices keeping in mind of the negative influences of rising price level in the economy. Since inflation is the virus of economy causing lower economic growth and high social and economic cost, it is necessary to identify the causes of inflation and mitigate with it. Many researchers have identified different factors causing higher price level, of which more money supply than what it is required is regarded as the major responsible factor.

Beck and Wieland (2010) opine as

"The notion that inflation is a monetary phenomenon is a central tenet of monetary economics. It implies that inflation is ultimately a consequence of monetary policy,

and the same conclusion is applied to deflation. This view is usually motivated by the quantity theory. The quantity theory states that sustained increases or decreases in the overall price level occur along with faster or slower growth rates of monetary aggregates adjusted for long-run output and velocity trends. On the basis of this theory, central banks have at times assigned an important role to monetary aggregates in the formulation of monetary policy".

Pinga and Nelson (2001) put their view that a strong positive linkage between change in money supply and aggregate price level occurs. This view supports the version of Quantity Theorists. However, it is controversial with Structuralists. According to Quantity Theorists, inflation mainly arises due to the change in money supply. But Structuralists argue that inflation arises as a consequence of poor economic growth with institutional factors like low agricultural productivity and unfavorably foreign trade situation. The central bank and government take expansion of credit and fiscal deficit as the remedial measures of inflation, which in turn, invites inflation in an economy. Thus Pinga and Nelson conclude that inflation is a monetary matter rather than structural phenomena.

The money supply and price level are found to be functionally related since the economic history and this relationship between these two macroeconomic variables have been found to have been explained in the form of Quantity Theory of Money since 16^{th} century. The quantity theory of money is one of the oldest but still existing economic thoughts, which emphasizes that changes in the general prices are determined first and foremost by changes in the quantity of money in circulation. The quantity theory of money has contributed in forming the central core of nineteenth century monetary analysis to provide dominant theoretical structure in the contemporary financial events. Taking into account the adverse impacts of inflation on the economy, there is a compromise among the world's leading central banks that the price stability is the most important single objective of monetary policy [King (1999); Blejer, et al. (2000)] and the central banks are committed to maintain low inflation. [Qayyum (2006)].

2.2 Conceptual Framework of Quantity Theory of Money

A number of frameworks have been introduced by the economists regarding the concept of Quantity Theory of Money. Ajuzie Immanuel, et.al. (2008) opines as *"The concept of the Quantity Theory of Money (QTM) was introduced in the economic theory in the 16th century. Jean Boldin in his book reprinted in 1924 argued that the reasons for the rise in French prices were abundance of gold and silver, monopolies, scarcity, the pleasure of princes, and devaluation of the currency. He asserted that prices had increased higher than they were fifty years back in France. He was primarily interested in determining the causes of the price rise in France. According to Boldin, gold and silver were used as currency in France and due to the over use of such items prices had increased. It was one of the first statements that linked price movement to movements in money stock (Klein, 1970). He noted that the increase in the supply of gold and silver used as money caused an increase in demand for French goods, resulting in the increase of prices at home abroad. In the 1690s, John Locke developed monetary theory and elaborated the discussion by examining the effects of money on trade, the role of the demand for money, and the importance of interest rate on the economy. He believed that money is a medium of exchange in trade (Klein, 1970) and that the amount needed depended on the "quickness of circulation", which we today refer to as "velocity" of circulation. He went on to define interest as the price for the hire of money, noting that the level of money depended on the relationship between demand and supply of money. Thus, when demand for money exceeded the supply, interest rate was higher and vice versa".*

Law (1705) argued that trade of a country is determined by money. If the country has more money, it can create full employment. He further added that as the country has more credit money in circulation, more people can get employment as opined by Law (1705). When the economy is experiencing below full employment, the expansion of size of circulation in required amount of money surely would help to induce full employment in the economy. (Klein, 1970)

The analysis of Law (1705) as mentioned by Klein (1970) has established the positive link between employment and amount of money in circulation comprising of metallic and bank money in the economy. This clearly emphasized that money in required quantity matters the real variables like employment and trade in the economy.

Cantillon (1755) was another 18^{th} century economists who also argued that increase in money causes the price to increase. He opines as *"All this money, whether lent or spent, will enter into circulation and will not fail to raise the price of products and merchandise in all the channels of circulation which it enters. Increased money will bring about increased expenditure and this will cause an increase of market prices in the highest years of exchange and gradually in the lowest".* Thus, Cantillon concludes that an increase in quantity of money raises prices through its effect on demand.

Likewise, the nineteenth century economists like Thornton, Ricardo and Mill gave a number of contributions in the field of monetary theory. Thornton (1802) concluded that more money resulted more inflation but there is no guarantee that increase in money causes output to rise. This argument emphasized that increase in money supply causes to increase merely the price level. Obviously, more money supply causes inflation but no guarantee of increasing output in the economy. This argument of Thornton (1802) is equally applicable even in present time and still is regarded that value of money depends upon quantity of money. When there is rapid increase in money supply, there will be rapid increase in general price level (inflation) and as growth rate of money supply exceeds the growth rate of output, inflation arises in the economy.

"Ricardo (1950) concluded that given a constant supply of money with no change in productivity, an increase in the rapidity of circulation (velocity) will lead to a price level rise. In his economic recommendation, he felt that the amount of paper money issued should be limited because its overuse would lead to price increases" (Klein, 1970). Ricardo's theory emphasized on the neutrality of money that changes in nominal quantity of money will have the effect only on nominal variables but not on real variables. This argument clearly implies that inflation appears as velocity of money is increased without increasing the productive capacity of the economy. If output increases along with the increase in velocity of money, inflation is not likely to occur. Thus, Ricardo recommended to increase in the level of output with the increase in quantity of money to combat with inflation in the economy.

Mill (1909), in his famous book *Principles of Political Economy* synthesized classical economics and concentrated on the relationship between money and price. According to him, value of money depends on the quantity and its rapidity of circulation.

All the above analyses emphasize that price level and value of money are highly influenced by the quantity of money in the economy. It is, therefore, economists from sixteenth century to early twentieth century have the common compromise that price level in the economy is strictly determined by the volume of money, where price level is taken as the direct function of money i.e., $P = f(M)$ and $\frac{\delta P}{\delta M} < 0$.

However, Keynes (1936) thoughts regarding the relationship between money supply and price are somewhat different. Keynesian versions on money and price relationship are dealt in the form of Phillips curve. The Phillips curve states that there is tradeoff between inflation (wage inflation) and unemployment. The lower unemployment rates are associated with high wage inflation and as rate of wage inflation declines, the unemployment rate increases in the short run. This implies that increase wage inflation has the positive effect on employment and output in the short run. According to Keynes, the increase in wages are not inflationary in the short run so long as the economy operates below the full employment level, but as economy reaches at full employment level, any increase in wage rate will have adverse impact on price level because the level of employment and output remains unchanged. So in the short run the increase in money supply results in inflation to increase that contributes unemployment to reduce. Hence Keynes assumes a direct but not necessarily proportional relationship between money supply and price level. The Keynesian reformulated QTM can be claimed to be superior to the classical QTM in the sense that traditional view was the direct and proportional relationship between money supply and price level, which is not supported by the recent empirical studies.

2.3 Quantity Theory of Money in the Early Twentieth Century

The classical (*e.g.* Adam Smith, David Hume, David Ricardo, and John Stuart Mill) and the neoclassical schools (*e.g.* Alfred Marshall, A. C. Pigou, Irving Fisher) state that inflation is a monetary phenomena (Snowdon and Vane, 2005). According to Classicists, volume of money determines the price level in the economy that operates with full employment and relative prices are determined by demand for and supply of real goods. These economists developed the monetary theory which can be taken as the analytical approach to explain the economic role of money. In course of explaining the economic role of money Irving Fisher, the classical economist formulated the *equation of exchange* associated with the quantity theory of money.

The *equation of exchange* can be represented as follows:

$$MV + M'V' = \sum PQ \quad [11] \tag{2.1}$$

where M is the amount of currency in the economy during a given year, V is the velocity of circulation of money, M' is the volume of demand deposit in the economy during the year, V' is the velocity of circulation of demand deposits, and $\sum PQ$ is the sum of (i) the average price, P, of a commodity purchased in the economy during the given year multiplied by the quantity, Q ,of it purchased, (ii) the average price, , P' of another commodity purchased during the given year multiplied by the quantity of it purchased, and (iii) for all the goods exchanged. Equation (2.1) is a foundation of equation (2.2) (Ajuzie Emmanuel I.S. et al. (2008) :

$$MV + M'V' = PQ + P'Q' \tag{2.2}$$

The popular and contemporary version of the *equation of exchange* used by economists today can be expressed as follows:

$$MV = PQ \tag{2.3}$$

Where, M is the average amount of money in the economy during a specific period, such as a year, and V is the number of times this money is spent on PQ, which is the sum of the values of a specific group of goods. Equation (2.3) is an identity and the difference between Fisher's and the contemporary version lies in the definition for M and PQ. There are three theoretical assumptions to the restatement of the old Quantity Theory of Money. First, V is fixed with respect to the money supply. Second, the supply of money is exogenously determined. Third, the direction of causation runs from M to P. Since V is fixed and M is exogenous, then an increase in the supply of money will lead exactly to a proportionate increase in the price level.

[11] Irving Fisher (1911). The Purchasing Power of Money.

Therefore, money supply expansions only cause price inflation. So, V and Q are held constant, the price P is taken as the function of money supply M and the functional relationship between money supply and price level can be given by equation (2.4). (Ajuzie Emmanuel I.S. et al., 2008)

$$P = f(M) \tag{2.4}$$

The Transaction Approach proposed by Fisher explains the causes of hyperinflation that may arise during the war and emergency period in the economy. Fisher's approach also explains the long term trend of price level. However, this approach cannot state the normal inflation during the peace time in the economy. This is the major shortcoming of this approach and this has invited the new Cambridge Approach of money-price relationship in which the shortcoming contained in Transaction Approach has been modified and improved.

The Cash-Balance Approach: The Cash-Balance Approach is also known as Cambridge approach demonstrates a proportional relationship between quantity of money and aggregate price level. The foundation of this relationship is less mechanistic than the transaction version of Fisher's quantity theory of money. The Cambridge approach focuses on money demand rather than money supply as opined by Marshall. Individuals want to hold money for their convenience in transactions compared with other stores of value. According to Pigou, currency held in the hand yields no income, so money will be held only insofar as its yield in terms of convenience and security outweigh the income lost by not simply using the money to purchase goods. (Froyen, 2006)

The Cash-Balance Approach to the Quantity Theory of Money[12] can be represented in the functional form by equation (2.5).

$$\pi = \frac{kR}{M} \tag{2.5}$$

Where, π = the purchasing power of money

$k =$ Proportion of income that people hold in the form of cash

[12] Alfred Marshall, A.C. Pigou, and John Maynard Keynes are associated with Cambridge University and are known as pioneers of Cash Balance Approach of Cambridge version, who focus on demand for money than money supply.

R = volume of real income

M = stock of supply of money in the country at a given time

This equation shows that the purchasing power of money or the value of money (π) varies directly with k or R, and inversely with M.

Since π is the reciprocal of the general price level; that is $\pi = \frac{1}{P}$ the equation, $\pi = \frac{kR}{M}$ can be expressed alternatively as:

$$\frac{1}{P} = \frac{kR}{M} \tag{2.6}$$

That is, $M = kPR$ (2.7)

If we multiply the volume of real income (R) by the general price level (P), we have the nominal national income (Y).

Hence, equation (2.7) is converted into:

$$M = kY \tag{2.8}$$

In equation (2.8), the notation Y represents total nominal income in the economy. We now can also write equation (2.7) in terms of the general price level as:

$$P = \frac{M}{kR} \tag{2.9}$$

Equation (2.9) implies that the price level (P) varies inversely with k or R and directly with M.

In the Cash Balance approach of Cambridge equation, k plays more important role than M to explain the change in purchasing power of money. Thus, equation (2.9) states that value of money depends upon the proportion of income held in the form of cash by people. There exists inverse relationship between purchasing power of money and the proportion of income held in the form of cash by individuals in the economy.

In the Cash Balance approach k was more significant than M for explaining changes in the purchasing power of money. This means that the value of money depends upon the demand of the people to hold money.

The direct and proportional relationship between money supply and price level is also supported by Milton Friedman and Rational Expectation Hypothesis. Milton Friedman argues that Phillips curve exists only in the short run but not in the long run. This means that the Phillips curve is vertical in the long run which again means there is a direct and proportional relationship between money supply and prices in the long run. (Friedman, 1968)

Similarly, the Rational Expectation Hypothesis (REH) claims that there is no existence of Phillips Curve in the short run. According to this hypothesis, there is direct relationship between money supply and price level; that is, any increase in money supply causes price level to change in the same direction. The level of output, according to REH, is determined independently of money supply. Like, oldest quantity theory of money and monetarists' approach, there occurs direct and proportional relationship between money supply and price.

There was a strong attack of J.M. Keynes over classical quantity theory of money. Johnson, Ley and Cate (2000)[13] write regarding Keynes' attack to classical quantity theory of money as:

"Keynes rejected the quantity theory he inherited from Marshall and Pigou and to which he himself had contributed [Keynes, 1924, 1930]. He rejected the quantity theory both theoretically and as a tool of applied policy [Keynes, 1924, pp. 65, 146-54; 1930, vol. II, bk. VII]. Keynes attacked the quantity theory on three grounds. First, he argued that the two assumptions upon which a stable velocity rests do not hold. Second, Keynes contended that people hold money for reasons other than transaction purposes [Cate and Johnson, 1997; Johnson and Cate, 2000; Johnson et al., 1997]. Finally, Keynes argued that it was unreasonable to assume that output could be treated as constant [Cate and Johnson, 1997; Johnson and Cate, 2000; Johnson et al., 1997]".

Same authors Johnson, Ley and Cate again write as: *"The second aspect of Keynes attack on the quantity theory addressed the assumption that people demand money*

[13] Retrieved from: https://www.researchgate.net/publication/225826473_Keynes%27_theory_of_money_and_his_attack_on_the_classical_model

only for transaction purposes. Keynes suggested instead that the demand for money may be divided into five categories. Three of these are:1) income deposits, money used to meet personal expenditures; 2) Business deposits, money used to meet business obligations; and 3) savings deposits, money used to meet personal (financial) investment needs. The remaining two categories cut across the first three categories. One of these Keynes called industrial circulation, money used to undertake normal business operations: gathering the factors of production, making the product, and delivering it to the consumer. The other he called financial circulation, money used to buy and sell titles to wealth: stocks and bonds. In his classification scheme, business circulation makes use of income deposits and a portion of business deposits, and financial circulation makes use of savings deposits and a portion of business deposits [Keynes, 1930, pp. 217-30, vol. I]".

Another aspect of Keynes' attack on the classical quantity theory was his rejection of that theory's assumption that output could be treated as constant. The orthodox model asserted that output was determined by employment (one aspect of the classical dichotomy). Since the economy was always in equilibrium at full employment, the level of output could be taken as a constant at the full employment level. By the time of the General Theory, Keynes was determined to show that less than full employment equilibrium was not only possible but probable. As part of this analysis, Keynes reversed the direction of causation from the equilibrium level of employment to the equilibrium level of output. Instead, Keynes argued that it was the equilibrium level of output that determined the equilibrium level of employment. Once it is established that less than full employment equilibrium is possible, it is unacceptable to assume that output can be taken as constant, as required by the quantity theory [Johnson et al., 1997].

2.4 Keynesian Views on Money-Price Relationship

Keynes accepted the classical view that increase in money supply causes rising prices or inflation only when the aggregate output corresponds to full employment and aggregate supply curve is vertical. Keynes published an article entitled 'How to Pay for the War' in 1940, in which he developed a demand side model incorporating inflation process with temporarily rigid prices in the labor market. The primary concern of Keynes was to provide space for the necessary increase in output during war where the economy had already reached the full employment level. At full employment level, as aggregate demand increases it results in inflationary gap. This inflationary gap can be removed either by taxation or by saving in such a way that aggregate demand equals existing output (Skidelsky 2000, 84).

Snowdon and Vane (2005) write

"Keynes, in his 'How to Pay for the War' (1940), advocated wartime fiscal restraint. This pamphlet is described by Vines (2003, p. 343) as a 'marvelous piece of applied economics' even if his plan was only partially adopted (Keynes believed that an alternative system of universal rationing amounted to 'Bolshevism'; see Skidelsky, 2000, p. 68). Keynes's analysis involved comparing aggregate demand, including war expenditures, with potential aggregate supply. Keynes (see Skidelsky, 2000, p. 84) defined the 'inflationary gap' as 'the amount of purchasing power which has to be withdrawn control as the most efficient allocation mechanism even if at the macro level there was likely either by taxation or primary saving ... in order that the remaining purchasing power should be equal to the available supplies on the market at the existing level of prices'. The aim of fiscal restraint (forced saving) was to eliminate the 'inflationary gap' by reducing consumption. It should be noted that Keynes's proposal reveals his great faith in the price mechanism rather than bureaucratic to be market failure requiring aggregate demand management".

At full employment level, when aggregate demand increases through increase in existing money supply, the general price level will increase. The shocks in demand in the economy at full employment level causes prices to rise and unanticipated profits of firms also rise as there is rigidity in normal wages (Aykut, 2002).

Al Yahyaei (2011), in his Doctoral Dissertation writes, *"Firms' action to meet the excess demand will create pressure on the labor market, which is already operating at full capacity. This will cause a competition between firms for employed workers, which will bid up normal wages and subsequently the real wages, which in turn will induce a new demand in the goods market leading to another increase in prices. If normal wages continue to lag in response to any excess in demand, an inflation spiral is expected to occur. Keynes suggested fiscal restraint (forced saving) in the form of increased tax or cuts in government spending in order to eliminate the inflation gap.*

The upshot here is that, in contrast to the classical proponents, who emphasized the monetary, demand side approach to inflation, Keynes emphasized the non-monetary, demand side approach to inflation that was prevalent with the cost-push argument for inflation".

Keynes (1936) claims that there exists a trade-off between inflation and unemployment. As money wage rises, the inflation and unemployment fall. When money supply increases, the level of employment, output and price increase. Keynes states that there is direct relationship between money supply and price level. However, the relationship between money supply and price level will not be proportional as in Fisher's Quantity Theory of Money.

According to Phillips (1958), as there is lower unemployment rate in the economy, the labor market will be tight so that the firms are induced to increase wage rate to attract the scarce labor force for work. When the rate of unemployment is higher, it will be easy to firms to reduce wage rate because of the loose labor market. This behavior of firms and labor market situation represents the average relationship between money wage and unemployment and gives the birth of Phillips curve representing the tradeoff between the wage inflation and unemployment, the tradeoff between them being the inverse. Phillips curve gained the popularity as policy guide during 1960s. However, Phelps (1967) and Friedman (1977) independently challenged the popularity of Phillips curve in the theoretical foundations. They argued that both employers and works are to focus on to real wages that must make the adjustment between demand for and supply of labor. There should be inflation-adjusted purchasing power of money wages to bring the labor market into equilibrium so that the unemployment rate would remain at a level associated with the real wage called natural rate of unemployment.

2.5 Monetarists' View on Money and Price

Monetarism is a school of thought in economics pioneered by Milton Friedman, a monetary economist. The monetarism argues that as there is excess expansion of money supply, it becomes inherently an inflationary in effect; and it is the duty of the monetary authorities to maintain price stability.

Monetarism is that economic thought on money-price which brought back the basic classical idea and stated that money stock determines the price level. The growth of money stock has the job to determine the rate of inflation. Friedman (1968) and Phelps (1967, 68) developed the models incorporating the adaptive expectations of the rate of inflation into Phillips Curve model. They state that actual inflation is determined by expected inflation and if inflation expectations were proved to be correct, Phillips Curve does not exist in short run. The wage inflations determine a single natural rate of unemployment and Phillips Curve passes through that natural rate of unemployment and hence the long run Phillips Curve becomes a vertical straight line parallel to Y-axis. According to them, any effort of government to reduce unemployment below the natural rate would be meaningless.

Monetarism emphasizes the long-run monetary neutrality and short-run monetary non-neutrality. It means money is not merely inflationary in short-run; it may have positive impact on output and employment. However, it is purely inflationary in the long-run. Friedman (1968) writes, *"Inflation is always and everywhere a monetary phenomenon"*. This clearly indicates that it is money supply due to which inflation arises in the economy. Regarding Monetarists' view, Cagan, 1987 writes:

"Monetarism is a school of economic thought that emphasizes the role of governments in controlling the amount of money in circulation. It is the view within monetary economics that variation in the money supply has major influences on national output in the short run and the price level over longer periods and that objectives of monetary policy are best met by targeting the growth rate of the money supply".

Friedman (1956) opines that a change in the stock of money causes price or income or both to change in the same direction so long as the money demand remains stable in short run. In the short run, the change in money supply is not only inflationary but it also affects the real value of national income and economic activities. When demand for money is stable, the effect of change in the supply of money on total expenditure and income is predictive. When the economy is operating below full employment, an increase in the supply of money would increase output and employment through increase in aggregate demand only in short run, but not in the long run. Hence, Friedman firmly emphasized that increase in supply of money in the short run causes both price and real variables like employment and output, but in the long run any increase in supply of money causes no more than change in price level when economy operates at full employment level. Hence, in short run economy is operating at less than full employment and increase in money supply will not be inflationary. But in the long run, the economy operates at full employment level and an increase in money supply will be inflationary in effect.

[14]In Friedman formulation total income (Y) is explained by nominal wealth (W) and its returns (r) and hence it is generated through following process.

$$Y = Wr$$

The wealth and returns can be estimated by individuals' expectations throughout their life time. And hence, Y becomes permanent income. Friedman argues that demand for money is proportional to the value of nominal transactions. So it is taken as the function of permanent income. Now, Friedman's demand for money can be recast as:

$$M = f(P, r_b, r_a, w, \frac{Y}{r}, \mu)$$

In this function, P is the price level, r_b the return on bonds, r_e the return on equities, r_a the return on real assets, w the ratio of human to nonhuman, $\frac{Y}{r}$ is total wealth, and u is the portmanteau variable.

In a simpler form: $M = f(P, r_b, r_e, \pi, Y)$

At equilibrium, the inflation rate should be equal to the nominal return on the entire (aggregate) stock of real (physical) assets. If individuals do not suffer money illusion, they are not fooled by changes to scale, and f is linearly homogeneous in prices and nominal return on the entire (aggregate) stock of real (physical) assets.

So, $\lambda \mathrm{M} = \mathrm{f}(\lambda \mathrm{P}, \mathrm{r_b}, \mathrm{r_e}, \pi, \lambda \mathrm{Y})$

This must hold for any value of λ, even $\lambda = \frac{1}{Y}$. This implies that:

More simply,

[14] http://www.authorstream.com/Presentation/Jolene-19530-Chicago-School-Historical-Background-2-Milton-Friedman-1912-Friedmans-Restatement-Quantit-as-Entertainment-ppt-powerpoint/

$\frac{M}{Y} = f(\frac{P}{Y}, \mathrm{r_b}, \mathrm{r_{e,}}\pi, 1)$

$M = \ f(\frac{P}{Y}, \mathrm{r_b}, \mathrm{r_{e,}}\pi, 1)\mathrm{Py}$

We can write, $Y = Py$

$M = f(*)Y$

This closely resembles the Cambridge form of the equation of exchange:

$M = kPY$

In the equation, $M = kPY$; the constant k represents the proportion of cash balances, equivalent to $\frac{1}{V}$ in the equation of exchange $MV = PY$.

2.6 Structuralists' View Regarding Inflation

Juan Noyola (1956) and Osavoldo Sunkel (1958) are the main contributers to the Structuralists theory of inflation. According to Structuralists view inflation in LDCs arises mainly due to the structural maladjustments and different types of rigidities created in the course of development activities. First the structural pressures arise in the economy and inflation arises and second when efforts to mitigate with inflation are enforced, it further expands known as propagating mechanism. Lioli (1974) and Watchter (1976) argue that the causes of the inflation are the pressures that comprise the structural constraints. According to them, LDCs in short run face the constraints like: (i) inelastic food supply, (ii) import bottlenecks, (iii) new provisions of development infrastructures causing taxes to increase, and (iv) structural deficiencies like stagnant agriculture, comparative disadvantages in terms of trade etc.

The structural maladjustments and pressures are mainly responsible to cause inflation in LDCs and the characteristics of these structural maladjustments and pressures leading propagating mechanism differ from country to country. These structural bottlenecks are related to rigidities and inelasticities from the supply side of the market. There are three most important structural factors causing the Structuralists inflation; the first is the imbalance between the agriculture and the industrial sector. Industrial sector has a rapid growth such as increasing income, increasing demand of both food and non-food items. Contrary to this, the agriculture sector in LDCs is not modernized and output is rigid and unresponsive to demand pressures. This inelasticity or rigidity in agricultural output especially, food results in rising price of food. Secondly, the bottlenecks arise from foreign trade sector. There is inelastic supply of exports of less developed countries. As a result, the export earnings of LDCs are not stable and sufficient. However, the imports are extremely higher to meet the increasing demand for foods and non-food items including capital goods to sustain the process of industrialization. This high level of imports as compared to exports causes the price of imported goods to increase in importing countries, and thereby inflation arises. Additionally, the increasing imports needs more foreign exchange for payments in abroad but meanwhile the domestic economy should face the problem of currency devaluation, which in turn, further broadens the foreign trade deficit. The increase in foreign trade deficit is also the cause of domestic inflation. The third structural factor responsive to cause inflation is the rigidities in the public sector arise mainly from an income inelastic taxation system, which is considered inefficient. This means that a higher public expenditure cannot be financed by imposing an increase in tax rates.

Ahiakpor (2014) also argues it is believed that the bottlenecks in the agricultural sector will have an adverse impact on food production. The rigidities or fall in food production causes food prices to increase. The increase in food price causes cost of living of wage earners and there are upward pressures on wages to maintain the previous living standard causing inflationary pressure in the economy. Likewise, the Structuralists inflationary pressures in LDCs arise also due to the lack of foreign exchange leading balance of payment deficits. The deficit BOP results in currency depreciation and import restrictions. The restriction on imports causes prices of imported goods to increase.

2.7 Rational Expectation Hypothesis

Early analysis of formation of expectations were characterized by emphasis on a weighted average of past changes (Fisher, 1930) and the role of exogenous psychological factors, i.e., 'animal spirit' (Keynes, 1936). In other words, expectations were assumed to be subject to a high degree of inertia but also to unexplained waves of optimism or pessimism. Following the World War II, expectations were modeled in some deterministic manner, mainly assuming that the expected value of a certain *variable could be proxied by its observed values in a recent past (Cagan, 1956; Frenkel, 1973; Holden and Peel, 1977). Alternative measures to the arbitrary modeling of price expectations could be based on financial market indicators or a survey-based data. While the former direct measurement of inflationary expectation uses some financial indicator such as forward interest rate for example (Mishkin, 1990; Svensson, 1993; Frankel and Lown, 1994; and Soderlind, 1995; among others), the latter uses some sample survey like Livingston Survey for the United States or the Gallup poll for the United Kingdom.*

Lucas (1981) has emphasized the matter of how individuals form expectations of the future. Expectations play a vital role in the economy because they influence all kinds of economic behavior of households, business firms and resource owners. Households decide how much to consume based on expectations of future income, and firms decide how much to invest based on expectations of future probability. These expectations depend on different factors, including the economic policies being pursued by the government. Lucas has argued that traditional methods of policy evaluation do not adequately take into account this impact of policy on expectations and, thereby on behavior.

According to Rational Expectation Hypothesis, Phillips Curve does not exist even in the short run. This implies that there is no tradeoff between inflation and unemployment. And, change in money supply causes price level to change not only in long run, but also in short run. The rational expectation hypothesis distinguishes the money supply in anticipated and unanticipated parts. The level of output is affected by unanticipated part of money, whereas the price level is affected by anticipated part of money, i.e. inflation can be taken as the function of anticipated part of money.

The Fisher's Quantity Theory of Money in the form of equation of exchange can be recast as:

$$M_t V_t = P_t Y_t \tag{2.10}$$

Where, $M_t = Money\ Supply\ at\ any\ time\ 't'$

$V_t = Constant\ Velocity\ of\ Money$

P_t= Price Level $at\ any\ time\ 't'$

Y_t=Real Output $at\ any\ time\ 't'$

Taking logarithm (ln) on both sides of equation (14), we get

$$lnM_t + lnV_t = lnP_t + lnY_t \tag{2.11}$$

The aggregate supply curve is given by the Lucas supply equation given by (2.12).

$$lnY_t = lnY_p + \beta(lnP_t - {}_{t-1}lnP_t{}^e) \tag{2.12}$$

Where,

$lnY_p = Full\ employment\ output\ in\ \log form$

${}_{t-1}\ lnP_t{}^e = Expected\ price\ level\ occuring\ at\ time\ t\ viewed\ from\ time\ t-1$

Let the monetary rule used by the policy authority be,

$$lnM_t = \alpha_1 lnY_{t-1} + \epsilon_t \tag{2.13}$$

Where, $E(\varepsilon_t / I_{t-1}) = 0$

Under the rational expectation hypothesis, price expectations are determined within the model in the light of past and present development of the price level. This can be expressed as:

$${}_{t-1}\ lnP_t{}^e = E(\varepsilon_t / I_{t-1}) \tag{2.14}$$

Equation (18) emphasizes that people's subjective and psychological expectation of the price level ${}_{t-1}\ lnP_t{}^e$ equals the mathematical expectation of the price level, given both the structure of the model and the information available.

From equations (2.11) and (2.12) we can write as:

$$lnM_t + lnV_t - lnP_t = lnY_p + \beta(lnP_t - {}_{t-1}lnP_t{}^e) \tag{2.15}$$

Taking mathematical expectation of both sides of the equation (19) as of time *t-1* gives

$$\alpha_1 Y_{t-1} + \bar{V}_{t-1} - {}_{t-1}\ lnP_t{}^e = Y_p \tag{2.16}$$

$${}_{t-1}lnP_t{}^e = \alpha_1 Y_{t-1} + \bar{V} - Y_p \tag{2.17}$$

Substituting equation (2.17) into equation (2.15) we have

$$lnP_t = \alpha_1 \ lnY_{t-1} + \bar{V} - Y_p + \frac{\epsilon_t}{1+\beta} \tag{2.18}$$

Therefore, the gap between actual price and expected price is

$$P_t - {}_{t-1} \ lnP_t{}^e = \frac{\epsilon_t}{1+\beta} \tag{2.19}$$

Finally, using Lucas supply equation, the output will be

$$Y_t = Y_p + \frac{\beta_{\epsilon t}}{1+\beta} \tag{2.20}$$

Equation (2.18) and (2.20) show that anticipated movements of money supply affect only the price level. Anticipated monetary policy has an effect on price because, with rational expectation, individuals take into account this policy. However, unanticipated movements of money supply affect real output.

2.8 Current Investigation of the Quantity Theory of Money

This section includes the current investigation and version of the economist regarding the quantity theory of money (QTM). Under it, we will analyze the latest and most renowned version of Ajuzie Emmanuel I.S. et al. (2008) has investigated the quantity theory of money in the current context. This new formulation of quantity theory of money includes the following assumptions.

- Money is exogenously determined.
- Value of circulation is determined by the changes in price levels rather than amount of money available or current price level.
- Changes in velocity of money occur due to the factors like changes in transportation, new financial institution and other exogenous factors.
- Velocity of money is assumed to remain more or less stable in the long run.
- Inflation is the long run phenomenon.
- Real GDP is determined by the availability of labor, capital, natural resources, knowledge, and entrepreneurship.

- Economy is assumed to operate with full employment in the long run.

Based on the above assumptions, current investigation of Quantity Theory of Money emphasizes that the *Equation of Exchange* is the basic theory of inflation which determines nominal GDP in the economy. The *Equation of Exchange* can be explained in the form of an identity that establishes the relationship among money supply, the income velocity of money, the GDP deflator and real GDP. The current investigation of QTM can be represented by equation (2.21).

$$\mathrm{M.V} = \mathrm{P.GDP} \tag{2.21}$$

Where, M is the total amount of money in circulation in an economy during a year. It is here considered as currency (including coins), bank deposits, and traveler's cheques. In the equation, the variable V is the velocity of money. This reflects financial institutions and other economic conditions. P is the GDP deflator. It is a weighted average of prices of all final goods and services produced in the economy. It is, therefore, the broadest-based measure of the nation's price level. GDP is the total market value of final goods and services produced in the economy during one year of time. A rise in money supply, through its impact on aggregate demand, results in an increase in nominal GDP. If velocity of money is held constant, an increase in nominal GDP is proportional to the increase in money supply. In order to determine the impact of a rise in money supply on inflation/price rate, we rewrite equation (2.21) to obtain equation (2.22):

$$\mathrm{dM/M} + \mathrm{dV/V} = \mathrm{dP/P} + \mathrm{dGDP/GDP} \tag{2.22}$$

Where, dM/M is the growth rate of money supply, dV/V is the growth rate of the velocity of money, dP/P is the growth rate of GDP deflator and a measure of the inflation rate, and $dGDP/GDP$ is the growth rate of real GDP or output growth rate. If velocity of money is constant, dV and, therefore, dV/V equal zero. Equation (2.22) becomes:

$$dM/M = dP/P + dGDP/GDP \tag{2.23}$$

Equation (2.23) states that growth rate of money supply equals the growth rate of inflation plus output growth rate. Rearranging terms and solving for growth rate of GDP deflator or inflation rate gives:

$$dP/P = dM/M - dGDP/GDP \tag{2.24}$$

Equation (2.24) states that the growth rate of inflation equals the growth rate of money supply minus growth rate of output. The growth rate of money supply is determined by the Central Bank and growth rate of output is determined by different factors like capital, labor, natural resources, development of infrastructure, industrialization, growth rate of investment and so on. The growth rate of real GDP fluctuates with respect to time. In the long run, the aggregate supply and real GDP, for instance, increase around 3 percent per annum. If price level is permitted to grow only at 3 percent, then price level will remain constant, i.e. there will not be inflation. The inflation occurs only when growth rate of money supply exceeds growth rate of real GDP in the economy.

Concluding, the current investigation regarding the QTM asserts that inflation cannot be explained taking money supply only excluding the output. The inflationary issue is explained by money supply in relation to growth rate of output.

2.9 Empirical Exploration on Money-Price Relationship

On the basis of theoretical development of money-price relationship, different types of empirical studies have been carried out by economists and researchers regarding the causal linkage between money supply and price level for different countries. These empirical studies have shown three types of causation between money supply and price level. Some of the very important findings and conclusions from empirical studies about money-price relationship have been mentioned below.

Brillembourg and Khan (1979) have examined the causal relationship between money supply and price level for USA by utilizing the Sims procedure by means of annual data from 1870 to 1975. This study found the unidirectional causality running from money supply to price level, which supported Monetarists' view. In the same analogy, the study of Lee and Li (1983) for Singapore also supported the Monetarists' view that money has caused the price level.

Darrat (1986) used the procedure recommended by Sargent (1976) to test the direction of causality between money supply and price level for Morocco, Tunisia and Libya for the period from 1960Q_1 to 1980Q_2. This study found the unidirectional causality running from narrow money supply to price level, which supported Monetarists' view that money mattered price level. However, Parikh and Starmer (1988) have explored the relationship between money supply and price level in Bangladesh using the monthly data during the period 1973-1986 and found the unidirectional feedback running from price to money. In this study, the strict exogeneity of money supply is rejected. The result of this study has denied the Monetarists' view but supports Structuralists' view.

Similarly, the study of Ramchandran and Kamaiah (1992) has also noticed the uni-directional causality running from money supply to price level for the economy of India as in case of Darrat (1986). On the other hand, the study of Aghevli and Khan (1978) for Brazil, Columbia, the Dominican Republic, and Thailand, has found bidirectional causality between money and prices. Likewise, Maish and Maish (1994) examined the question of causality between money and price in the context of Asian developing economy, India. This study supported monetarists' view that money supply was leading variable and price was lagging variable in the context of India when they studied the linkage between money supply and price during the period 1961-1990. Contrary to this, Mohammad (1996) in his study of the linkage between money, real income and prices in Saudi Arabia concludes that real income contributes significantly in explaining in changes in money, and prices are also significant in predicting changing in money. This study supports Structuralists' view.

According to Dave and Rami (2008)," The first elaborate causality study on money-output-prices in India seems to have done by Nachane and Nadkarni (1985). They carried out an exclusive theoretical investigation of various causality tests viz., Sims, Hsiao's Final Prediction Error, Cross Correlation Test and Transfer Function Test ranging over the period 1960-61 to 1981-82 on quarterly data for India. The findings of the entire tests showed the unidirectional causality running from money supply to price level. Dave and Rami (2008) themselves have conducted the research study of money-price relationship for the economy of India using the monthly data from 1953 to 2005. They have used the Granger Causality test for both types of money supply and price level and found the unidirectional causality running from price level to money supply. The finding of Dave and Rami is not only conflicting with QTM but also it is defective. The main drawback of this study is to misuse of econometric methodology where Granger Causality test has been carried out without employing Cointegration Test and Vector Error Correction Modeling.

Masih and Masih (1998) have studied the causal relationship between money supply (M_1 and M_2) and prices in four Southeast Asian developing countries like Thailand, Malaysia, Singapore, and Philippines by using the monthly data for the concerned variables from January 1961 to April 1990. From this study it is observed that money supply has caused price supporting the monetarists view. The finding of Masih and Masih is quite conflicting with that of Dave and Rami.

Pinga and Nelson (2001) have examined the causal linkage between money supply and aggregate price level for twenty-six countries, and found the mixed but paradoxical results. For Malaysia, no causal linkage between money supply and price level has been observed, which supported Structuralists' view. On the other hand, money supply is found causing price level for Kuwait, Paraguay and USA, but there is found to be bidirectional Granger causality between money supply and price level for other countries, which supported Monetarists' view.

Boughrara (2002) has studied the characteristics of the Tunisian monetary policy and found that price level is found causing money supply but price level is not caused by money supply, which supported Structuralists' view that money has neutral effect on price. Kudoh and Bhattacharya (2002) concluded surprisingly that tight monetary policies are inflationary when the real interest rates are below growth rate of the economy. This view challenges the Monetarists' view that even tight money policies bring inflation in the economy.

Tang (2004), on the other hand, has explored the causality between broad money supply (M_2) and prices in Malaysia from 1970:Q_1 to 1998:Q_4 using modified Wald test. He found that only money supply causes price level, which supports the monetarist view. Qayyum (2006) investigates the linkage between excess money and growth of inflation for Pakistan and concludes that money supply in the first round affects real GDP growth and in the second round it affects the inflation. His findings support the Monetarists' view that excess money supply is responsible to cause inflation.

Frankel (2007) has argued that an unanticipated increase in the money stock will react commodity prices quickly and lead the adjustment in final good price indices such as the CPI while both sets of prices are determined in the long run by the money supply. This study is also found to be in harmony with monetarists' view that money supply matters the price level.

Ghazali, et al. (2008) have examined the causality between money supply and price level by the methodology of Johansen's Cointegration test and Granger Causality tests based on Toda and Yamamoto for the economy of Malaysia using monthly data over the period 1974-2006. The authors conclude that there is long run equilibrium relationship between money supply and price level for Malaysia during the study period. There is unidirectional causality running from money supply (both M_1 and M_2) to price level for Malaysia.

Similarly, Mukhopadhayay and Barma (2008) have studied the relationship between money supply and price level in the South Asian Economy including India, Nepal and Sri-Lanka by employing the econometric methodologies like Cointegration test, Vector Error Correction Modeling, Granger Causality test, Vector Autoregressive, Impulse Response Function and Variance Decomposition By using the quarterly data from 1987q1 to 2005q1 for money supply (M_1 & M_2) and price level for the economy of India, following results have been observed.

- Money supply M_1 and price level are cointegrated.
- Money supply M_2 and price level are cointegrated.
- The VECM shows that there is bidirectional causality between money supply. M_1 and price level as well as Money supply M_2 and price level for India.
- There is bidirectional Granger causality between money supply M_1 and price level, but unidirectional Granger causality between money supply M_2 and price level running from M_2 to price as reported by traditional Granger causality test.
- VAR implies that there is bidirectional causality between money supply M_1 but unidirectional causality running from M_2 to price level.

a) The impulse response function asserts that variations in price around the long run base are short lived.

b) Variations in money supply are mainly due to monetary shocks

c) Shocks transmitted through the channels of money and price are short lived

d) The shocks have no appreciable impact on the long run base levels of price and money supply

The Variance Decomposition analysis shows that:

a) Price level exhibits delayed response to shocks transmitted through money supply M_1 and M_2 channel but price level responses to shocks transmitted through price channel are immediate

b) M_1 money supply shocks are more dominant than M_2 money supply shocks in price shocks

The conclusion made by Mukhopadhayay and Barma from the Money-price Relationship for India is regarded as superior to other studies for the same country because according to them "The historical data set may not provide reliable guideline for making policy decisions" even if money supply and price level are related in India in direction only that supports monetarists view but negligible in magnitude and rejects monetarists view. The authors conclude that Indian prices are influenced by non-monetary factors like commodity crisis, rise in oil price, import restrictions, inefficient public distribution system etc.

Following results are reported for Nepal with the same nature of data and econometric tools applied by the same authors.

- price and money supply (M_1 & M_2) are cointegrated
- Bidirectional causality between money supply (M_1 & M_2) and price level as reported by VECM, Granger causality test and VAR
- Money supply (M_1 & M_2) are failed to influence the variations in price as reported by Impulse Response Function
- Price shocks are more important than monetary shocks for total variations in price level in Nepal as suggested by Variance Decomposition

Like economy of India, authors conclude that price variations in Nepal are found to be far from being a 'Monetary Phenomenon' where monetary shocks cause very little variation in price level. From this study also it is observed that money-price relationship for Nepal supports monetarists view only in direction but not in magnitude.

Another study of Mishra, Mishra and Mishra (2010), who have examined the causality between money supply and price level for Indian economy using the annual data from 1951 to 2009, have found that

- Money supply and price level are cointegrated as reported by Johansen Cointegration test.
- In short run, there is bi-directional causality between money supply and price level as reported by Vector Error Correction Model (VECM)
- There is uni-directional causality running from price level to money supply as reported by Granger Causality test.

The finding from the study supports monetarists view regarding money-price relationship in short run only. Since money does not cause price in the long run for India, the relationship between the concerned variables does not support the view of monetarists in the long period. The authors opine "This evidence regarding the short-run dynamic adjustment among money supply and price level indicates that active monetary policy to stabilize short-run fluctuation in prices must be handled with caution, as it would intensify rather than moderate price fluctuations in the long-run".

Similarly, Cronin (2010) has explored the relationship between money supply and price level for the US economy using the quarterly data from 1959q1 to 2007q2 and employing the methodology of Variance Decomposition under VAR modeling. The following results have been detected in the study.

- It is money that has the strongest relative importance among the variables in explaining the behavior of the CPI at longer horizons
- The decomposition also points to money being an independent variable within the system of price and money variables

Cronin findings reveal that it is not money that causes inflation in the US economy during the study period, which supports the Structuralists' view.

All the above mentioned studies are associated with the relationship between money supply and price level. All findings focus that price level/inflation is caused by the increase in money supply. However, many economists and researchers do not agree that prices are caused by money supply only. Different studies have shown that not only money supply and price level are related but prices are influenced by different factors such as level of output, rate of interest, price of petroleum, increase in cost of production, commodity crisis and other political and institutional factors. The following section will cover some of the important researches that are contextually relevant to the proposed study.

A number of studies relating to the relationship between money supply and price level are available in the economic literature for different countries. However, there are very few researches on money-price relationship for economy of Nepal. Nepal Rastra Bank (NRB), central bank of Nepal has studied the relationship between money supply and price level for Nepal in 2004, but this study is not complete and it has not employed the recent econometric models to find the concrete causality between the concerned variables. Additionally, after 2004, there is dramatic change in inflation where it has been converted to double digit from single digit since 2007. In this sense, study of the relationship between money supply and price level carried out by NRB is not relevant and cannot throw full light on Nepalese inflation.

There is another study carried out by Mukhopadhyay and Barma in 2008 for Nepal associated with money-price relationship. This study is very popular among the research scholars of macro- econometrics that entail the modern econometric tools. However, this study has also used the data of money supply and price level from 1987 to 2005 only. This study cannot tell about the inflationary situation of Nepalese economy after 2005, where economy of Nepal is bearing a high growth of inflation around 13 % per annum after 2007[15].

[15] See Economic Survey 2010/11, MOF, Government of Nepal

Since the main research problem is to find the real causes of double digit inflation of Nepalese economy, the present study throws some light on double digit inflation of Nepal by covering the data associated with the concerned variables up to 2011. The present study is associated not only with the direction of causality between money supply and price level but also the magnitude so that real factors that determine Nepalese inflation can be explored.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Nature and Source of Data

The present study is associated with the utilization of secondary data on Money Supply and Price Level for the economy of Nepal. The data of concerned variables are taken from various issues of Economic Bulletin of Nepal Rastra Bank. Quarterly data on money supply and price level ranging from $1976Q_1$ to $2012Q_2$, a total of 143 periods have been used in the present study. The present study has employed the data sets of money supply and price level transformed in logarithmic form to minimize the problem of heteroscedasticity.

Besides, the present study utilizes the quarterly data of Indian wholesale price index (WPI) transformed into logarithmic form to examine the impact of Indian inflation on Nepalese inflation. The WPIs are taken from Reserve Bank of India (RBI).

Likewise, the present study utilizes the annual data of remittance[16] and population growth to find the impact of remittance on inflation of Nepal. While analyzing the impact of remittance on inflation, the annual data of remittance and inflation as well as population growth have been employed. The political instability is taken as dummy variable while analyzing the relationship between annual inflation and remittance. The data for remittance are taken from Economic Survey of Nepal and data associated with population are taken from International Monetary Fund (IMF).

Finally, the impact of anticipated money supply on price level is also analyzed by using the quarterly data of inflation and anticipated money supply. The anticipated money supply data are the derived data using the ARIMA structure of money supply.

[16] Due to the non-availability of quarterly data of remittance, the impact of remittance on Nepalese inflation has been analyzed using the annual data of concerned variables.

3 .2 Variables and Measures

Price Level: price level means the general price level or representative price level. It is the Consumer's Price Index (CPI) calculated by Nepal Rastra Bank by collecting the price of certain commodities from different retail business centers of the country. The CPI is constructed taking a certain year as base period using the Laspeyres' formula as a weighted arithmetic average. The formula is expressed in statistical notation as follows:

$$Ln_0 = \sum Q_0 P_{i-1}(P_i/P_{i-1}) / \sum Q_0 P_0 = \sum \frac{Pi}{Pi-1} \times - \frac{Q0 \times Pi - 1}{Q0P0} \qquad (3.1)$$

Where,

Ln_0 = the index number for the period (i) with base period (*o*) equal to 100.

($Qo\ P_{i-1}$) = the index expenditure weights adjusted for price change to the preceding period

(P_i / P_{i-1}) = the change in price from the preceding period to the current period

$QoPo$ = the index expenditure weight

Money Supply: In Nepal, total money supply consists of narrow money and broad money. The narrow money (M_1) consists of currency in circulation plus demand deposits, whereas broad money (M_2) includes M_1 plus time deposits or quasi money.

The data sets of money supply M_1, money supply M_2 and consumer's price index (CPI) after transforming logarithmic form are represented by $LnM_{1t,} LnM_{2t}$ and $LnCPIP_t$ respectively. Other variables are described in the related chapters and sections.

3.3 Techniques of Data Analysis

The econometric techniques have been applied to analyze the data as the main research methodology in the present study. The econometric techniques used by the present study have been briefly explained below.

3.3.1 ADF Unit Root Test

The present study includes the time series data. The time series data generally contain unit root. If regressions are run without checking unit root, the results will be spurious. So it is necessary to test unit root of the time series data. If the time series data contain unit root, the series will be non-stationary series. Our regression needs stationary series, and it can be achieved by differencing the series.

There are various methods for unit root test, one of which is the Augmented Dickey Fuller (ADF) unit root test. The Dickey-Fuller test was extended by, among many other authors, Said and Dickey (1984) to take into account when $\{Y_t\}$ follows an AR (ρ) process. In the literature it is known as Augmented Dickey-Fuller (ADF) test. Lagged values of $Y's$ were introduced in the following equations to take into account of the fact that (Y_t) follows an AR (ρ) process. Said and Dickey approach yields test statistics with the asymptotic critical values as those tabulated by Dickey and Fuller. There are three possibilities in ADF unit root tests.

When the time series is flat (i.e. doesn't have a trend) and potentially slow-turning around zero, use the following test equation:

$$\Delta y_t = \theta y_{t-1} + \alpha_1 \Delta y_{t-1} + \alpha_2 \Delta y_{t-2} + \cdots + \alpha_\rho \Delta y_{t-\rho} + \varepsilon_t \tag{3.2}$$

Where ε_t is a pure white noise error term ($\varepsilon_t \sim i.i.d.$) and $\Delta y_{t-1} = y_{t-1} - y_{t-2}$, $y_{t-2} = y_{t-2} - y_{t-3}$ and so on. "The number of lagged difference terms to include is often determined empirically, the idea being to include enough terms so that the error term is serially uncorrelated" (Gujrati, 2007, pp. 836).

where the number of augmenting lags (ρ) is determined by minimizing the Schwartz Bayesian Information Criterion or minimizing the Akaike Information Criterion or lags are to be dropped until the last lag is statistically significant. There are different econometric software such as Eviews, Stata and others, allow us all of these options for us to choose the suitable lags from the given variable/s under study. Notice that this test equation does not have an intercept term or a time trend. What we want to use for our test is the t-statistic associated with the ordinary least squares estimate of. This is called the Dickey-Fuller t- statistic. The Dickey-Fuller t-statistic does not follow a standard t-distribution as the sampling distribution of this test statistic is skewed to the left with a long, left-hand-tail.

The null hypothesis of the Augmented Dickey-Fuller t-test is:

$H_0: \theta = 0$ (The data needs to be differenced to make it stationary)

Versus the alternative hypothesis of

$H_1: \theta < 0$ (The data is stationary and doesn't need to be differenced)

When the time series is flat and potentially slow-turning around a non-zero value, use the following test equation:

$$\Delta y_t = \alpha_0 + \theta y_{t-1} + \alpha_1 \Delta y_{t-1} + \alpha_2 \Delta y_{t-2} + \cdots + \alpha_\rho \Delta y_{t-\rho} + \varepsilon_t \qquad (3.3)$$

Equation (3.3) has an intercept term in it but no time trend. Again, the number of augmenting lags (p) is determined by minimizing the Schwartz Bayesian information criterion or minimizing the Akaike information criterion or lags are dropped until the last lag is statistically significant. We then use the t-statistic on the θ coefficient to test whether you need to difference the data to make it stationary or not. Notice the test is left-tailed.

The null hypothesis of the Augmented Dickey-Fuller t-test is:

$H_0: \theta = 0$ (The data needs to be differenced to make it stationary)

Versus the alternative hypothesis of

$H_1: \theta < 0$ (The data is stationary and doesn't need to be differenced)

When the time series has a trend in it (either up or down) and is potentially slow-turning around a trend line you would draw through the data, use the following test equation:

$$\Delta y_t = \alpha_0 + \theta y_{t-1} + \gamma_t + \alpha_1 \Delta y_{t-1} + \alpha_2 \Delta y_{t-2} + \cdots + \alpha_\rho \Delta y_{t-\rho} + \varepsilon_t \qquad (3.4)$$

Notice that this equation has an intercept term and a time trend. Again, the number of augmenting lags (p) is determined by minimizing the Schwartz Bayesian information criterion or minimizing the Akaike information criterion or lags are dropped until the last lag is statistically significant.

last lag is statistically significant. We then use the t-statistic on the θ coefficient to test whether we need to difference the data to make it stationary or you need to put a time trend in your regression model to correct for the variables deterministic trend. Notice the test is left-tailed.

The null hypothesis of the Augmented Dickey-Fuller t-test is:

$H_0: \theta = 0$ (The data needs to be differenced to make it stationary)

Versus the alternative hypothesis of

$H_1: \theta < 0$ (The data is trend stationary and needs to be analyzed by means of using a time trend in the regression model instead of differencing the data)

Sometimes if we have data that is exponentially trending then we might need to take the log of the data first before differencing it. In this case in our Dickey-Fuller unit root tests we will need to take the differences of the log of the series rather than just the differences of the series.

3.3.2 Philips-Perron Unit Root Test

Phillips(1987), Phillips and Perron (1988) generalized the DF tests to situations where disturbance processes, ε_t are serially correlated, other than by augmenting the initial regression with lagged dependent variables as in the ADF procedure. PP test is a non-parametric modification to the standard Dickey-Fuller t-statistic to account for the autocorrelation that may be present if the underlying data generation process (DGP) is not AR (1). Instead of adding AR terms in the DGP to account for (possible) MA terms, they modify the test statistic. However, Schwartz (1989) showed that PP test suffers from poor size properties if the MA term is large negative. Thus, ADF and PP tests suffer from quite opposite problems. While the ADF test does not suffer from as severe size distortions, it is not as powerful as the PP test.

The PP approach is to add a correction factor to the DF test statistic; suppose the AR (1) model is,

$$y_t = \mu + \varphi_1 y_{t-1} + \varepsilon_t, \ [t = 1 \ldots T] \tag{3.5}$$

With $Var(\varepsilon_t) \equiv \sigma_\varepsilon^2$. If ε_t is serially correlated the ADF approach is to add lagged ΔY_t to 'whiten' the residuals. To illustrate the alternative approach the test statistic $T(\varphi_1\text{-}1)$ has been considered which is distributed as ρ_μ from the maintained regression with an intercept but no time trend. The PP modified version is,

$$Z\rho_\mu = T(\varphi_1 - 1) - CF \tag{3.6}$$

Where the correction factor CF is

$$CF = 0.5(s^2_{Tl} - s_\varepsilon^2) / \left(\sum_{t=2}^{T} (Y_{t-1} - \bar{Y}_{-1})^2 / T^2 \right) \tag{3.7}$$

And, $$s_\varepsilon^2 = T^{-1} \sum_{t=1}^{T} \varepsilon_t^2 \tag{3.8}$$

$$s^2_{Tl} = s_\varepsilon^2 + 2 \sum_{s=1}^{l} W_{sl} \sum_{t=s+1}^{T} \varepsilon_t \varepsilon_{t-s} / T \tag{3.9}$$

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

$$\bar{Y}_{-1} = \sum_{t=2}^{T} Y_t / (T-1) \qquad \text{(Patterson 2002:264)} \tag{3.10}$$

The PP test does not require us to specify the form of the serial correlation of Δy_t under the null. In addition, the PP test does not require that the ε's are conditionally homoscedastic (an implicit assumption in the ADF test). If we apply the ADF test and have under-specified (p), the AR order, the test will be miss-sized. If we apply the ADF test and over-specify p, the test's power will suffer. These problems are avoided in the PP test, but if we can correctly specify (p), the PP test will be less powerful than the ADF test. Also, the PP test requires a "bandwidth" parameter selection (as part of the construction of the Newey-West covariance estimator) that creates finite sample problems analogous to those associated the lag length selection issue in applying the ADF test.

3.3.3 Cointegration Test: The Johansen's Approach

The present study has employed the Johansen (1988) and Johansen and Juselius (1990) technique to find the number of Cointegrating vector. The cointegration test helps to examine the long run equilibrium relationship between money supply (both M_1 and M_2) and price level. This procedure proposes Maximum likelihood (ML) estimation and evaluates multiple cointegrating vectors. The Johansen's cointegration test considers the following equations.

Let X_t be a vector of N time series, each of which is I(1) variable, with a vector autoregressive (VAR) representation of order k,

$$X_t = \pi_1 X_{t-1} + ... + \pi_k X_{t-k} + \varepsilon_t \tag{3.11}$$

Where, π_i are $(N \times N)$ matrices of unknown constants and ε_t is an independently and identically distributed (i.e. iid) n-dimensional vector with zero mean and variance matrix $\sum_e$ i.e. N $(0, \sum_e)$. The estimable equation for the cointegrating relationship is as follows:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k-1} + \pi X_{t-k} + \varepsilon_t \tag{3.12}$$

Where, Δ is the first difference operator.

$$\Gamma = \left(1 - \sum_{j=1}^{i} \pi_j\right), i = 1...(k-1)$$

$$\pi = \left(1 - \sum_{j=1}^{k} \pi_j\right)$$

In equation (3.12), all terms in X_t except πX_{t-k} are in first difference. According to Johansen and Juselius (1990) method, the rank of π determines the number of cointegrating vectors among the variables in X where π is an $(N \times N)$ matrix. If matrix π is of zero rank, the variables in X_t are said to be integrated of order one or a higher order implying the absence of a cointegrating relationship between the variables. In this case, the matrix π is null and equation ( ) reduces to a VAR in first difference. Similarly, if π is full rank, i.e. Rank (π) = N, all components of the system of equations are I(0) rather than I(1), that is, the variables in the system are stationary and the cointegration analysis is irrelevant. If Rank (π) =1, then there is a single cointegrating vector and the expression πX_{t-1} is the error correction term (ECT). Further, if the rank of π is $1 \leq$ Rank (π) (N-1), then there is the cointegrating case with the number of linearly independent cointegrating vectors being r = Rank (π). If π is of reduced rank, 0<r<n, π can be expressed as $\pi = \alpha\beta'$ where α & β are ($n \times r$) matrices, with r denoting the number of cointegrating vectors. Hence, although X_t itself is not stationary, the linear combination given by $\beta' X$ is stationary. Johansen and Juselius (1990) propose two likelihood ratio tests for the determination of the number of cointegrated vectors. One is the maximum Eigen value test which evaluates the null hypothesis that there are at most r cointegrating vectors against the alternative of $r + 1$ cointegrating vectors. The maximum Eigen value statistic is given by,

$$\lambda_{\max} = -T \ln(1 - \lambda_{r+1}) \tag{3.13}$$

Where, $\lambda_{r+1} \ldots \lambda_n$ are the n-r smallest squared canonical correlations and T = the number of observations. The second test is based on the trace statistic which tests the null hypothesis of r cointegrating vectors against the alternative of r or more cointegrating vectors. The statistic is given by,

$$\lambda_{trace} = -T \sum \ln(1 - \lambda_i) \tag{3.14}$$

In order to apply the Johansen and Juselius procedures, a lag length must be selected for the VAR. The lag length is selected on the basis of various criteria like SIC, LR, AIC FPE, HQ etc.

3.3.4 Vector Error Correction (VEC) Models

A vector error correction (VEC) model is a restricted VAR designed for use with non-stationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the *error correction* term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

The estimable VEC models are:

$$\Delta lnCPI_t = \gamma_1 + \rho_1 Z_{1t-1} + \sum_{i=1}^{n} \alpha_i (\Delta lnCPI_{t-i} + \Delta lnM_{t-i}) + \epsilon_{1t} \quad (3.15)$$

$$\Delta lnM_t = \gamma_2 + \rho_2 Z_{1t-1} + \sum_{i=1}^{n} \beta_i (\Delta lnCPI_{t-1} + \Delta lnM_{t-i}) + \epsilon_{2t} \quad (3.16)$$

Where, $\Delta LnCPI_t$= first difference of CPI in log form

ΔlnM_t= first difference of Money Supply (either M_1 or M_2) in log form

$Z_{1_{t-1}}, Z_{2_{t-2}}$ are the first lags of error terms in equation (3.15) & (3.16) respectively and γ_1, γ_2 are intercepts of equation (3.15) & (3.16) respectively. α_i are the coefficients of lagged ΔlnP_t&ΔlnM_t in equation (3.15) and β_i are the coefficients of lagged ΔlnP_t&ΔlnM_tin equation (3.16). In the estimation of VEC models, at least one of ρ_1 , ρ_2 should be non-zero.

3.3.5 Granger Causality

The technique of Granger causality was developed by C.W.J. Granger in 1969. It is an econometric method to find the causal relationship between two variables under stud. If two variables X and Y are found to be cointegrated, then we can use the Granger causality technique to find one way or two way causality. If only X causes Y or only Y causes X, then there will be unidirectional causality. But if X causes Y and Y also causes X, then there will be bidirectional causality running from X to Y and Y to X.

The models of Granger causality are given by the following equations (3.17) & (3.18).

$$\Delta LnCPI_t = \sum_{i=1}^{n} \alpha_i \, \Delta LnM_{t-i} + \sum_{i=1}^{n} \beta_j \, \Delta LnCPI_{t-j} + u_{1t} \quad (3.17)$$

$$\Delta LnM_t = \sum_{i=1}^{n} \gamma_i \, \Delta lnCPI_{t-i} + \sum_{j=1}^{n} \delta_j \, \Delta \mathrm{ln} M_{t-j} + u_{2t} \quad (3.18)$$

Where, $\Delta LnCPI_t$ first difference CPI in log form

ΔLnM_t= first difference of Money Supply in log form

Both variables used in equations (3.17) and (3.18) are known to be stationary.

3.3.6 Distributed Lags Models

In order to find the influence of money supply on price level, following OLS regression models have been used, where change in price level $dLnCPI_t$ is dependent variable and change in money supply $dLnM_{kt}$ with lagged terms are independent variables.

The distributed lag model (Gujrati, 2009, pp 678) for the regression of $dLnP_t$ on $dLnM_{kt}$ has been presented through equation (3.19).

$$dLnCPI_t = \alpha + \sum_{i=0}^{n} \beta_j dLnM_{kt-i} + + \varepsilon_t \quad (3.19)$$

Where,

$dLnCPI_t$ = Change of CPI in Log form

$dLnM_{kt-i}$ = Change of money supply in log form up to lag i = 0,1,2….n ($k = 1, 2$)

β_j = Rate of change of $dLnCPI_t$ with respect to unlagged & lagged $dLnM_{kt}$ (*j =1, 2…n & k=1,2*)

ε_t = Residual/ Error term, and α stands for constant term.

Other necessary statistical and econometric methodologies have been analyzed in the subsequent chapters and sections.

CHAPTER FOUR

MODELING OF FORECASTING INFLATION IN NEPAL

4.1Introduction

Inflation is a burning economic problem in the developing countries like Nepal that brings adverse effects on the macroeconomic variables like loss of purchasing power of domestic currency, unfavorable balance of payment (BOP) situation, decrease in national output, increase level of unemployment, increase in immoral activities such as theft, murdering, black marketing etc. inflation will have great social and economic costs like poverty, high income inequality and other chaos in social and economic lives. Due to these reasons, the central monetary authority of every economy has the common goal of price stability.

Inflation forecasting plays vital role in the monetary policy perspectives. A number of research studies have been carried out regarding inflation forecasting. Present researches suggest that inflation's predictors like monetary measures, output gap and others have become less sensitive for inflation determination and now inflations are claimed to be more unpredictable. Univariate models tend to show a better forecasting capacity than those based on various inflation theories, such as the Phillips curve. Traditionally, in industrialized countries the Phillips curve has played a predominant role in inflation forecasting, and according to Stock and Watson (1999), Atkenson and Ohanian (2001) and Canova, (2002), it would seem to perform better in terms of forecasting error than other alternative models. In recent years there have been indications, in the United States in particular, that the Phillips curve became unstable as from the eighties, and that perhaps for this reason, its forecasting ability has weakened, in general being overcome by univariate models.

Isakova (2007) opines that central bank should have the full information regarding the economic performance of the country. The central banks should acquire the knowledge on the behavior and interrelationships between and among the macroeconomic indicators to develop effective monetary policies. More the central banks are aware about the macroeconomic indicators; more effective the monetary policies are formulated. The inflation forecasts are most inevitable to formulate the monetary policy in such a way as to stabilize macroeconomic variables like price, output, employment, rate of interest, foreign exchange etc. thus, it is the duty of monetary economists to provide maximum information regarding the inflationary processes in the economy to assist central bank to formulate the suitable monetary policies for economic stability.

Although inflation forecasting is necessary for the economy, it is very difficult job in developing countries like Nepal due to the reasons that economic activities are highly unstable and volatile. Besides, the data on macroeconomic indicators are so reliable due to some reasons like measurement error, imperfect method of measurement, lack of record keeping of the related data etc.

A number of empirical studies are available in the economic literatures regarding the determinants of inflation in developing countries that show inflation is a country-specific phenomenon, and the determinants of inflation differ from country to country. The effectiveness of monetary policy of a country, therefore, depends on the ability of economists to develop a suitable and reliable model that could contribute in acquiring knowledge on the existing economic events forecast for future. So far as the forecasting of inflation is concerned, the central bank will be able to formulate the monetary targets, goals and policies to make the economy walk in the right track maintaining the economic stability.

The central role of inflation expectations has long been recognized in both macroeconomic theory and stabilization policy analysis. Wage bargaining, price setting, asset allocation and investment, all depend on inflationary expectation on one way or another. While inflation expectations received scrupulous attention in market economies over a long period of time, interest for the topic in the former socialist economies arose only with liberalization attempts at the beginning of transition. Given the lack of experience with open inflation on the part of economic agents in majority of transition economies, the literature on the formation of expectations in these economies is still rather trivial. (Nikolic, 2003).

Long-term nominal commitments such as labor contracts, mortgages and other debt, and price stickiness are widespread features of modern economies. In such a world, forecasting how the general price level will evolve over the life of a commitment is an essential part of private sector decision-making. The existence of long-term nominal obligations is also among the primary reasons economists generally believe that monetary policy is not neutral, at least over moderate horizons. While macroeconomists continue to debate whether these non-neutralities give rise to beneficially exploitable trade-offs for monetary policymakers, the recent New Keynesian formulation of optimal policy has raised the prominence of inflation forecasting in policymaking (Woodford (2003). Central banks aim to keep inflation stable, and perhaps also to keep output near an efficient level. With these objectives, the New Keynesian model makes explicit that optimal policy will depend on optimal forecasts (Svensson, 2005), and further that policy will be most effective when it is well understood by the general public. These results helped bolster a transparency revolution in central banking. A centerpiece of this revolution has been the practice of central banks announcing forecasts of inflation and other key variables.

4.2 ARMA/ARIMA Modeling for Forecasting

The dependence of one variable on other/s is very common in time series observations. To model this time series dependence, we start with univariate ARMA models. To motivate the model, basically we can track two lines of thinking. First, for a series X_t, we can model that the level of its current observations depends on the level of its lagged observations. For example, if we observe a high inflation realization this quarter, we would expect that the inflation in the next few quarters will be high as well. This way of thinking can be represented by an AR model. The AR (1) (autoregressive of order one) can be written as:

$$X_t = \psi X_{t-1} + \varepsilon_t \qquad (4.1)$$

Where$\varepsilon_t \sim iid(0, {\sigma_t}^2)$ and we keep this assumption through this analysis. Similarly, $AR(p)$ (autoregressive of order ρ) can be written as:

$$X_t = \psi_1 X_{t-1} + \psi_2 X_{t-2} + \cdots + \psi_\rho X_{t-\rho} + \varepsilon_t \qquad (4.2)$$

Alternatively, we can model that the observations of a random variable at time t are not only affected by the shock at time t, but also the shocks that have taken place before time t. For example, if we observe a negative shock to the economy, say, a catastrophic earthquake, then we would expect that this negative effect affects the economy not only for the time it takes place, but also for the near future. This kind of thinking can be represented by an MA model. The $MA(1)$ (moving average of order one) and $MA(q)$ [moving average of order (q)] can be written as:

$$X_t = \varepsilon_t + \theta\varepsilon_{t-1} \tag{4.3}$$

And

$$X_t = \varepsilon_t + \theta_1\varepsilon_{t-1} + \theta_2\varepsilon_{t-2} + \cdots + \theta_q\varepsilon_{t-q} \tag{4.4}$$

If we combine these two models [model (4.2) and model (4.4)], we get a general $ARMA(p,q)$ model,

$$X_t = \psi_1 X_{t-1} + \psi_2 X_{t-2} + \cdots + \psi_\rho X_{t-\rho} + \varepsilon_t + \varepsilon_t + \theta_1\varepsilon_{t-1} + \theta_2\varepsilon_{t-2} + \cdots + \theta_q\varepsilon_{t-q} \tag{4.5}$$

Economic time series are usually non-stationary that contain unit root. These non-stationary time series are said to be integrated. Hence, the differencing of integrated series is necessary to obtain the stationary series. A time series is said to be integrated of order one as its first difference is stationary and denoted by $I(0)$. In the same manner, if a time series becomes stationary after second differencing, it can said to be $I(2)$, and its second difference is stationary and can be expressed as $I(0)$. In general, if a time series is $I(d)$ after differencing it d times, the series becomes an $I(0)$.

Therefore, if we have to difference a time series d times to make it stationary and apply the $ARMA\ (p,q)$ model to it, then our model converts into $ARIMA(p,d,q)$. Thus, we have the Autoregressive Integrated Moving Average $ARIMA$ with p autoregressive terms, d number of times needed to get difference series and q number of moving average terms.

4.3 ARMA/ARIMA Structure: The Box-Jenkins Approach

The box-Jenkins approach popularized by Box and Jenkins (1970)[17] is one of the most widely used methodologies for the analysis of time series data. It is popular because of its generality; it can handle any series with or without seasonal elements, and it has well-documented computer program.

The basic steps in Box-Jenkins approach are:

[17] Box and Jenkins (1970). Time Series Analysis. First Edition.

- Differencing the series to achieve stationarity. The stationary series can be achieved by differencing by studying the graph of correlogram and unit root tests.
- Estimation of tentative $ARMA$ model by inspecting the correlogram of difference series.
- Having chosen a particular $ARMA$ modeling, and having estimated parameters, it is necessary to examine whether the selected model fits the data reasonably well. If the selected $ARMA$ model is not efficient, we should develop another $ARMA$ model by the same procedures.

4.4 Stability Test of ARMA/ARIMA Modeling

4.4.1 Durbin-Watson Test

The Durbin Watson test is a famous method for testing the serial correlation problem. The serial correlation is a serious problem contained in regression where the residuals are serially correlated. Due the presence of serial correlation, the predicted value of dependent variable in the regression is highly questioned that the estimated value has no reliability. It is a statistic on the basis of which the reliability of estimated coefficient of independent variable that affects dependent variable can be assessed. The D-W statistic can be computed using the following formula.

$$d = \frac{\sum_{t=2}^{n} (\varepsilon_t - \varepsilon_{t-1})^2}{\sum_{t=1}^{n} \varepsilon_t^2}$$

Where, d represents Durbin-Watson (D-W) statistic, ε_t the observed error term or $\left(Y_t - \hat{Y}_t\right) = Y_t - a - bX_t$. The value of d always lies between zero and four. If value of d is zero, then there exists perfect positive correlation among the residuals, and there occurs perfect negative correlation when d is equal to 4. If the error terms are uncorrelated, the expected value of d is equal to 2. There occurs positive first order serial correlation if value of d is further below 2, and as value of d is further above 2 there exists negative serial correlation among the residuals. However, D-W test alone is inconclusive to detect the serial correlation.

The critical values of d for a given level of significance can be tabulated as the pairs of lower d and upper d (d_L& d_U). As the value of d falls between $d_L and\ d_U$, the D-W test becomes inconclusive.

H_0:$\rho = 0$ (No serial correlation)

H_1:$\rho > 0$ (Positive serial correlation)

If $d < d_L$, reject H_0, while if $d < d_U$, do not reject H_0

However, the critical test limits for negative serial correlation are (4 - d_L) and (4- d_U).

H_0:$\rho = 0$ (no serial correlation)
H_1: $\rho < 0$ (negative serial correlation)
If d < (4 - d_U), do not reject H_o, if (d > 4 - d_L), reject H_o.

4.4.2 Residual Diagnostics

4.4.2.1 Correlogram-Q-Statistics for Autocorrelation

Residual Diagnostics/Correlogram-Q-statistics is another test for autocorrelation or serial correlation based on residuals of estimated ARMA model. For this, we run correlogram of Residual Square, together with the Ljung-Box Q-statistics for high-order serial correlation. If there is no serial correlation in the residuals, the autocorrelations and partial autocorrelations at all lags should be nearly zero, and all Q-statistics should be insignificant with large p-values.

4.4.2.2 Normality Test: Jarque-Bera Statistic

In order to find whether or not the residuals of regression equation are normally distributed, we apply Jarque-Bera statistic with the null hypothesis that residuals are normally distributed. With the help of estimated Jarque-Bera statistic corresponding to its probability, we can make the decision that residuals are normally distributed or not normally distributed. If the probability value of Jarque-Bera statistic is above 5 % (0.05), the residuals are claimed to be normally distributed and there will not be serial correlation problem, that is, residuals are not serially correlated and the estimated ARMA model represents the goodness of fit. Contrary to this, if probability of Jarque-Bera statistic is less than 0.05 the residuals are not normally distributed and estimated ARMA does not represent the goodness of fit, there is strong evidence of serial correlation. However, Jarue-Bera test alone is not the sufficient tool for testing normality and serial correlation.

4.4.2.3 Lagrange Multiplier (LM) Test

The D-W test assumes that the regressors are nonstochastic, that is, their values are fixed in repeated sampling. But the assumption of regressors as nonstochastic may not always be true. If the regressors are not nonstochastic, then D-W will not be valid either in finite, or small samples or in large samples. The assumption of D-W test is very difficult to maintain in time series econometric models. (Gujrati, 2009, pp 482). Thus, in case of time series econometric models with large samples the Breusch-Godfrey Lagrange Multiplier (B-G LM) test.

Breusch (1978) and Godfrey (1978) have developed a test of autocorrelation for time series econometric model with nonstochastic regressors, the lagged values of regressand; higher-order autoregressive schemes; and simple or higher-order moving averages of white noise error terms ε_t.

Consider the model with two regressors with reference to a ρ^{th} order autoregressive scheme,

$$Y_t = \beta_1 + \beta_2 X_{1t} + \beta_3 X_{2t} + \varepsilon_t \tag{4.6}$$

Assume that the error term ε_t follows the ρ^{th} order autoregressive, AR(ρ) scheme as follows:

$$\varepsilon_t = \rho_1 \varepsilon_{t-1} + \rho_2 \varepsilon_{t-2} + \cdots + \rho_\rho \varepsilon_{t-\rho} + u_t \tag{4.7}$$

The null hypothesis H_0 to be tested is given by:

$$H_0\colon \rho_1 = \rho_2 = \cdots = \rho_{\rho=0} \tag{4.8}$$

If H_0 is not rejected, there will not be serial correlation of any order. The B-G LM test follows following steps.

(1) Estimate equation (4.6) using OLS regression.

(2) Find the residuals $\hat{\varepsilon}_t$ and regress $\hat{\varepsilon}_t$ on the X_t. But if the model consists more than one X_t variable and including them also obtain $\varepsilon_{t-1,}\varepsilon_{t-2} \ldots \varepsilon_{t-p}$

Thus, we will have the following regression model:

$$\hat{\varepsilon}_t = \alpha_1 + \alpha_2 X_t + \hat{\rho}_1 \hat{\varepsilon}_{t-1} + \hat{\rho}_2 \hat{\varepsilon}_{t-2} + \cdots + \hat{\rho}_\rho \hat{\varepsilon}_{t-\rho} + u_t \tag{4.7}$$

Obtain R^2 from equation (4.7).

If the sample size is large, B-G LM model gives as:

$$(n-\rho)R^2 \sim \chi_\rho{}^2 \tag{4.8}$$

Now, in B-G LM model, we can define a $\chi_\rho{}^2$ variable with h degrees of freedom as:

$$\frac{SSR_R - SSR_U}{\hat{\sigma}_R^2} \sim \chi_\rho{}^2 h \tag{4.9}$$

Where h is degree of freedom, equal to order of autoregression $(h=\rho)$. SSR is the sum of squares residuals for the restricted and unrestricted equations and $\hat{\sigma}_R^2$, the estimated variance of the restricted equation. Now, equation (4.9) can be extended as:

$$\frac{SSR_R - SSR_U}{\hat{\sigma}_R^2} = \frac{SST - SSR}{SST/N} = NR^2 = T \times R^2 \tag{4.10}$$

After finding the value of $T \times R^2$, it should be compared with the relevant critical value for χ^2 where the degree of freedom, h is the order of the autoregressive scheme. The null hypothesis of the B-G LM test is: Ho: 'no autocorrelation, will be rejected if $T \times R^2 > \chi^2$h critical value.

4.5 ARCH and GARCH Estimation for Forecasting

The autoregressive conditionally heteroscedastic (ARCH) process introduced by Engle (1982) is taken as one of the well known and most often used modeling, which can be applied for the highly volatile economic and financial time series with non-constant variance (heteroscedastic). The RCH model has been generalized by different authors like Bollerslev (1986), Gourieroux (1997) and so on. (Berkes, Horvath and kokoszka, 2003)

The ARCH modeling process was introduced by Engle (1982), which states that time series have the conditional variance over time. The ARCH modeling with heteroscedasticity is proven useful in different economic phenomena. For example, Engle (1982, 1983) and Engle and Kraft (1983) have built the ARCH modeling for the inflation rate. Coulson and Robins (1985) concluded that the estimated inflation volatility is related to some key macroeconomic variables. (Bollerslev, 1986).

The traditional time series models assume that conditional variance remains constant. But in reality, most of the economic and financial series frequently exhibit the non-constant conditional variance. Nortey, et.al.(2014) argue that heteroscedasticity affects the accuracy of forecasts confidence limits. So it is requisite to construct suitable model of time series for forecasting. Since the economic and financial time series are highly volatile with non-constant variance (heteroscedastic), the ARCH model and its variants like GARCH and EGARCH models have been developed for modeling such volatile time series with non-constant variance for forecasting.

However, the present study is concerned with the modeling of inflation for forecasting using ARCH and GARCH, where the conditional error variance is taken as the function of the past realization of the time series. Economists argue that inflation for the periods are usually followed by further periods' inflation, which means periods of high inflation are followed by further periods' inflation and vice-versa.

4.5.1 Developing ARCH/GARCH Model

While developing an ARCH model, it is necessary to examine three conditions. First is the conditional mean equation; second the conditional variance; and third error distribution, each of which can be mentioned below.

The GARCH(1, 1) Model

Let us commence with the simplest $GARCH\ (1, 1)$ model,

$$Y_t = X_t'\theta + \varepsilon_t \tag{4.11}$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{4.12}$$

The mean equation given in (4.11) can be written as a function of exogenous variables with an error term. The σ_t^2 in equation (4.12) is the one-period ahead forecast variance based on past information; it is called the conditional variance. The conditional variance equation specified in (4.12) is a function of three terms, a constant term ω, the ARCH term ($\varepsilon^2{}_{t-1}$) and the GARCH term ($\sigma^2{}_{t-1}$).

GARCH (1, 1) model consists of a first-order autoregressive GARCH term in and a first-order moving average ARCH term. The ARCH model is a special case of a GARCH model where there will not be the lagged forecast variances in the conditional variance equation.

This type of specification can be found in financial market. In financial market, a trader's forecast of current period's variance is generated by a weighted average of long term average, the forecasted variance from last period (GARCH term), and information about volatility observed in the past period (ARCH term). If the return from asset becomes large, the trader can increase the estimate of the variance for the next period. This trend occurs not only in financial market but also in economic sphere like inflation, where larger inflation in current time is likely to be followed by further large inflation in future.

Based on the above logic, if the lagged variance is recursively substituted on the right hand side of equation (4.12), we may arrive at the current conditional variance as a weighted average of all the lagged squared residuals given by equation (4.13).

$$\sigma_t^2 = \frac{\omega}{1-\beta}\alpha\sum_{j=1}^{\infty}\beta_{j-1}\,\varepsilon_{t-j}^2 \tag{4.13}$$

Equation (4.13) can be presented as:

$$\sigma_t^2 = \omega + (\alpha+\beta)^2\varepsilon_{t-1}^2 + v_t - \beta v_{t-1} \tag{4.14}$$

Where, $v_t = \varepsilon_t^2 + \sigma_t^2$

Equation (4.14) implies that the squared errors follow the heteroscedastic ARMA (1,1) process. The term $(\alpha+\beta)$ in equation (4.14) represents the autoregressive root that governs volatility shocks.

The GARCH (q, p)Model

Higher order GARCH models, denoted GARCH (q, p), can be estimated by choosing either q or p greater than 1 where q is the order of the autoregressive GARCH terms and p is the order of the moving average ARCH terms. The representation of the hence, the modeling of GARCH (q, p) can be written as:

$$\sigma_t^2 = \omega + \sum_{j=1}^{q}\beta_j\,\sigma_{t-j}^2 + \sum_{i=1}^{p}\alpha_i\sigma_{t-i}^2 \tag{4.15}$$

4.6 Stability of the ARCH-GARCH Model

Goodness of fit of the ARCH-GARCH model is based on residuals and is more specifically on the standardized residuals (Talke, 2003). The residuals are assumed to be independently and identically distributed following either a normal or standardized t-distribution (Tsay, 2002) or (Gourieroux, 2001). Plots of the residuals such as the histogram, the normal probability plot and the time plot of the residuals can be used.

If the model fits the data well the histogram of the residuals should be approximately symmetric. The normal probability plot should be a straight line while the time plot should exhibit random variation. The ACF and the PACF of the standardized residuals are used for checking the adequacy of the conditional variance model. The Engle's test and the Ljung Box Q-test are used to check the validity of the ARCH effects in the data. Having established that our model fits the data well, we can now use the fitted model to compute forecasts.

4.6.1 Model selection Criteria

The selection of suitable model from the given time series is a serious challenge in statistical and econometric modeling. There are different criteria for selecting the suitable model. If the selected model is suitable, it represents the goodness of fit and bears the property of stability of the model. The most common model selection criteria are AIC and BIC, on the basis of which the researchers can develop the reliable model. If fitted model suitable, the forecasting is more reliable.

4.6.1.1 The Akaike Information Criterion

The Akaike information criterion (AIC) was developed by Professor Hirotugu Akaike in 1971 and introduced in 1973 as an extension to the maximum likelihood principle for the selection of suitable model. "Akaike (1973) defined the most well-known criterion as AIC = - $\ln L + p$, where L is the likelihood for an estimated model with p parameters". (Hjorth,1994). The estimated model is claimed to be suitable if the value of AIC is minimum for the particular lag. We employ different lags in the proposed model and go on observing the AIC value on a trial and error basis. The fitted model with minimum AIC can be taken as the suitable model.

4.6.1.2 The Schwartz Criterion

The Schwartz Criterion also called Bayesian information criterion (BIC) is related to the Bayes factor and is useful for model comparison in its own right. The BIC of a model is defined as:

$$\frac{SC}{BIC} = -\,2ln(likelihood) + \ (k \ + \ klnN)$$

Where k denotes the number of parameters and N denotes the number of observations or equivalently, the sample size. BIC penalizes more complex models (those with many parameters) relative to simpler models. This definition permits multiple models to be compared at once; the model with the highest posterior probability is the one that minimizes BIC.

A desirable model is one that minimizes the AIC or the BIC. The other criteria are the R2 associated with the model which is the proportion of variability in a data set that is accounted for by the statistical model (Salkind, 2007). However, as Harvey (1991) indicated that the coefficient of determination (R^2) has a limitation in that, a model which can pick out the trend reasonably well will have R^2 close to unit. In general a model selected by two different criteria mentioned above may differ and thus it should be emphasized that the selection of an ARCH-GARCH model depends on the selection criteria used (Talke, 2003).

4.6.2 Lagrange Multiplier Test for ARCH Effects

The Lagrange Multiplier (LM) test examines whether there is any ARCH effect up to order q in the residuals with null hypothesis of no ARCH effect up to order q in the residuals of estimated GARCH model. The ARCH LM test can be used to identify whether the standardized residuals exhibit further ARCH. If the variance equation is correctly modeled, there cannot be the ARCH effect in the standardized residuals.

The squared series a_t^2 is used to check for conditional heteroscedasticity, where $a_t = r - \mu$ is the residual of the ARMA model. For checking heteroscedasticity, the Lagrange multiplier test is used. This test is equivalent to usual F statistics test. The null hypothesis is: H_0: $\alpha_1 = \alpha_2 = \cdots = \alpha_m = 0$

4.7 Graphical Plot of $LnCPI_t$ and $dLnCPI_t$

The raw data sets associated with inflation ($LnCPI_t$) is plotted in Figure-4.1. From the plot of line graph of $LnCPI_t$, it is observed that the data sets are varying with respect to time that seems to be non-stationary. The non-stationary data sets produce spurious regression results unless they are converted into stationary form. So it is necessary to convert the data sets into stationary with first difference. The line graph of $LnCPI_t$ in first difference is presented in Figure-4.2.

Figure-4.1: Line Graph of $LnCPI_t$ in Level Form

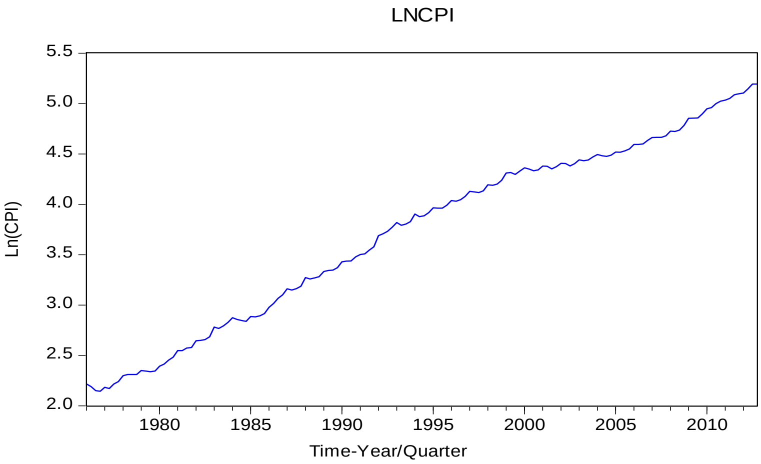
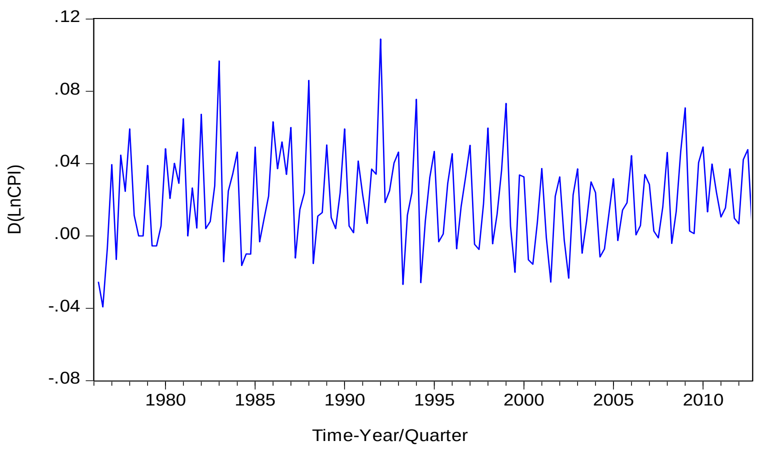


Figure-4.2: Line Graph of $LnCPI_t$ in First Difference



The plot of $LnCPI_t$ in its first difference is not found to be varying with time. The ups and downs of the data sets are the indication of stationarity.

ADF unit root test is the very important econometric technique to examine the stationarity of the data sets. ADF test statistic has to be rejected in order to have stationary process because null hypothesis of Augmented Dickey Fuller test assumes the presence of unit root in time series data. After taking differences and logarithms, the ADF statistics increased significantly and the probability of accepting null hypothesis becomes zero at 1% critical level. Therefore, we rejected the null hypothesis which implied that there was no unit root and the series are stationary.

From Table-4.1, it is observed that the null hypothesis of "$LnCPI_t$ has unit root" cannot be rejected even at 10 % level of significance as reported by t-statistic of ADF unit root test. However, the null hypothesis "$dLnCPI_t$ has unit root" is rejected at 5 % level of significance. Therefore, it can be concluded that $LnCPI_t$ is non-stationary at level form and is stationary at first difference. The first difference of $LnCPI_t$ represents the inflation rate. So, we use the first difference of $LnCPI_t$ as a dependent variable in OLS regression of forecasting inflation.

Table- 4.1: ADF Unit Root Test of $LnCPI_t$

Variable	ADF test statistic	Prob value	Lag length	Test Critical Values 1%	5%	10%
$LnCPI_t$	-1.0482	0.7347	8	-3.4778	-2.8822	-2.5779
$dLnCPI_t$	-3.2268	0.0205	7	-3.4778	-2.8822	-2.5779

4.8 Modeling of ARMA

In order to develop $ARMA(q,p)$ modeling it is necessary to examine suitable AR and MA terms of the stationary variable, $LnCPI_t$. For this, we can have tentative ideas for $ARMA$ with the help of correlogram. Table-4.2 presents the correlogram of $LnCPI_t$

Table-4.2: Correlogram of $LnCPI_t$

```
. ac dlncpi, lags(15) level(99.9)

. corrgram dlncpi, lags(20)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1       -0.0226  -0.0227  .07635  0.7823
2       -0.2207  -0.2242  7.4369  0.0243
3       -0.0826  -0.1133  8.4743  0.0372
4        0.5891   0.5697  61.626  0.0000
5       -0.1814  -0.2898  66.701  0.0000
6       -0.3082  -0.1659  81.459  0.0000
7       -0.1538  -0.1346  85.158  0.0000
8        0.5812   0.3554  138.39  0.0000
9       -0.1254  -0.0503  140.89  0.0000
10      -0.2181   0.0554  148.49  0.0000
11      -0.0666   0.0247  149.21  0.0000
12       0.5566   0.1108  199.47  0.0000
13      -0.1046   0.0160  201.26  0.0000
14      -0.2517  -0.0764  211.69  0.0000
15      -0.1321  -0.0917  214.59  0.0000
16       0.5162   0.1464  259.13  0.0000
17      -0.1797  -0.1081  264.57  0.0000
18      -0.2515   0.0509  275.31  0.0000
19      -0.1213  -0.1130  277.83  0.0000
20       0.5640   0.2843  332.68  0.0000
```

From Table-4.3, it is observed that ACFs are statistically different from zero at lags 2,4,5,6,8,10 &12 but PACFs are statistically different from zero at lags 2,4,5,6 and 8. Based on PACF, we can model $LnCPI_t$ with its AR(2,4,5,6,8) and including MA(1) term as:

$$dLnCPI_t = c + \varphi_1 dLnCPI_{t-2} + \varphi_2 dLnCPI_{t-4} + \varphi_3 dLnCPI_{t-5} + \varphi_4 dLnCPI_{t-6} + \varphi_5 dLnCPI_{t-8} + \theta_1 \varepsilon_{t-1} \quad (4.16)$$

The OLS results in accordance with model (4.16) are presented through Table-4.3.

Table-4.3: Results from ARMA Modeling with AR (2,4,5,6,8) & MA(1)

Dependent Variable: $dLnCPI_t$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	$\alpha_1 =$ 0.0105	0.0034	3.0832	0.0025
$dLNCPI_{t-2}$	$\varphi_1 =$ 0.0362	0.0801	0.4519	0.6521
$dLNCPI_{t-4}$	$\varphi_2 =$ 0.3831	0.0766	4.9961	0.0000
$dLNCPI_{t-5}$	$\varphi_3 =$ -0.1209	0.0608	-1.9875	0.0489
$dLNCPI_{t-6}$	$\varphi_4 =$ -0.1510	0.0776	-1.9439	0.0540
$dLNCPI_{t-8}$	$\varphi_5 =$ 0.3563	0.0767	4.6449	0.0000
ε_{t-1}	$\theta_1 =$ 0.1716	0.0891	1.9240	0.0565

R^2 =0.5393, $\bar{R}^2$ =0.5184, S.E. of regression=0.0178, D-W stat=2.0127

From Table-4.4, it is observed that the coefficients of AR at lag 4,5 and 8 are significant at 5 % level, where as the coefficients of AR (6) and MA(1) are significant at 10 % level. However, the coefficient of AR (2) is not significant even at 10 % level.

Although the coefficient of AR (2) is not significant, the D-W statistic is 2.01~2. This implies that the residuals of $ARMA$ model (4.1) are not correlated. This $ARMA$ model (4.1) is free from serial correlation. Due to this fact, there is goodness of fit of the $ARMA$ model. Therefore, $ARMA$ model (4.16) can be taken as the suitable model of inflation forecasts during the study period in the economy of Nepal.

However, ARMA model (4.16) is still not efficient model due to the reason that the coefficient of $AR(2)$ is not significant. The $AR(2)$ term being meaningless in the $ARMA$ model, this needs omission from $ARMA$ model (4.16). But the decision of omitting the $AR(2)$ term from $ARMA$ model (4.16) or not depends on redundant test.

Under Redundant test, the null hypothesis is that the regression of $dLnCPI_t$ on its AR and MA terms has the redundant variable $dLnCPI_{t-2}$. When the redundant test is applied to the regression model, the null hypothesis is not rejected as reported by t-statistic, F-statistic and Log Likelihood Ratio in Table-4.4, and it can be concluded that $dLnCPI_{t-2}$ term is redundant that can be withdrawn from the regression model (4.16).

Table-4.4: Redundant Test

Redundant Variables: $dLNCPI_{t-2}$

Test-statistic	Value	Degree of Freedom	Probability
t-statistic	0.455551	132	0.6495
F-statistic	0.207527	(1, 132)	0.6495
Likelihood ratio	0.218361	1	0.6403

When the regressor $dLnCPI_{t-2}$ is dropped from ARMA equation (4.16), our new ARMA equation becomes:

$$dLnCPI_t = \alpha + \varphi_1 dLnCPI_{t-4} + \varphi_2 dLnCPI_{t-5} + \varphi_3 dLnCPI_{t-6} + \varphi_4 dLnCPI_{t-8} + \theta_1 \varepsilon_{t-1} \tag{4.17}$$

The results from regression in accordance with equation (4.17) are presented through Table-4.5.

Table-4.5: Results from ARMA Modeling with AR (4,5,6,8) & MA(1)

Dependent Variable: $dLnCPI_t$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	α_1 = 0.0110	0.0032	3.4002	0.0009
$dLNCPI_{t-4}$	φ_1 =.-0.1234	0.0597	-2.1632	0.0323
$dLNCPI_{t-5}$	φ_2 = -0.1291	0.0752	4.6574	0.0000
$dLNCPI_{t-6}$	φ_3 = 0.3502	0.0763	5.0187	0.0000
$dLNCPI_{t-8}$	φ_4 =0.1676	0.0879	1.9064	0.0587
ε_{t-1}	θ_1= -0.3833	0.0032	3.4002	0.0009

R^2 =0.5386, $\bar{R}^2$ =0.5212, S.E. of Regression=0.0177, D-W stat=2.0005

Table-4.5 shows the results of ARMA model after dropping AR (2) term from ARMA model (4.16). The coefficients of all ARMA terms are found to be statistically significant at 5 % and 10 % level. The value of $\bar{R}^2$ is improved in equation (4.17) as compared to equation (4.16). The D-W statistic is also found to be improved, which is 2, which means the residuals are free from serial correlation. The ARMA model represents the goodness of fit to the data.

Therefore, after redundant test our ARMA model (4.16) converts as:

$$dLnCPI_t = 0.011 - 0.1234\, dLnCPI_{t-4} - 0.1291\, dLnCPI_{t-5} + 0.3502\, dLnCPI_{t-6} + 0.1676\, dLnCPI_{t-8} - 0.3833\, \varepsilon_{t-1} \quad (4.18)$$

4.8.1 Residuals Diagnostic Tests

For the efficiency of ARMA model (4.17) or (4.18), further some tests are necessary to perform as residuals diagnostic tests.

4.8.1.1 Correlogram of Squared Residuals

For the stability of ARMA model (4.18), we test the serial correlation with the help of correlogram of square residuals. The correlogram of squared residuals of ARMA model (4.18) has been presented through Table-4.6.

Table-4.6: Correlogram of Squared Residuals of ARMA Equation (4.18)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.025	-0.025	0.0900	-	9	-0.018	-0.025	1.9100	0.984
2	0.038	0.037	0.2973	0.586	10	-0.023	-0.021	1.9924	0.992
3	-0.052	-0.050	0.6870	0.709	11	0.029	0.024	2.1250	0.995
4	0.038	0.034	0.8921	0.827	12	-0.071	-0.078	2.9050	0.992
5	0.049	0.054	1.2402	0.871	13	0.073	0.068	3.7422	0.988
6	0.014	0.011	1.2693	0.938	14	0.048	0.060	4.0972	0.990
7	0.063	0.064	1.8547	0.933	15	-0.004	-0.014	4.0997	0.995
8	-0.007	-0.001	1.8631	0.967	16	0.102	0.115	5.7596	0.984

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 fitted ARMA model (4.18) are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of the ARMA model (4.17) or (4.18).

4.8.1.2 Breusch-Godfrey LM Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation have been presented through Table-4.7.

Table-4.7: Breusch-Godfrey Serial Correlation LM Test

Summary	Statistics	Degree of Freedom	Probability
F-statistic	0.261774	F(1,132)	0.6098
$T \times R^2$	0.274932	χ^2 (1)	0.6000

As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test of Table-4.7, the null hypothesis of no autocorrelation cannot be rejected. The B-G LM test implies that residuals are not serially correlated. Due to the non-presence of serial correlation, the ARMA model of equation (4.17) is considered as the consistent model for forecasting of inflation in Nepalese economy.

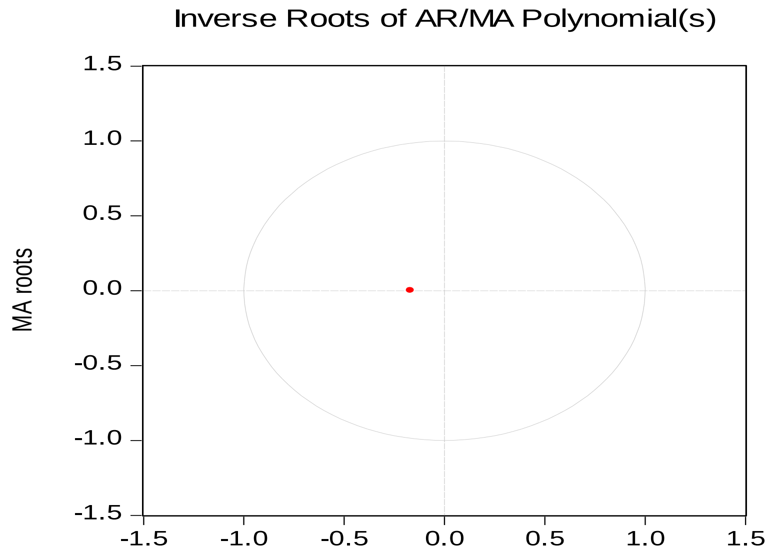
4.8.2 Inverse Roots of ARMA Polynomials

The inverse root of ARMA polynomials is another test for consistency of ARMA model. The modulus of the root represents the consistency of the model. If modulus is less than 1, the fitted ARMA model is claimed to be the model of best of fit. In Table-4.8, the modulus is $0.167 < 1$ representing the invertible ARMA model.

Table-4.8: Inverse Roots of ARMA Polynomial

MA Root(s)	Modulus
-0.167624	0.167624

Figure-4.3: Inverse Roots of ARMA Polynomials



The graph view plots the roots in the complex plane where the horizontal axis is the real part and the vertical axis is the imaginary part of each root. If the estimated ARMA process is (covariance) stationary, then all AR roots should lie inside the unit circle. If the estimated ARMA process is invertible, then all MA roots should lie inside the unit circle. Table-4.8 view displays all roots in order of decreasing modulus (square root of the sum of squares of the real and imaginary parts).

For imaginary roots (which come in conjugate pairs), we also display the cycle corresponding to that root. The cycle is computed as: $\frac{2\pi}{\alpha}$, where ,. $\alpha = \tan(\frac{i}{r})$, and i and r are the imaginary and real parts of the root, respectively

4.8.3 ARMA Frequency Spectrum

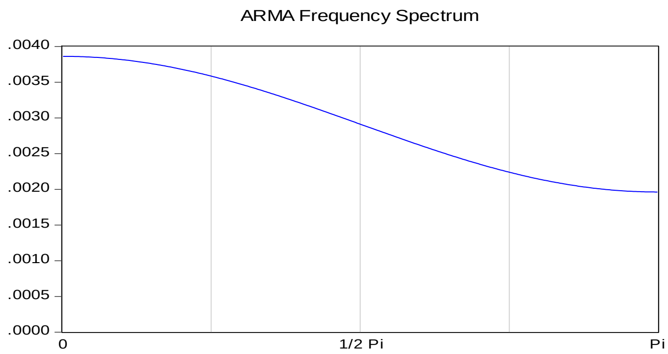
The ARMA frequency spectrum of an ARMA equation represents the range of the estimated ARMA terms in the frequency domain irrespective of time domain. In time domain we examine the autocorrelation functions of the time series, where as in frequency domain we can observe cyclical characteristics of the fitted ARMA model.

The spectrum of an ARMA process can be written as a function of its frequency, λ, where λ is measured in radians, and thus takes values from $-\pi \; to \; \pi$. If a series has strong AR components, the shape of the frequency spectrum will contain peaks at points of high cyclical frequencies. If spectrum density is decreasing, the power is concentrated on low frequency, corresponding to gradual long-range fluctuations.

Contrary to this, if spectrum density is increasing, the power is concentrated on high frequency, which reflects the fact that such a process tends to oscillate.

In Figure-4.4, frequency spectrum tends to fall; meaning the power of frequency spectrum is concentrated on low frequency. This implies that there is a gradual long-range fluctuation of inflation in the economy of Nepal.

Figure-4.4: Graph of Frequency Spectrum of ARMA model (4.13)



4.9 Estimation of ARCH/GARCH Models

4.9.1 GARCH (1,1) Model and Its Stability

Under GARCH modeling, first we have fit GARCH (1,1) model and observed the ARCH effects on it. Table-4.9 presents the results from GARCH (1,1) model using backcast values for the initial variances and computing Bollerslev-Wooldridge standard errors .

The ARCH estimation with 'Variance Equation' contains the coefficients, standard errors,Z-statistics and P-values for the coefficients of the variance equation. The coefficient of ε_t^2 (-1) ^{2} is the ARCH parameter α and coefficient of GARCH (-1) is the GARCH parameter, β. In the results, the sum $\alpha + \beta$ < 1, indicating that volatility shocks of inflation are not persistent. The value of α is significant at less than 1% level as reported by Z-statistic, but the value of β is not significant even at 10 % level.

Table-4.9: Results from GARCH (1,1)

Method: ML - ARCH (Marquardt) - Normal distribution

Bollerslev-Wooldridge robust standard errors & Covariance

Presample variance: backcast (λ = 0.7)

GARCH = c + $\alpha \times \varepsilon^2{}_t$(-1)^2 + β ×GARCH(-1)

Variable	Coefficient	Std. Error	Z-statistic	Prob.
$Constant$	c = 0.0006	0.0003	1.9165	0.0553
ε_t^2(-1)^2	α = -0.0843	0.0196	-4.2933	0.0000
$GARCH(-1)$	β = 0.4767	0.3375	1.4124	0.1578

Our next step is to examine the ARCH effect of the estimated GARCH (1,1) model. If serial correlation is present in the fitted model, we can conclude that ARCH effect is prevalent in the estimated GARCH model. Histogram Jarque-Bera test, correlogram test and ARCH LM test are carried out to examine the ARCH effect. Table-4.10 shows the correlogram of squared residuals of estimated GARCH model.

The values of ACFs and PACFs in Table-4.10 do not tend to zero and the Q-statistics are significant at lags above 3 with low/zero probability values. Since the Q-statistics are significant as reported by the corresponding probability values, the null hypothesis of no autocorrelation cannot be rejected. It means there is the presence of autocorrelation in the residuals of GARCH (1,1). This indicates that there is ARCH effect in the estimated GARCH (1,1) model.

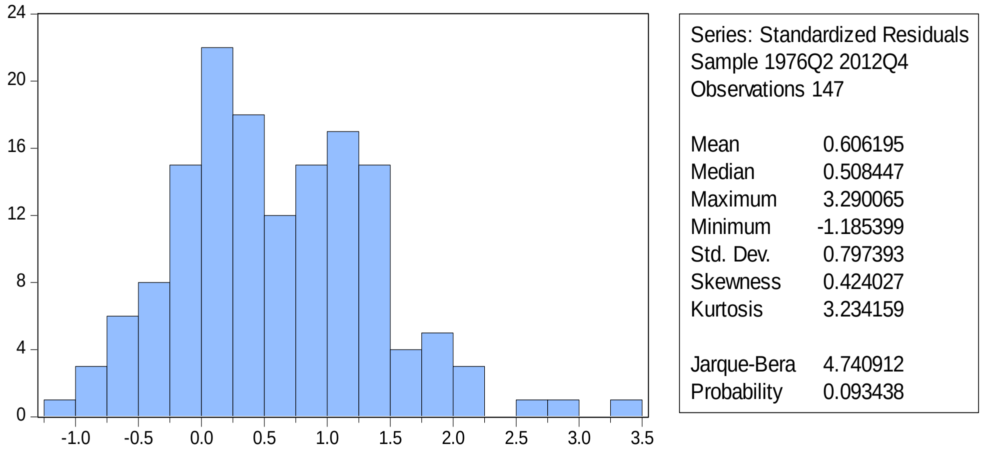
Table -4.10: Correlogram of Squared Residuals of GARCH (1,1) Model

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.033	-0.033	0.1609	0.688	7	-0.126	-0.104	37.404	0.000
2	-0.109	-0.110	1.9436	0.378	8	0.478	0.361	73.467	0.000
3	-0.073	-0.081	2.7445	0.433	9	-0.131	-0.115	76.189	0.000
4	0.416	0.406	29.270	0.000	10	-0.135	-0.042	79.081	0.000
5	-0.129	-0.150	31.854	0.000	11	-0.109	-0.049	81.009	0.000
6	-0.141	-0.086	34.933	0.000	12	0.326	0.038	98.212	0.000

After testing ARCH effect by correlogram technique, the next step is to examine the Histogram-normality test of the standardized residuals. Figure- 4.5 shows the Histogram (left panel) and descriptive statistics (right panel). The coefficient of

Kurtosis is 3.23 > 3, which represents leptokurtic, strong indication of non-normality in the distribution of standardized residuals. This non-normality distribution implies that there is ARCH effect in the fitted GARCH (1,1) model. Thus, it can be concluded that the estimated GARCH (1,1) model lacks the stability condition.

Figure-4.5: Histogram-Normality Test of Standardized Residuals of GARCH (1,1)



Since GARCH (1,1) model lacks consistency, it is necessary to change the order of GARCH model and test the consistency. After checking thoroughly, the GARCH (1,2) model is found to be stable model of forecasting inflation in Nepalese economy.

4.9.2 GARCH (1,2) Model

The results from GARCH (1,2) are presented through Table-4.11. From Table-4.11 it is observed that the coefficient of ARCH(1) is significant at less than 1 % level. Likewise, the coefficients of GARCH (1) and GARCH (2) are also strongly significant at less than 1 % level. The sum of ARCH and GARCH coefficient is $\alpha + \beta_1 + \beta_2 = -0.68 < 1$, which implies that volatility shocks in inflation are not persistent.

Table-4.11: Results from GARCH (1,2) Model

Bollerslev-Wooldridge robust standard errors & covariance

Presample variance: backcast (parameter = 0.7)

GARCH = c + $\alpha \times \varepsilon_t^2$(-1) + $\beta_1 \times$ GARCH(-1) + $\beta_2 \times$ GARCH(-2)

Variable	Coefficient	Std. Error	Z-statistic	Prob.
C (constant)	c = 0.0018	0.0002	8.3807	0.0000
ε_t^2(-1)	α =-0.1369	0.0315	-4.3387	0.0000
$GARCH(-1)$	β_1 = 0.4075	0.0246	16.5287	0.0000
GARCH(-2)	β_2 = -0.9583	0.0300	-31.8391	0.0000

The next step is to examine the stability condition of estimated GARCH (1,2) model. First we examine the Histogram-Normality test of the residuals of GARCH (1,2). Figure-4.6 shows the Histogram and related descriptive statistics of normality test of residuals of GARCH (1,2).

Coefficient of Kurtosis is 3.02~ 3. The Jarque-Bera statistic is 0.013, which is not significant. Very low value of Jarque-Bera statistic and Kurtosis coefficient (=3) indicate that the residuals of GARCH (1,2) are normally distributed. The Histogram-Normality test supports the stability of GARCH (1,2) model because there is no ARCH effect.

Another important test for the stability of GARCH model is GARCH LM test. Table-4.12 presents the results from GARCH LM test.

Figure-4.6: Histogram-Normality Test of Residuals of GARCH (1,2)

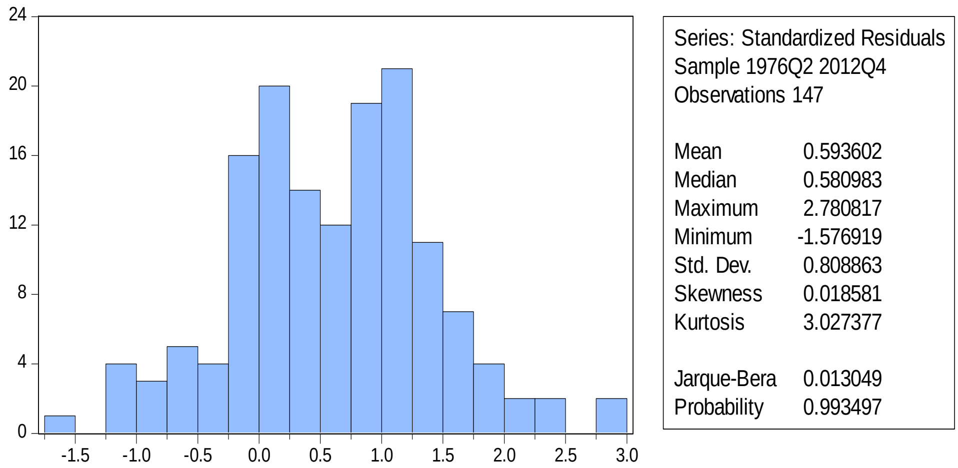


Table-4.12: GARCH LM Test

(Heterossedasticity Test: ARCH)

Summary	Statistics	Degree of Freedom	Probability
F-statistic	0.1142	F(1,144)	0.7358
$T \times R^2$	0.1157	χ^2 (1)	0.7337

Test Equation

Dependent Variable: $weighted\ \varepsilon^2{}_t$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	0.9769	0.1400	6.9752	0.0000
$weighted\ \varepsilon^2{}_t$(-1)	0.0282	0.0834	0.3380	0.7358

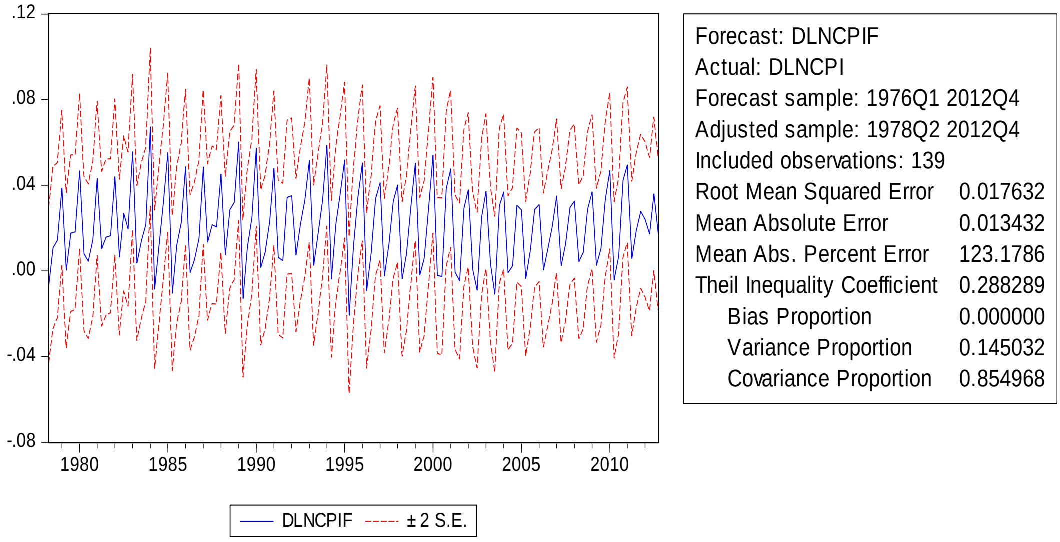
The null hypothesis of no ARCH up to order q cannot be rejected as reported by probability of F-statistic and Chi-Square statistic shown by upper part of Table-4.12. The absence of ARCH effect is associated with stability of GARCH model.

Thus, Histogram-Normality test and GARCH LM test are good indications that our estimated GARCH (1, 2) is a stable and consistent model for forecasting inflation for the economy of Nepal.

4.10 Forecasting Inflation by ARMA and ARCH Process

The most important use of ARMA models is to forecast future values of the sequence of a dependent variable. Since our objective is to examine the formation of inflation expectation based on its own history, it is necessary to test the performance of our ARMA in accordance with model (4.17). This is done by applying static forecasting, or one step ahead forecasts, and presented in the Fig. 4.7.

Figure-4.7: Static Forecast of ARMA{(4,5,6,8),1} Model With the Structural Break

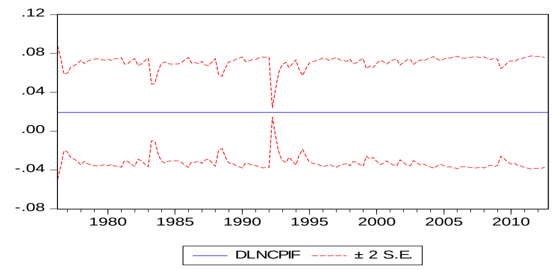


The first two forecast error statistics depend on the scale of the dependent variable. These can be used as a relative measure to compare forecasts for the inflation series across different models; the smaller the error, the better the forecasting ability of that model according to that criterion. Theil (1961) inequality coefficient always lies between zero and one. The estimated ARMA model does not indicate a perfect fit as indicated by Theil inequality coefficient, which is 0.28 representing the moderate degree of fit of the model. The mean squared forecast error can be decomposed as: the bias proportion, which tells us how far the mean of the forecast is from the mean of the actual series; the variance proportion, which tells us how far the variation of the forecast is from the variation of the actual series; and the covariance proportion, which measures the remaining unsystematic forecasting errors. Note that the bias, variance, and covariance proportions add up to one. In our model, the sum of these three coefficients is equal to unity. (Quantitative Micro Software, LLC: 2009, Eviews 7: user's Guide II)

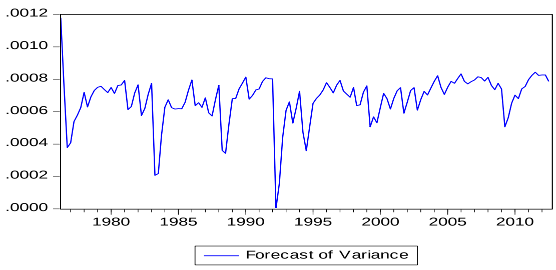
In our model, the bias proportion is extremely small, indicating that the mean of the forecasts does a decent job of tracking the mean of the dependent variable. In other words, since the extent to which average values of simulated and actual series deviate from each other is negligible, there is no indication of systematic error in the model. Furthermore, somewhat larger, but still very small, the variance proportions indicates that most of the bias is concentrated on the covariance proportions. Hence, our one-step ahead forecast of ARMA{(4,5,6,8),1} model of inflation seem to perform reasonably well.

We have also applied one-step ahead forecast on the estimated GARCH (I,2) model described **In *Section 4.14.2***. The procedure includes computing static forecast of the mean, its forecast standard error, and the conditional variance. The upper part of the Fig. 4.8 shows the forecast of the dependent variable from the mean equation together with the two standard deviation bands. The lower part of the graph is the forecast of the conditional variance.

Figure-4.8: One-Step Ahead Forecasts on GARCH (1,2)



Forecast: DLNCPIF	
Actual: DLNCPI	
Forecast sample: 1976Q1 2012Q4	
Adjusted sample: 1976Q2 2012Q4	
Included observations: 147	
Root Mean Squared Error	0.026272
Mean Absolute Error	0.021354
Mean Abs. Percent Error	238.7373
Theil Inequality Coefficient	0.501565
Bias Proportion	0.001599
Variance Proportion	NA
Covariance Proportion	NA



As compared GARCH (1,2) to ARMA{(4,5,6,8),1}, it is found to be unreasonably fit whose Theil Inequality Coefficient is 0.5 (very high). For the reasonably fit of the model, the sum of bias proportion, variance proportion and covariance proportion must be one, but here the coefficients of variance proportion and covariance proportion are not available. Therefore, nothing can be interpreted from forecast results of GARCH (1,2) model and it is not comparable to ARMA{(4,5,6,8),1} model. So, further comparison between ARMA and GARCH models is not necessary. Thus, ARMA {(4,5,6,8),1} is far better efficient for forecasting inflation for the economy of Nepal.

4.11 Conclusion of Chapter Four

The following are the conclusions of Chapter Four.

- The Consumers' Price Index in logarithmic form $LnCPI_t$ is found to be non-stationary at level but it is stationary at its first difference.
- ARMA{(2,4,5,6,8),1}model for $dLnCPI_t$ is found to be efficient as indicated by D-W statistic. However, the coefficient of AR(2) term is not statistically significant. As a result, this model still lacks the robustness.
- AR(2) term of the ARMA model needs omission as reported by redundant test.
- After dropping $dLnCPI_{t-2}$ from ARMA model, the new estimated ARMA{(4,5,6,8),1} is found to be efficient due to the non-presence of serial correlation problem. Additionally, this model is found to be efficient as modulus of inverse roots lies inside unit circle.
- *The inflation of Nepal during the study period is found to be long-range fluctuating as reported by Frequency Spectrum of estimated* $ARMA\{(4,5,6,8),1\}$ *model.*
- The GARCH(1,1) model for inflation forecasting is not found to be stable due to the presence of ARCH effect as reported by Correlogram of Squared Residuals and Histogram Normality (J-B) test.
- GARCH(1,2) model of forecasting inflation is found to be efficient model as the residuals are not autocorrelated.
- ARMA{(4,5,6,8),1} model is found to be more efficient than GARCH(1,2) model for forecasting inflation in Nepal. It is because the Theil inequality coefficient under ARMA{(4,5,6,8),1} is smaller (0.28) than that of GARCH(1.2) model with Theil inequality coefficient 0.5.

Thus, ARMA{(4,5,6,8),1} model is recommended for forecasting of inflation in the economy of Nepal.

CHAPTER FIVE

IMPACT OF REMITTANCE ON INFLATION

Though a number of factors are responsible causing inflation in Nepal, this chapter is devoted to analyzing the impact of remittance along with instability, and growing population on inflation in Nepal. The next chapter endeavors to examine the role of Nepalese money supply and Indian inflation on price level in the economy of Nepal.

5.1 Political Instability

Over the past several decades Nepal has witnessed significant political instability. Since the restoration of multi-party democracy in 1990 alone, more than eighteen different governments have been formed and numerous cabinet reshuffles and no-confidence motions have occurred. A Maoist insurgency launched in earnest in 1996 has resulted in more than 15,000 deaths and considerable damage has been inflicted upon both public and private infrastructure and assets. Since 1990, a number of strikes and other political activities have caused the country's economy close to being fully paralyzed.

Though multiparty democracy is claimed to be the best political system in a country, Nepal has victimized by political instability after restoration of multiparty democracy in 1990. No government has been run full-fledge after 1990. Feng (1997) opines that irregular changes in government bring political instability. In contrast to the uncertainty caused by regime interruption resulting from irregular government change, major regular government change offers policy adjustments without fundamental change in the political order. In the short run, major regular government change may create uncertainty in some economic areas, and its effect on growth may be ambiguous. In the long run, however, major regular government change reflects a pattern of system adjustability and government accountability in favor of economic performance, and is thus likely to produce higher growth (Feng, 1997, p. 397).

Due to the political instability, there have been problems in policy formulations. Even if some policies are formulated, such formulated policies could not have been implemented effectively when government changed within very short period. After it as new government was formed, same problems were experienced. This political instability in Nepal has slowed the pace of industrialization. New investors could not have been attracted to invest in industries including hydropower. Nepal has been able to generate hydropower less than one percent of its total potential. Inadequate electricity, poor road infrastructure and slow pace of industrialization are mainly due to the political instability in Nepal. In the absence of these factors, Nepal is compelled to depend upon imports from India and other countries. If commodities are imported, instead of producing them in own country, the price level automatically rises. Same has occurred in Nepal also and double digit inflation is being experienced for last eight years.

Nepal does not lack resources for economic development as it was mentioned in the past. The donors can provide aid. In addition, remittance inflows have been increasing, which can be used to import capital and technology. Many domestic and non-resident Nepali are ready to invest in industries and social infrastructure. Moreover, Nepal can easily attract foreign direct investments because of tremendous potentiality in hydropower and tourism, and being in a strategic location between two growing nations China and India. Despite this, the ongoing political conundrum has been keeping Nepal as a hostage to start off economic prosperity. So long as economic prosperity is not gained, price stability is impossible. So, for economic prosperity, first there should be political stability and economic prosperity, in turn, brings price stability in a country.

5.2 Remittance

Remittance plays crucial role in the economic development of developing and underdeveloped countries. It has both positive and negative effect on the economy by contributing economic growth and economic development. As a positive effect, Yaseen (2012) discusses that the spread channels by which the funds of remittances of the emigrated workers can have positive effects on the growth of their home country; The transmitted funds can fund the dynamic investment, moreover , when these funds are deposited in financial institutions whether local or intentional in terms of savings, this will imply a significant increasing and raising in the financial resources of these financial institutions, hence it will encouraging these institutions to expand its performance by granting more credit to the companies in their markets for short or long term loans, and granted by non banking financial institutions to companies or households; on the other hand, when the families of the emigrated workers encounter difficulties of credit rationing, the remittances enable them to get out of these difficulties and are able to finance their needs for consumption or their capital expenditures. Of course, in order this effect takes place, it is necessary that the families which receive these funds, be driven to do that.

In the literacy on remittances, one finds a number of theoretical as well empirical papers in which the impacts of the remittances on the macroeconomic performance of the recipient countries are estimated to be rather negative. These negative effects can be gathered and analyzed around three analytical topics: first, the insensible monetary penalty of the entry of foreign currencies in a low developed country open to the movements of capital, this throughout their sound effects on the exchange rate level of the home currency and on the domestic price level. Second, the uses of these funds, either within the family of the migrant worker or by the worker himself who chooses to spend his savings through real estate investment. Finally, the effect of the remittances can be also negative in terms of lacking among the members of the family remained in home country. These types of risk are considered as critical from a macroeconomic point.

The remittances, in some beneficiary countries or families, can stimulate members of the family who profit from these incomes, living in the country of migrants' origin, to be satisfied to live within this without working or by withdrawing from the local labor market; one observes also scenarios in which these recipients use remittances while launching themselves in showy consumptions or of luxury goods often imported from abroad, certain expenditure in projects not very relevant or in badly studied investments can lead to the wasting of these funds.

Reinhart and Rogoff (2004) opine that different exchange rate regimes have considerably a number of effects on macroeconomic variables in the economy. Under a fixed exchange rate regime, for instance, an increase in remittances will move resources from the tradable to the non-tradable sector. This will result in an increase in the price level. Since the exchange rate is fixed, the country cannot adjust its international relative prices after a negative shock to the tradable sector. The nominal depreciation is, thus, prevented, and as a result, the tradable output contracts and the price level rises.

On the other hand, under a flexible exchange rate regime, since international relative prices can be adjusted following a large inflow of remittance, the resulting effect will be a rising price level and appreciation of the exchange rate. Ball, et.al. (2012) provides evidence that the fixed exchange rate regime the remittance temporarily increases inflation and GDP in small open economy. Likewise, Narayan, et.al. (2011) studied the impact of remittance on inflation for 54 developing countries employing Arellano and Bond panel dynamic estimator, Arellano and Bover, Blundel and Bond system generalized moments and found that remittance generates inflation. According to them, the effect of remittance on inflation is more pronounced in the long run.

5.3 Population Growth

Population growth is closely tied to economic development. On the one hand, labor shortages will slow the rate of economic growth in industrialized countries, but on the other hand, a high birthrate in a developing country may stress limited renewable resources. Governments in western and other industrialized countries like Japan are challenged to create effective immigration policies and programs to increase the birthrate, while countries with weaker economies pursue public health policies to reduce population growth. Globally, a smaller population presents multiple benefits from an ecological perspective, but some economies are challenged by low birthrates and are redirecting their need for unskilled labor to countries with higher population and lower wage demands.

Population increase put forth supplementary strain on natural resource utilization. People have to fed, housed, and dressed; as population raises, the requirement for food and materials swells. The escalating utilization of land and resources, at some position go beyond the carrying facility and causes the natural resources ineffective or exhausted. This could effect in economic hardship. Specifically every addition in population has directed to more troubles than settlement. As high growth of population takes place in the country, the resources will be emptied in investing basic infrastructure such as schooling, health care, even feeding etc. in such a situation, there will be less saving that causes less capital formation. As a result, scarcity of output is causing price to rise.

5.4 Trend of Remittance in Nepal

As Nepal introduced trade and economic liberalization policies in the mid-1980s, the international labor market gradually opened up to the job-seeking Nepali youths. Though there was a long history of labor migration in the country, Nepal witnessed most of the young population migrating every year for the search of work abroad in the recent decades because of economic as well non-economic factors. The work related emigration, excluding India, increased from about ten thousands in early 1990s to more than 300 thousands in 2010.

Table-5.1 portrays the flow of remittance income and percentage change in remittance from 1999/00 to 2011/12. The Table reveals that remittance income has increased by 62.44 % from 1999/00 to 2000/01 and this percentage increase reduced to 48.91 % in FY 2001/02. Remittance is found to be increased by 185.33 % in FY 2002/03. The FY 2002/03 was extremely favorable for Nepalese economy in terms of remittance. After 2002/03, the remittance incomes are found to be increasing at fluctuating rate.

Table-5.1: Remittance Income and Percentage Change

Year	Remittance (Million Rs)	Percentage Change	Year	Remittance (Million Rs)	Percentage Change
1999/00	603.14	-	2006/07	13942.15	29.79
2000/01	979.76	62.44	2007/08	19421.56	39.30
2001/02	1458.98	48.91	2008/09	21399.89	10.18
2002/03	4163	185.33	2009/10	23296.32	8.86
2003/04	5662.98	36.03	2010/11	33336.68	43.09
2004/05	6178.48	9.10	2011/12	9274.86	50.11
2005/06	10741.74	15.81			

Source: Economic Survey 2013/14

Figure-5.1: Line Graph of Remittance

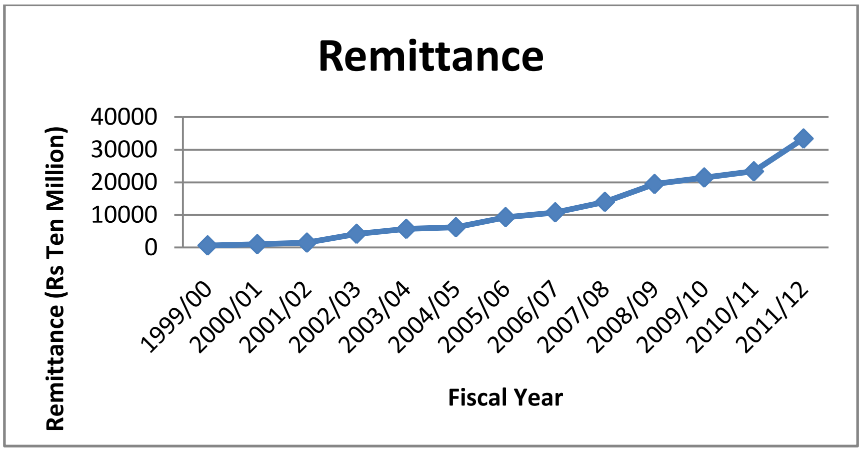


Figure-5.1 represents line graph of remittance income (Ten Million Rs) from FY 1999/00 to 2011/12. The flow of remittance is found to be increasing continuously during the study period as reported by rising line of remittance.

5.4.1 Trend of Remittance by Hodrick-Prescott Filter

The Hodrick-Prescott Filter is a smoothing method that is widely used among macroeconomists to obtain a smooth estimate of the long-term trend component of a series. The method was first used in a working paper (circulated in the early 1980's and published in 1997) by Hodrick and Prescott to analyze postwar U.S. business cycles.

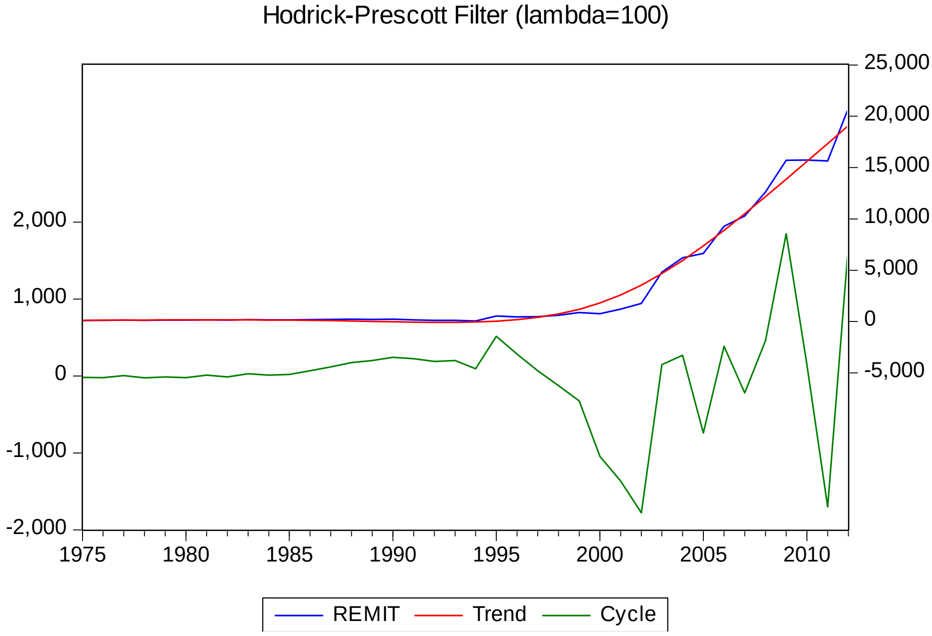
Technically, the Hodrick-Prescott (HP) filter is a two-sided linear filter that computes the smoothed series s of y by minimizing the variance of y around , subject to a penalty that constrains the second difference of s. That is, the HP filter chooses s to minimize:

$$\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda \sum_{t=2}^{T-1}\left((s_{t+1} - s_t) - (s_t - s_{t-1})\right)^2 \qquad (5.1)$$

The penalty parameter λ controls the smoothness of the series σ. The larger the λ, the smoother the σ. As $\lambda = \infty$, s approaches a linear trend.

Figure-5.2 presents the trend of remittance in real terms by Hodric-Prescott (H-P) filter, which suggests that remittance had started at the review period at around Rs101 (in ten million) and continued in three digits till 2000 and thereafter increased to four digits from 2001. This continued to increase in all periods except slight fall in 2011.

Figure-5.2: Trend of Remittance (Real) by H-P Filter



5.5 Empirical Analysis

(Impact of Remittance, Population Growth and Political Instability on Inflation)

In order to analyze the impact of remittance, population growth and political instability on inflation empirically, the econometric techniques such as Johansen's Cointegration Test, Vector Error Correction Models and Granger Causality Test have been used. Though the present research has employed the quarterly data sets of money supply and price level, in this section annual data sets of remittance, population growth and inflation have been used. The quarterly data of population is not available in Nepal. Likewise, data associated with remittance are also not available on quarterly basis. That is why, for analyzing the impact of remittance, population growth[18] and political instability on inflation, annual data[19] sets of concerned variable are used. For political instability, the dummy variable has been used for which dummy takes the value 1 for presence of political instability and otherwise zero. In Nepal, the political instability has been experienced since 1996 and till the last of study year. However, there was more or less political stability prior to 1996 though there was party-less

[18] The data on Population is taken from World Bank Fact Book 2014.

[19] The data on CPI and Remittance are taken from Economic Survey 2012/13 (Ministry of Finance, Kathmandu, Nepal).

Panchayat system in Nepal. Therefore, the dummy takes 1 for each year after 1995 and 0 prior to 1996.

The annual data sets of CPI have been transformed into logarithmic form. The $LnCPI$ is found to be non-stationary at level form and stationary at first difference. The first difference[20] of $LnCPI$ is represented as P_t and it is the representative of inflation. The nominal data sets of remittance are first converted into real term taking 2005/06 as base year and transformed into logarithmic form. $LnRemittance$ is also found to be non-stationary at level form and stationary at first difference. The first difference of $LnRemittance$ is represented by $Remit_t$. Similarly, first difference of $LnPopulation$ is taken as the proxy of population growth and represented by PG_t. In Nepal, the political instability is associated with frequent changes in government and non-occurrence of local level election. After the restoration of multiparty democracy in 1990, full-fledged government was conducted till 1996. Thereafter, due to political instability in Nepal, government changed frequently that brought political instability. The last local election was held in 1999. Thereafter, the local level election has not been held up to the present time. Due to the political instability, there was lacking of policy variables to control inflation. Two types of dummies have been used in the present study as the representatives of political instability. The first is the frequent changes of government and second is the non-occurrence of local level election.

The functional form of inflation is given by:

$$P_t = f(Remit_t, \mathrm{PG_t}, \mathrm{Polins_t})$$

Under $\mathrm{Polins_t}$, two dummies such as $\mathrm{Govch_t}$ and $Noelct_t$ have been used which represent Government Change and No Election in local level respectively.

In linear form,

$$P_t = \alpha_1 Remit_t + \alpha_2 \mathrm{PG_t} + \alpha_3 \mathrm{Govch_t} + \alpha_4 Noelct_t + \varepsilon_t \tag{5.2}$$

[20] However, the non-stationary variables are used in Cointegration and VEC models and stationary variables are used in Granger Causality test.

5.5.1 Johansen's Cointegration Test

Before carrying out the cointegration test of Johansen, it is necessary to find out the appropriate lag of the concerned variables under analysis length. There are various criteria for selecting the lag length. Table-5.2 reveals the selection of lag length through VAR technique.

Table-5.2: VAR Lag Order Selection Criterion

(Endogenous variables $P_t, Remit_t, PG_t$)

Lag	Log L	LR	FPE	AIC	SC	HQ
0	8.8370	NA	0.0001	-0.353763	-0.21771	-0.3079
1	214.3926	361.2794	9.48e-10	-12.2662	-11.7220	-12.0831
2	258.4506	69.42475	1.15e-10	-14.3909	-13.4386*	-14.0705*
3	264.7296	8.7524	1.41e-10	-14.2260	-12.8655	-13.7682
4	279.8747	18.357*	1.05e-10*	-14.5984	-12.8298	-14.0033
5	289.1739	9.5809	1.18e-10	-14.6166*	-12.4398	-13.8841

It is observed from the Table- 5.2 that HQ and SC statistics for lags 2 are significant at 5 % level. So lags 2 are selected for each endogenous variable in their autoregressive and distributed lag structure in estimable cointegrating equations and VEC models.

The Johansen method of cointegration is based on Max-Eigen and Trace Statistic value. The following results have been revealed for Johansen approach while allowing linear deterministic trend (intercept and trend in cointegrating equation and no intercept in VAR) in the data.

Table 5.3: Cointegration Test Based on Maximum Eigen Value ($\lambda_{\max}$)

Endogenous Variables: $P_t, Remit_t, PG_t$ and $Polins_t$(Govech and No Elect) as exogenous variable

Order of VAR = 2 Sample: 1975-2012

H_0	H_a	λ_i	$\lambda_{\max}$	0.05 Critical Value
r = 0*	r = 1	0.5596	28.7029	25.8232
r ≤ 1*	r = 2	0.3178	13.3864	19.3870

Table-5.4: Cointegration Test Based on Trace Statistic (λ_{Trace})

H_0	H_a	λ_i	λ_{Trace}	0.05 Critical Value
r = 0*	r = 1	0.5596	53.6639	42.9152
r $\leq$1*	r = 2	0.3178	24.9610	25.8721

Using second order VAR of the three endogenous variables $(P_t, Remit_t, PG_t)$ and Polins_t as exogenous variable under investigation, the hypothesis of r = 0 is strongly rejected in favor of the alternative hypotheses r = 1 employing the maximum Eigen-value test as reported by the 4th column of Table 5.3. The maximum Eigen-value test of r = 1 versus r = 2 fails to reject the null hypothesis of k = 1, implying one cointegrating vector. Based on the Maximum Eigen-Value Test, one cointegrating vector (r =1) is detected among the endogenous variables $P_t, Remit_t, PG_t$ and Polins_t as exogenous variable. Thus, on the basis of maximum Eigen-value test, the variables under study are found to be cointegrated.

Turning to the trace test as reported by Table 5.4, the null hypothesis r $\leq$1 cannot be rejected while the hypotheses r = 0 is rejected at 5 percent significant level indicating one cointegrating vector (r =1). The Trace test also indicates that the variables under study are cointegrated.

Both Maximum Eigen-Value test and Trace Test indicate that the variables $P_t, Remit_t\ and\ PG_t$ are cointegrated, there is found to be long run equilibrium relation among these variables during the study period 1975-2012.

5.5.2 Vector Error Correction (VEC) Models

A vector error correction (VEC) model is a restricted VAR designed for use with non-stationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the *error correction* term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

As indicated by VAR lag selection criteria in Table-5.2, lags 2 are suitable for each endogenous variable in accordance with SC and HQ criteria. The estimable VEC models are presented as:

$$dP_t = \gamma_1 + \rho_1 Z_{1_{t-1}} + \alpha_1 dP_{t-1} + \alpha_2 dp_{t-2} + \alpha_3 dRemit_{t-1} + \alpha_4 dRemit_{t-2} + \alpha_5 dPG_{t-1} + \alpha_6 dPG_{t-2} + \mu_1 Govch_t + \mu_2 Noelc_t + \varepsilon_{1t} \quad (5.3)$$

(dP_t as dependent variable and dP_t at lag 1 and 2, $dRemit_t$, dPG_t at lag 1 and 2; and $Govch_t$ and $Noelc_t$ as independent/exogenous variables)

$$dRemit_t = \gamma_2 + \rho_2 Z_{2_{t-1}} + \beta_1 dP_{t-1} + \beta_2 dp_{t-2} + \beta_3 dRemit_{t-1} + \beta_4 dRemit_{t-2} + \beta_5 dPG_{t-1} + \beta_6 dPG_{t-2} + \mu_1{}' Govch_t + \mu_2{}' Noelc_t + \varepsilon_{1t} \quad (5.4)$$

($dRemit_t$ as dependent variable and dP_t at lag 1 and 2, $dRemit_t$ as well as dPG_t at lag 1 and 2 and $Govch_t$ and $Noelc_t$ as independent/exogenous variables)[21]

The results from Vector Error Correction Models of equation (5.3) are presented through Table-5.5. From Table-5.5, it is observed that:

i) With dP_t as dependent variable the coefficient of error correction term ($Z_{1_{t-1}}$), ρ = -0.44 is significant at 1% level, which indicates that the short run shocks significantly affect the long run relationship among the variables $dP_t, dRemit_t, dPG_t$ and $Polinst_t$.

ii) The negative value of ρ = -0.44 indicates that dP_t , following any positive short run shocks, declined. Consequently, the short run shocks appeared to pull down the dP_t below the long run equilibrium level.

iii) The absolute value of the coefficient of Z_{t-1} to be lower than unity, i.e. $|\rho_1| < 1$, which implies that dP_t converged to the long run equilibrium level following a short run shocks. Thus, long run relationship between dP_t as dependent variable and$dRemit_t, dPG_t$ and; $Govch_t$ and $Noelc_t$ independent variables is found to be stable. Consequently, the short run dynamics defined an 'equilibrium' process.

[21] Other equations can be formulated by the similar process.

iv) The coefficient of $dRemit_{t-1}$ is positive and significant only at 10% level. This implies that there is little economic significance regarding the relationship between inflation and remittance in short run. The remittance at time $'t-1'$ is found causing the inflation at time $'t'$.

Table-5.5: Vector Error Correction Modeling

Dependent Variable: dP_t

Variable	Coefficient	Std. Error	t-Statistic
$Constant$	γ_i = -0.1256	0.0852	-1.4731
Z_{1t-1}	ρ_1 = -0.4404	0.1275	-3.4521
dP_{t-1}	α_2 = 0.1452	0.1459	0.9952
dP_{t-2}	α_3 = -3000	0.1465	-2.0479
dPG_{t-1}	α_4 = -3.9583	11.2216	-0.3527
dPG_{t-2}	α_5 =13.5690	12.2348	1.1090
$dRemit_{t-1}$	β_1 = 0.0343	0.0183	1.8699
$dRemit_{t-2}$	β_2 = 0.0071	0.0147	0.4841
$Govch_t$	μ_1= 0.0213	0.0243	0.1132
$Noele_t$	μ_2= 0.0045	0.0123	0.1932

5.5.3 Granger Causality Test Based on Wald Test

In order to know the causality among the variables under study, we have applied the Granger causality/ Block exogeneity Wald test (Enders, 2003, p. 284). This test detects whether the lags of one variable can Granger-cause any other variables in the VAR system. The null hypothesis is that all lags of one variable can be excluded from each equation in the VAR system. For example, this test helps to answer whether or not all lags of $dRemit_t$ can be excluded from the equation of dP_t or not. Rejection of the null hypothesis means that if all lags of $dRemit_t$ cannot be excluded from the dP_t equation then dP_t is an endogenous variable and there is causality of $dRemit_t$ on dP_t. The test statistic is (Enders, 2003, p. 282)

$$(T-3\rho-1)(Log|\sum re| - Log|\sum un|) - \chi^2(2\rho) \quad (5.5)$$

Where T is the number of observations; $\sum un$ is variance/covariance matrices of the unrestricted VAR system; $\sum re$ is variance/covariance matrices of the restricted system when the lag of a variable is excluded from the VAR system; and p is the number of lags of the variable that is excluded from the VAR system.

The results from VEC Granger causality/block exogeneity Wald test have been presented through Table-5.6 that portrays the block exogeneity Wald tests of three equations. Equation first has the dependent variable dP_t; equation second and third have the dependent variables dPG_t and $dRemit_t$ respectively. Equation first has the hypotheses:

H_{01}: dPG_t does not Granger cause dP_t up to lag 2 H_{a1}: dPG_t Granger causes dP_t up to lag 2

H_{02}: $dRemit_t$ does not Granger cause dP_t up to lag 2 H_{a2}: $dRemit_t$ Granger causes dP_t up to lag 2.

Table-5.6: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent Variable: dP_t Exogenous Variable $Polins_t$

Excluded	Chi-square	DF	Prob.
dPG_t	7.7205	2	0.0211
$dRemit_t$	3.8000	2	0.1496

The probability value of excluded variable dPG_t is 0.0211 and Chi-square statistic at 2 degree of freedom is 7.720. There is strong evidence of rejecting the null hypothesis H_{01} as indicated by Chi-square statistic and probability value. This allows us to consider the alternative hypothesis H_{a1}. Therefore, it can be concluded that dPG_t up to its 2 lags has Granger caused dP_t.

However, the null hypothesisH_{02}: $dRemit_t$does not Granger cause dP_t up to lag 2, cannot be rejected as implied by low χ^2 and high probability value. This concludes that $dRemit_t$ up to lag 2 has not Granger caused dP_t.

It is, therefore, under VEC model, only the dependent variable dP_t is found Granger caused by the independent variable, dPG_t up to lags 2. Hence, it can be concluded that Nepalese inflation is caused by population growth. There is no evidence of remittance causing inflation in Nepal during the study period 1975-2012.

5.6 Stability of VEC Model

For the stability of the estimated VEC model of equation (5.3), we perform the Portmanteau test and VEC Heteroscedasticity test to examine whether any autocorrelation exists in residuals. If residuals of estimated VEC model of equation

(5.3) are not autocorrelated, then the model bears the property of stability or efficiency.

5.6.1 Portmanteau Test

A Portmanteau test computes the multivariate Box-Pierce/Ljung-Box Q-statistics for residual serial correlation up to the specified order (Lütkepohl, 1991, 4.4.21 & 4.4.23). We report both the Q-statistics and the adjusted Q-statistics (with a small sample correction). Under the null hypothesis of no serial correlation up to lag h , both statistics are approximately distributed χ^2 with degrees of freedom $k^2(h-p)$ where p is the VAR lag order. The asymptotic distribution is approximated in the sense that it requires the MA coefficients to be zero for lags $> h-p$. Therefore, this approximation will be poor if the roots of the AR polynomial are close to one and h is small. In fact, the degree of freedom becomes negative for $h < p$.

The null hypothesis for Portmanteau test is: there are no autocorrelations up to lag h. To reject or accept the null hypothesis depends on the corresponding probabilities of Q-statistic and Adjusted Q-statistic. If these Q-statistic and Adjusted Q-statistic are not significant up to lag h, then there is no evidence of rejecting the null hypothesis. Otherwise, the null hypothesis is rejected.

If null hypothesis is not rejected, the residuals are not correlated and the estimated VAR/VEC model is claimed to be stable model. Table-5.7 presents the Portmanteau test of the residuals based on VEC model of equation (5.3) with modification[22].

The estimated VEC model (5.3) after excluding the exogenous variable, political instability becomes:

$$dP_t = -0.1537 - 0.3187Z_{1_{t-1}} + 0.0884dP_{t-1} - 0.3394 * dp_{t-2} + 0.0213dRemit_{t-1}$$

(-2.1605)[23] (-3.997) (0.624) (-2.3676) (1.374)

$$+0.0035dRemit_{t-2} - 7.4303dPG_{t-1} + 19.1492dPG_{t-2}$$

(0.2546) (-0.7014) (1.5133) (5.6)

[22] The VEC model of equation (5.3) has included *political instability* such as government changes and no election as exogenous variable, but the DF and Probability values of Portmanteau test of residuals may not be of the VEC model with exogenous variable. Therefore, we develop the VEC model excluding the exogenous variable and apply Portmanteau test.

[23] Figure in parenthesis shows t-statistic.

From estimated VEC model of equation (5.6) with dP_t as dependent variable (where $Polinst_t$ as exogenous variable is avoided), it is observed that

i) The coefficient of error correction term ($Z_{1_{t-1}}$), ρ = -0.31 is significant at 1% level, which indicates that the short run shocks significantly affect the long run relationship among the variables $dP_t, dRemit_t \; and \; dPG_t.$ The speed of convergence of equilibrium of (0.31) implies that inflations are adjusted by 31 % of the past two year's deviation from equilibrium.

ii) The negative value of ρ = -0.31 indicates that dP_t , following any positive short run shocks, declined. Consequently, the short run shocks appeared to pull down the dP_t below the long run equilibrium level.

iii) The absolute value of the coefficient of Z_{t-1} to be lower than unity, i.e. $|\rho_1| < 1$, which implies that dP_t converged to the long run equilibrium level following a short run shocks. Thus, long run relationship between dP_t as dependent variable and $dRemit_t \; and \; dPG_t$ independent variables is found to be stable. Consequently, the short run dynamics defined an 'equilibrium' process.

After estimating VEC model in equation (5.6), our next job is to check the stability test VEC residuals through Portmanteau Tests for Autocorrelations.

In Table-5.7, the Q-statistic and Adjusted Q-statistic of VEC Residual Portmanteau tests are not significant as reported by their corresponding probability values. The null hypothesis 'no residual autocorrelations up to lag $h = 5$' cannot be rejected, which implies that the VEC residuals are not autocorrelated. No autocorrelation of VEC residuals as implied by Portmanteau tests represents the goodness of fit of the VEC model with dP_t as dependent variable and $dRemit_t \; and \; dPG_t$ as independent variables up to lag 2.

Table-5.7: VEC Residual Portmanteau Tests for Autocorrelations

Null Hypothesis: no residual autocorrelations up to lag h

Lags	Q-Stat	Prob.	Adj. Q-Stat.	Prob.	DF
1	1.7680	NA*	1.8200	NA*	NA*
2	15.4451	NA*	16.3260	NA*	NA*
3	19.1469	0.2611	20.3749	0.2038	16
4	29.7947	0.2321	32.3966	0.1469	25
5	42.6650	0.1464	47.4119	0.0630	34

5.6.2 VEC Heteroscedasticity Test

White's (1980) test is a test of the null hypothesis of no heteroscedasticity against heteroscedasticity of unknown, general form. The test statistic is computed by an auxiliary regression, where we regress the squared residuals on all possible (non redundant) cross products
of the regressors.

The $(T \times R^2)$ statistic is White's test statistic, computed as the number of observations times the centered R^2 from the test regression. The exact finite sample distribution of the F-statistic under H_0 is not known, but White's test statistic is asymptotically distributed as a χ^2 with degrees of freedom equal to the number of slope coefficients (excluding the constant) in the test regression.

If H_0 is not rejected as reported by the χ^2-statistic and its corresponding probability value, it can be concluded that the VEC residuals are not suffering from heteroscedasticity problem, and the estimated VEC model is consistent. Table-5.8 reveals the results from VEC Residual Heteroscedasticity Tests.

Table-5.8: VEC Residual Heteroscedasticity Tests

Joint test:

Chi-sq	df	Prob.
84.30282	84	0.4702

Individual components:

VEC Residual Heteroscedasticity Tests: No Cross Terms (only levels and squares)

Dependent	R-squared	F(14,20)	Prob.	Chi-sq(14)	Prob.
res1× res1	0.5000	1.4285	0.2272	17.5001	0.2305
res2× res2	0.3281	0.6978	0.7520	11.4861	0.6475
res3× res3	0.6609*	2.7850	0.0181	23.1337	0.0581
res2× res1	0.3759	0.8604	0.6064	13.1565	0.5142
res3× res1	0.6188	2.3196	0.0419	21.6604	0.0859
res3× res2	0.3889	0.9094	0.5636	13.6140	0.4788

Looking at the individual component (lower part of Table-5.8), R^2 of res3× res3 is found to be significant as implied by F-statistic (but not by χ^2-statistic) rejecting the null hypothesis. However, the χ^2-statistic of Joint test implies that the null hypothesis is not rejected, which means residuals are homoscedastic. Thus, the VEC Residual Heteroscedasticity test confirms that there is no heteroscedasticity problem in the residuals of estimated VEC model of equation (5.6). Thus, the estimated VEC model is econometrically meaning full and sound.

5.7 Conclusion of Chapter Five

The Chapter Five concludes:

- Inflation, remittance, population growth and political instability (exogenous variable) are cointegrated. There is one cointegrating vector among the variables as reported by Johansen's Cointegration test.
- The short run shocks significantly affect the long run relationship among the variables under study as reported by VEC modeling.
- There is little economic significance between inflation and remittance for which the remittance at lag 1 has caused the inflation.

- As reported by Granger causality/block erogeneity Wald test, Nepalese inflation is found Granger caused by population growth only. The inflation is not Granger caused by remittance during the study period.
- The VEC model of equation (5.3) failed to represent the stability condition due to the inclusion of political instability (government change and no election) as the exogenous variable. The Portmanteau test of autocorrelation denied to estimate the values till it is removed.
- After removing the dummies for political instability (exogenous variables) from equation (5.3), we have formulated VEC model (5.6).
- VEC model (5.6) shows that short run shocks significantly affect the long run relationship among the variables under study.
- The coefficient of error correction term $Z_{1_{t-1}}$ of equation (5.4) is significant at 0.01 level, implying the short run shocks significantly affect long run relationship between the variables under study.
- No autocorrelation and heteroscedasticity have been detected in the residuals of the VEC model (5.6).
- VEC model (5.6) is the econometrically meaning full model.

CHAPTER SIX

UNIT ROOT TEST OF MONEY SUPPLY AND PRICE LEVEL

6.1 Introduction

In order to develop models for time series data, it is necessary to identify whether the data is stationary or not. Only those series are called stationary, which are assumed to be invariant with respect to time. If the time series data change over time, the series are taken as non-stationary data. A stationary time series has three basic properties (Baral, 2007).

(a) A stationary series fluctuates around a constant long run mean.

$E[Y]_t$ is independent of t.

Or,

$$E[Y]_t = E\,[Y_{t-s}] = \mu \tag{6.1}$$

(b) It has a finite variance.

$$E\,(Y_t - \mu)^2 = E(Y_{t-s} - \mu)^2 = \sigma_y^2 \tag{6.2}$$

$[\mathrm{var}(Y_t)=\mathrm{var}(Y_{t-s})= \sigma_y^2]$

$\mathrm{Var}(Y_t)$ is a finite, positive constant and independent of t.

(c) $\mathrm{Cov}\,[Y_t,Y_s]$ is a finite function of t-s, but not of t or s.

$E\,[(Y_t - \mu)(Y_{t-s} - \mu)] = E[(Y_{t-j} - \mu)(Y_{t-j-s} - \mu)] = \gamma_s$

$$[\mathrm{Cov}(Y_t, Y_{t-s})=\mathrm{Cov}(Y_{t-j}, Y_{t-j-s})] \tag{6.3}$$

where μ, σ_y^2 and all γ_s are constants. That is, the mean, variance and co-variance are invariant to the time origin.

Testing for stationarity can be performed with the help of unit root test and/or correlogram. This chapter is first devoted to unit root test employing various techniques. The correlogram technique does not represent of well identification of stationarity. It gives only the roughly idea regarding the stationarity. So, we have not employed the correlogram technique for stationarity in this chapter. However, the graphical plot of the stationary and non-stationary series has included in Annex.

6.2 Unit Root Test

Suppose we have a series $\{Y_t\}$ that can be generated by an AR (1) process, say

$$Y_t = Y_t\, \alpha + \rho Y_{t-1} + \varepsilon_t \tag{6.4}$$

Where $|\rho| < 1$ and ε_t is white noise error term. The parameter in equation (6.4) can be computed by OLS regression. The estimator is claimed to be efficient and robust, and the series becomes stationary because $|\rho| < 1$. If the value of $\rho = 1$, the series $\{Y_t\}$ is non-stationary. That is, if the coefficient of Y_{t-1} is equal to one, we face with unit root problem. Hence, the unit root null hypothesis is: $H_o = \rho = 1$

While testing the null hypothesis of unit root, we use the following equation-

$$\Delta Y_t = \alpha + \rho Y_{t-1} + \varepsilon_t \tag{6.5}$$

Where, $\gamma = \rho - 1$, ΔY_t - first difference of the series Y_t . The null hypothesis of unit root is, $H_0 = \gamma = 0$. If 'γ' is in fact zero, we can write equation (6.5) as

$$\Delta Y_t = Y_t - Y_{t-1} + \varepsilon_t \tag{6.6}$$

Time series data, which we often use in practice for economic modeling, almost have a unit root at level and such series are known as non-stationary time series. They are also called random walk time series. If the series have the characteristics of non-stationarity or random walk at level, then we have to find its successive differences to obtain the stationarity of the series. For meaningful OLS regression, the series must be stationary. OLS regression with non-stationary series generates spurious regression results. That is why, the econometric models are developed using only the stationary time series.

6.2.1 Augmented Dickey-Fuller (ADF) Unit Root Test

The Augmented Dickey Fuller (ADF) is the renowned test that has been developed to check the unit root of univariate time series. In order to test for the existence of unit roots, and to determine the degree of differencing necessary to induce stationarity, we have applied the augmented Dickey-Fuller test. Dickey and Fuller (1976, 1979), Said and Dickey (1984), Phillips (1987), Phillips and Perron (1988), and others developed modifications of the Dickey-Fuller tests where ε_t is not white noise. These tests are called "augmented" Dickey-Fuller (ADF) tests. The results of the augmented Dickey-Fuller test (ADF) determine the form in which the data should be used in any subsequent econometric analyses. The estimable equation for ADF unit root test is given by:

$$\Delta Y_t = \mu + \gamma Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \beta_t + \varepsilon_t \qquad (6.7)$$

Where, Y_t follows an AR (k) process. In the literature it is known as Augmented Dickey-Fuller (ADF) test. In equation (6.7), the constant term μ is said to be drift term. In the equation, the notation t denotes the time trend, and p is the lag length of the time series and ε_t is defined as white noise error term. For the analysis of deterministic trend in the time series, we can use the Likelihood Ratio test recommended by Dickey and Fuller (1981). Additionally, we can follow the test sequence recommended by Patterson (2000) with following estimable equations.

$$\Delta Y_t = \mu + \gamma Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \beta_t + \varepsilon_t \qquad (6.8)$$

$$\hat{\tau}_\beta, H_0 : \gamma = 0, H_a : \gamma < 0; \phi_3, H_0 : \gamma = 0, \beta = 0, H_a : \gamma \neq 0, \text{ and/or } \beta \neq 0$$

$$\Delta Y_t = \mu + \gamma Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \varepsilon_t \qquad (6.9)$$

$$\hat{\tau}_\mu, H_0 : \gamma = 0, H_a : \gamma < 0; \phi_1, H_0 : \mu = 0, \gamma = 0, \beta = 0, H_a : \mu \neq 0, \text{ and/or } \gamma \neq 0$$

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \beta t + \varepsilon_t \qquad (6.10)$$

$$\tau, H_0 : \gamma = 0, H_a : \gamma < 0$$

Equation (6.8) is related to ADF test with constant as exogenous, equation (6.9) is based on constant and linear trend as exogenous and ADF test with no exogenous is presented in equation (6.10).

The ADF unit root test has the null hypothesis: H_0: Y_t has unit root. If the computed value of t-statistic is not significant, there is no evidence of rejecting the null hypothesis, that is, the variable Y_t has unit root; which confirming the variable Y_t as non-stationary. Contrary to this, if the computed t-statistic is significant after transforming the variable into first/second difference, the null hypothesis is rejected and we accept the alternative hypothesis that the variable dY_t/d^2Y_t has no unit root implying that dY_t/d^2Y_t is a stationary series, appropriate to employ in OLS regression. Table-6.1 presents the results from ADF Unit Root test taking 'Constant' as exogenous variable.

Table- 6.1: Augmented Dickey Fuller Unit Root Test on Variables

Exogenous: Constant Null Hypothesis: The variable has a unit root

[Sample: - $1976Q_1$ - $2012Q_2$]

Variable	ADF test statistic	Prob* value	Lag length	Test critical values		
				1%	5%	10%
$lnCPI$	-1.0482	0.7347	8	-3.4778	-2.8822	-2.5779
$dlnCPI$	-3.2268	0.0205	7	-3.4778	-2.8822	-2.5779
lnM_1	-0.1451	0.9412	4	-3.4789	-2.8827	-2.5781
$dlnM_1$	-4.4395	0.0004	3	-3.4789	-2.8827	-2.5781
lnM_2	-0.9026	0.7782	5	-3.4771	-2.8819	-2.5777
$dlnM_2$	-6.3229	0.0000	5	-3.4771	-2.8819	-2.5777
Exogenous: Constant, Linear trend						
$lnCPI$	-1.5529	0.8063	8	-4.0254	-3.4424	-3.1458
$dlnCPI$	-3.3350	0.0649	7	-4.0254	-3.4424	-3.1458
lnM_1	-4.2602	0.5527	8	-4.0264	-3.4429	-3.1461
$dlnM_1$	-6.4721	0.0048	5	-4.0254	-3.4424	-3.1458
lnM_2	-2.0226	0.5836	4	-4.0244	-3.4420	-3.1456
$dlnM_2$	-3.8653	0.0160	4	-4.0249	-3.4422	-3.1457
Exogenous: None						
$lnCPI$	2.8091	0.9988	4	-2.5812	-1.9430	-1.6152
$dlnCPI$	-4.0863	0.0001	2	-2.5811	-1.9493	-1.6152
lnM_1	-8.9028	0.000	2	-2.6240	-1.9493	-1.6112
$dlnM_1$	10.5434	1.0000	0	-2.6185	-1.9484	-1.6121
lnM_2	-0.3553	0.5501	5	-2.6272	-1.9498	-1.6114
$dlnM_2$	-5.2730	0.0000	4	-2.6272	-1.9498	-1.6114

*MacKinnon (1996) One-sided P-values ** Automatic based on SIC

From Table-6.1 it is observed that all the variables: $lnCPI$, lnM_1 and lnM_2 are suffering from unit root at level forms in all distinct cases such as exogenous-constant, exogenous- constant and linear trend and exogenous-none, because the absolute value of ADF test statistics are less than the critical values. The null hypothesis 'variable has unit root' cannot be rejected even at 10 percent level of significance indicating that all variables have unit root at level form, which means these variables are non-stationary at level forms.

However, while taking the first difference of all variables and testing the ADF unit root, there is no evidence of accepting the null hypothesis because the absolute value of ADF-statistics are found to be more than the critical values in three distinct cases: exogenous- constant, exogenous- constant and linear trend and exogenous-none. The null hypothesis that 'the variable has unit root' is strongly rejected under all cases as the variables are transformed in to the first difference. Thus, the variables under study are identified stationary at first difference.

Hence, the ADF unit root test implies that our variables under analysis are non-stationary at level forms and they are stationary at first difference.

6.2.2 Dickey-Fuller-GLS Unit Root Test

The DF-GLS unit root test, elaborated by Elliott, Rothenberg and Stock, based on the t-test of the hypothesis $H_0 = 0$ in the regression equation,

$$dY_t^d = a_0 dY_t^d + a_1 dY_{t-1}^d + \cdots + a_p dY_{t-p}^d + \varepsilon_t \tag{6.11}$$

Where, Y_t^d is the locally de-trended seriesY_t. The local de-trending depends on whether we consider a model with drift only or a linear trend (Maddala, 2002:550). The latter case is based on the following equation,

$$Y_t^d = Y_t - \beta_0 - \beta_1 T \tag{6.12}$$

The DF-GLS Unit root test has been performed on the basis two equations (equations 6.13 & 6.14)

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

$$Y_t^\mu = \alpha Y_{t-1}^\mu + \sum_{i=1}^k \varphi_i \, dY_{t-i}^t + \varepsilon_t \tag{6.13}$$

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

$$Y_t^\tau = \alpha Y_{t-1}^\mu + \sum_{i=1}^k \varphi_i \, dY_{t-i}^\tau + \varepsilon_t \tag{6.14}$$

Where Y_t^τ is the GLS de-trended real output (and other variables). For the DF-GLS test with SIC lag selection, there are no additional unit root rejections.

The results of the DF-GLS unit root test (Table- 6.2) also illustrates the same conclusion as ADF test when constant and linear trend are taken as exogenous. This mean the null hypothesis of a unit root is rejected when the variables are in first differences. Again, conclusions that the variables are non stationary at level form and stationary at first differences have been drawn on the basis of second case also (i.e. exogenous- constant and linear trend) in DF-GLS unit root test.

Table 6.2: Dickey-Fuller-GLS Unit Root Test on Variables

Exogenous: Constant   Null Hypothesis: The variable has a unit root

Variable	ERS DF-GLS test statistic	Lag length	Test critical values*		
			1%	5%	10%
$lnCPI$	0.9319	4	-2.5812	-1.9430	-1.6152
$dlnCPI$	-2.6052	2	-2.5811	-1.9430	-1.6152
lnM_1	1.0506	4	-2.5814	-1.9431	-1.6152
$dlnM_1$	-2.6813	3	-2.5814	-1.9431	-1.6152
lnM_2	1.3662	4	-2.5814	-1.9431	-1.6152
$dlnM_2$	-3.2825	1	-2.5812	-1.9430	-1.6152

* Mackinnon (1996)

Exogenous: Constant, Linear trend

Variable	ERS DF-GLS test statistic	Lag length	Test critical values*		
			1%	5%	10%
$lnCPI$	-2.1690	4	-2.5284	-2.9870	-2.6970
$dlnCPI$	-8.9131	0	-2.5248	-2.9840	-2.6940
lnM_1	-1.5988	4	-3.5308	-2.9890	-2.6990
$dlnM_1$	-3.9256	3	-3.5308	-2.9890	-2.6990
lnM_2	-1.7189	4	-3.5308	-2.9890	-2.6990
$dlnM_2$	-3.5484	2	-3.5296	-2.9890	-2.6980

From Table-6.2, it is observed that all the variables: $lnCPI$, lnM_1 and lnM_2 suffer from unit root at level forms under both cases, that is, constant as exogenous and constant and linear trend as exogenous because the DF-GLS test statistics in absolute form for all variables are less than the critical values at 1%, 5% and 10% level. The null hypothesis cannot be rejected even at 10% level of significance representing that these variables are non-stationary at level forms. However, the variables $lnCPI$, lnM_1 and lnM_2 do not contain the unit roots at their first differences in both cases: constant as exogenous and constant and linear trend as exogenous, because the null hypothesis is strongly rejected at 1% level of significance for all variables under study. This clearly indicates that the variable under study, $lnCPI$, lnM_1 and lnM_2 are stationary at first differences.

6.2.3 Phillips-Perron Unit Root Test

The Phillips-Perron unit root test does not reject the null hypothesis "variable has a unit root" on variables when they are in level as reported by Phillips-Perron test statistic and probability value (Table-6.3). The hypothesis is rejected when the variables are in first differences. Hence it can be concluded that the variables are stationary when they are in first differences and non-stationary at level in all cases of exogeneity.

Table 6.3: Phillips-Perron Unit Root Test on Variables

Exogenous: Constant　　　　Null Hypothesis: The variable has a unit root

Variable	Phillips-Perron test statistic	Prob* value	Band** -width	Test critical values 1%	5%	10%
$lnCPI$	-0.3815	0.9081	10	-3.4751	-2.8811	-2.5772
$dlnCPI$	-12.4618	0.0000	10	-3.4755	-2.8812	-2.5773
lnM_1	-0.9856	0.7575	12	-3.4758	-2.8814	-2.5774
$dlnM_1$	-12.9296	0.0000	12	-3.4761	-2.8815	-2.5775
lnM_2	-0.3051	0.9201	7	-3.4758	-2.8814	-2.5774
$dlnM_2$	-11.1193	0.0000	7	-3.4761	-2.8815	-2.5775
Exogenous: Constant, Linear trend						
$lnCPI$	-1.4234	0.8503	10	-4.0216	-3.4406	-3.1448
$dlnCPI$	-12.4595	0.0000	10	-4.0221	-3.4408	-3.1449
lnM_1	-2.1304	0.5242	11	-4.0225	-3.4411	-3.1450
$dlnM_1$	-13.0028	0.0000	12	-4.0230	-3.4413	-3.1452
lnM_2	-1.9732	0.6106	8	-4.0225	-3.4411	-3.1450
$dlnM_2$	-11.0784	0.0000	7	-4.0230	-3.4413	-3.1452
Exogenous: None						
$lnCPI$	7.6558	1.0000	10	-2.5807	-1.9430	-1.6152
$dlnCPI$	-10.1560	0.0000	10	-2.5808	-1.9430	-1.6152
lnM_1	10.9693	1.0000	12	-2.5810	-1.9430	-1.6152
$dlnM_1$	-9.6141	0.0000	11	-2.5811	-1.9430	-1.6152
lnM_2	12.6531	1.0000	8	-2.5810	-1.9430	-1.6152
$dlnM_2$	-5.9605	0.0000	9	-2.5811	-1.9430	-1.6152

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

6.2.4 KPSS Unit Root Test

To circumvent the limitation that ADF test always has a low power, Kwiatkowski, Phillips, Schmidt, and Shin (1992) proposed an alternative test which Y_t is assumed to be stationary under the null. The KPSS test is a Lagrange multiplier test and the test statistic can be computed by firstly regressing the dependent variable Y_t on a constant or a constant and a time trend t. And then save the OLS residuals ε_t and compute the partial sums $S_t = \sum_{s=1}^{t} \varepsilon_s$ for all t. Further the test statistic is given by (Verbeek 2004)[24].

$$KPSS\ LM = \sum_{i=1}^{T} \frac{S_t^2}{\hat{\sigma}_t^2} \tag{6.15}$$

Where, $S_t = \sum_{s=1}^{t} \varepsilon_s$ and $\hat{\sigma}_t^2$ is the estimated error variance from the regression.

$$Y_t = \alpha + \beta t + \varepsilon_t \tag{6.16}$$

For the conclusion to be robust, we use the unit root test and the stationary test jointly. The results of these two tests can be compared and see if the same conclusion is obtained. If the contradictive results are reached based on both ADF and KPSS tests, KPSS test is preferred due to the drawbacks of ADF tests.

Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root test (Table-6.4) on variables does not support the null hypothesis that the variable is stationary when the variables are in level form. However, the null hypothesis that the variable is stationary is not rejected in both cases (constant as exogenous and constant and linear trend) when the variables are in first difference. Thus, the KPSS unit root test verifies that all the variables under study are non-stationary at level forms and these variables are stationary at their first differences.

[24] Verbeek, M. (2004). A guide to modern econometrics. Rotterdam, Johan Wiley& Sons.

Table- 6.4: KPSS Unit Root Test on Variables

Exogenous: Constant Null Hypothesis: The variable is stationary

Variable	KPSS test statistic (LM-stat.)	Band width**	Residual variance (no correction)	HAC Corrected Variance (Bartlett kernel)
$lnCPI$	1.4376	10	0.8041	8.1967
$dlnCPI$	0.1436	10	0.0006	0.0005
lnM_1	1.4338	10	2.3603	23.9967
$dlnM_1$	0.1623	12	0.0019	0.009
lnM_2	1.4376	10	3.0911	31.2658
$dlnM_2$	0.1301	7	0.0009	0.0011
Asymptotic critical Values*		1%	5%	10%
		0.7390	0.4630	0.3470

Exogenous: Constant, Linear Trend

$lnCPI$	0.3062	10	0.0116	0.1157
$dlnCPI$	0.1257	10	0.0006	0.0005
lnM_1	0.2676	10	0.0131	0.1234
$dlnM_1$	0.0718	12	0.0019	0.0008
lnM_2	0.2286	10	0.0138	0.1287
$dlnM_2$	0.1197	7	0.0009	0.0011
Asymptotic critical Values*		1%	5%	10%
		0.216000	0.146000	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table-1) **Newey-West using Bartlett kernel

6.2.5 ERS Point-Optimal Unit Root Test

Elliott et al. (1996) (ERS[25], thereafter) developed a unit root test based on a quasi-difference detrending of the series in order to increase power of Dickey-Fuller (1979, 1981) tests. They suggest the Dickey-Fuller Generalized Least Squares (DF-GLS) test using the following regression.

$$d\tilde{Y}_t = \beta_0 \check{Y}_{t-1} + \sum_{j=1}^{k} \beta_j \, d\check{Y}_{t-j} + \varepsilon_t \qquad (6.17)$$

where, $\tilde{Y}_t$ is the locally detrended series Y_t. The DF-GLS t-test is performed by testing the null hypothesis $\beta_0 = 0$ against the alternative $\beta_1 < 0$. The local

[25] Elliott, G., Rothenberg, T.J., Stock, J.H. (1996). Efficient tests for an autoregressive unit root. Econometrica 64, 813-836.

detrending series is defined by

$$\tilde{Y}_t = Y_t - \acute{\psi} Z_t \tag{6.18}$$

Where Z_t equals to 1 for the constant mean case, and (1; t) for the linear trend case, and $\acute{\psi}$ is the GLS estimator obtained by regressing $\bar{Y}$ on $\bar{Z}$ where

$$\bar{Y} = (\mathrm{Y}_1, (1 - \overline{\alpha}\mathrm{B})\mathrm{Y}_2, \ldots, (1 - \overline{\alpha}\mathrm{B})\mathrm{YT})' \tag{6.19}$$

$$\bar{Z} = (\mathrm{Z}_1, (1 - \overline{\alpha}\mathrm{B})\mathrm{Z}_2, \ldots, (1 - \overline{\alpha}\mathrm{B})\mathrm{ZT})' \tag{6.20}$$

and $\overline{\alpha} = 1 + {}^{\bar{c}}/_{T}$. They also consider a point optimal test of the unit root null hypothesis $\alpha = 1$ against the alternative $\alpha = \overline{\alpha}$ given by

$$PT = [(\overline{\alpha}) - \overline{\alpha}(1)]/S_{ar}^2 \tag{6.21}$$

where $S(a)$ is given by $(Y_a - Z_a \psi')'$ $(Y_a - Z_a \psi)$ and S_{ar} is the autoregressive spectral density estimator of the long-term variance. The value of $\bar{c}$ is chosen such that the asymptotic power of test is 50% against the local alternative $\overline{\alpha} = 1 + {}^{\bar{c}}/_{T}$. ERS advise $\bar{c} = -7$ for the constant mean case.

Table-6.5 portrays the results from ERS Point-Optimal unit root test under two cases: constant as exogenous and constant and linear trend as exogenous. The ERS statistics for all variables under both cases of exogeneity are found to be greater than the test critical values when the variables are in level forms. This clearly indicates that the null hypothesis ‘variable has unit root’ cannot be rejected even at 10% level of significance. It means all variables are non-stationary at level forms under both cases of exogeneity. However, the ERS statistics for all variables under both conditions of exogeneity are found to be less than the test critical values when the variables are first differenced. The null hypothesis is strongly rejected for all variables under both cases implying that all the variables are stationary at first difference.

Table 6.5: ERS Point-Optimal Unit Roots Test on Variables

Exogenous: Constant Null Hypothesis: The variable has a unit root

Variable	ERS test statistic (P-statistic)	HAC Corrected Variance(Spectral OLS auto regression)	Lag length	Test critical values 1%	5%	10%
$lnCPI$	1366.045	0.000818	4	1.9308	3.1388	4.2468
$dlnCPI$	0.72612	0.001035	1	1.9312	3.1382	4.2452
lnM_1	3588.13	0.001002	4	1.9316	3.1376	4.2436
$dlnM_1$	0.07274	0.010629	1	1.9320	3.1370	4.2420
lnM_2	3231.21	0.001509	4	1.9316	3.1376	4.2436
$dlnM_2$	1.1939	0.001542	1	1.9320	3.1370	4.2420

Exogenous: Constant, Linear trend

$lnCPI$	15.0182	0.000973	4	4.1592	5.6496	6.8236
$dlnCPI$	1.3989	0.001033	1	4.1613	8.6494	6.8229
lnM_1	17.0632	0.001178	4	4.1634	5.6492	6.8222
$dlnM_1$	0.2339	0.010744	1	4.1655	5.6490	6.8215
lnM_2	12.6774	0.001882	4	4.1634	5.6492	6.8222
$dlnM_2$	1.5831	0.001543	1	4.1655	5.6490	6.8215

*Elliott-Rothenberg-Stock (1996, Table 1) ** Spectral OLS AR based on SIC

6.2.6 Ng-Perron Modified Unit Root Test

Ng-Perron modified unit root test has been recently introduced in Econometrics in 2001. Ng-Perron unit root test is the modified form of Phillips-Perron Phillips and Perron (1988) Z_α and Z_t statistics, the Bhargava (1986) R_1 statistic, and the Elliot, Rothenberg and Stock (1996) Point Optimal statistic based on GLS detrended data Y_t^d

$$.\kappa = \sum_{t=2}^{T} (Y_{t-1}^d)^2 / T^2 \qquad (6.22)$$

And. the GLS-detrended modified statistics are written as

$$MZ_\alpha^d = (T^{-1}(Y_T^d)^2 - f_0)/(2\kappa)$$
$$MZ_t^d = MZ_\alpha \times MSB$$
$$MSB^d = (\kappa / f_0)^{1/2}$$
$$MP_T^d = \begin{cases} (\bar{c}^2\kappa - \bar{c}T^{-1}(Y_T^d)^2)/f_0 & if \quad x_t = \{1\} \\ (\bar{c}^2\kappa + (1-\bar{c})T^{-1}(Y_T^d)^2)/f_0 & if \quad x_t = \{1, t\} \end{cases}$$

(6.23)

$$\text{where} \quad \bar{c} = \begin{cases} -7 & if \quad x_t = \{1\} \\ -13.5 & if \quad x_t = \{1, t\} \end{cases} \tag{6.24}$$

Table-6.6 displays the results from NG-Perron Modified unit root test based on MZa, MZt, MSB and MPT test statistics for the variables under study. From this table-6.6 it is observed that

(a) MZa statistics for all variables at level form under both cases of exogeneity are not significant at any level.

(b) The MZt statistics for all variables at level form under both cases of exogeneity are not significant at any level.

(c) MSB and MPT statistics for all variables at level form under both cases of exogeneity are also not significant at any level.

(d) MZa, MZt, MSB and MPT statistics testify that the variables under study at level form under both conditions of exogeneity are suffering from unit root; and hence, all the variables are non-stationary at level form under both of the conditions of exogeneity.

(e) However, all the variables under study under both of the conditions of exogeneity are found to be stationary as reported by MZa, MZt, MSB and MPT statistics.

It is, therefore, the NG-Perron Modified Unit Root test confirms that all the variables at level form are non-stationary and these are stationary at their first difference. Not only this, all six tests of unit root confirm that the variables under study such as $lnCPI$, lnM_1 and lnM_2 are stationary at their first differences. These variables are integrated of order 1 and can be denoted as $I(1)$. So for robust regression, these $I(1)$ variables can be used except Johansen's Cointegration test and Vector Error Correction Modeling, it is because the Eviews econometric software automatically transforms the series in to stationary if the series are $I(1)$. It means, the Eviews requires $I(1)$ series for computing cointegration and VECM.

Table 6.6: Ng-Perron Modified Unit Root Test on Variables

Exogenous: Constant Null Hypothesis: The variable has a unit root

Variable	Lag length*	Ng-Perron test statistics				HAC corrected variance
		MZa	MZt	MSB	MPT	
$lnCPI$	4	1.1166	1.0315	0.9238	62.0204	0.0146
$dlnCPI$	2	-12.1024	-2.4547	0.2028	2.0450	0.0003
lnM_1	4	1.21006	1.2110	1.0008	72.8856	0.0397
$dlnM_1$	2	-56.1437	-5.2951	0.0943	0.4441	0.0001
lnM_2	4	1.5366	1.9672	1.2802	122.279	0.0321
$dlnM_2$	1	-18.8276	-3.0234	0.1605	1.4647	0.0009
Asymptotic Critical Values	1%	-13.8	-2.58	0.174	1.78	
	5%	-8.1	-1.98	0.23	3.17	
	10%	-5.7	-1.62	0.275	4.45	

Exogenous: Constant, Linear Trend

Variable	Lag length*	Ng-Perron test statistics				HAC corrected variance
		MZa	MZt	MSB	MPT	
$lnCPI$	4	-6.5517	-1.7994	0.2746	13.9142	0.001063
$dlnCPI$	2	-66.7914	-5.76701	0.08624	1.4489	0.000906
lnM_1	4	-5.8886	-1.6801	0.28532	15.4303	0.001262
$dlnM_1$	1	-351.902	-13.2645	0.03769	0.25926	0.009760
lnM_2	4	-2.77062	-1.16315	0.41982	32.4575	0.000699
$dlnM_2$	0	-548721	-5.23572	0.09542	1.6715	0.001282
Asymptotic Critical Values	1%	-23.8	-3.42	0.143	4.03	
	5%	-17.3	-2.91	0.168	5.48	
	10%	-14.2	-2.62	0.185	6.67	

6.3 Conclusion of Chapter Six

Following conclusions are drawn from Chapter Six.

- The price level transformed in logarithmic form ($LnCPI$) is non-stationary at level form. However, it is stationary at first difference as indicated by various unit root test such as ADF unit root test, DF-GLS unit root test, PP unit root test, KPSS unit root test, ERS point optimal unit root test and Ng-Perron modified unit root test.

- Both money supply (M_1 and M_2) in logarithmic form (LnM_1 and LnM_2) are non-stationary at level. However, these variables are stationary at first difference as confirmed by different unit root tests mentioned above.

CHAPTER SEVEN

COINTEGRATION, VECTOR ERROR CORRECTION MODELING AND GRANGER CAUSALITY

7.1 Introduction

This chapter endeavors the relationship between narrow money supply and price level, and broad money supply and price level during the study period from $1976Q_1$ to $2012Q_2$ through Johansen's Cointegration test, Vector Error Correction Modeling (VECM) and Granger Causality test. First, we analyze the relationship between money supply (both M_1 and M_2) and price level employing the Johansen's Cointegration test. If variables under study are found to be cointegrated, we can use VECM to examine the relationship between money supply and price level. After developing VECM, we apply the stability and diagnostic test to examine the robustness of the VECM. And, this chapter ends with the verification of relationship between the variables through Granger Causality test.

7.2 Selection of Suitable Lags

Before employing the Johansen's Cointegration test, it is necessary to select suitable lags to be used for the endogenous variable in regression. There are various criteria for selecting the lag length. Table 7.1 reveals the selection of lag length through VAR technique.

From Table-7.1 it is observed that Schwarz and Hannan-Quinn statistics are significant at lag 5 and LR, FPE and Akaike information statistics are significant at lag 9. Lag 9 is very high lag to use in regression for analyzing the relationship between two endogenous variables. Lag 5 under SC and HQ is somewhat suitable as compared to lag 9. So, we use lag 5 as the suitable lag for each endogenous variable in regression of cointegration and VECM narrow money supply and price level.

Table-7.1: VAR Lag Order Selection Criteria

Endogenous variables: $LnCPI_t$ & LnM_{1t} Exogenous variable: constant

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-37.2880	NA	0.006334	0.6138	0.6584	0.6319
1	541.9674	1131.358	7.91e-07	-8.3744	-8.2408	-8.3201
2	548.2865	12.14455	7.63e-07	-8.4107	-8.1879	-8.3201
3	587.4708	74.08278	4.40e-07	-8.9604	-8.6485	-8.8337
4	604.0081	30.74902	3.62e-07	-9.1563	-8.7553	-8.9934
5	637.6478	61.49757	2.28e-07	-9.6194	-9.1293*	-9.4203*
6	640.2768	4.723981	2.33e-07	-9.5980	-9.0187	-9.3626
7	641.0406	1.348537	2.45e-07	-9.5475	-8.8790	-9.2759
8	648.5259	12.98244	2.32e-07	-9.6019	-8.8443	-9.2941
9	661.9428	22.85054*	2.01e-07*	-9.7491*	-8.9024	-9.4050
10	664.3007	3.942221	2.06e-07	-9.7234	-8.7876	-9.3432
11	667.2347	4.813567	2.10e-07	-9.7067	-8.6818	-9.2903
12	670.5016	5.257646	2.13e-07	-9.6953	-8.5812	-9.2426
13	674.2848	5.970366	2.15e-07	-9.6919	-8.4887	-9.2030
14	674.8269	0.838576	2.27e-07	-9.6379	-8.3455	-9.1128
15	676.3154	2.255934	2.37e-07	-9.5986	-8.2172	-9.0373
16	679.2294	4.325580	2.42e-07	-9.5817	-8.1111	-8.9842
17	682.4068	4.617140	2.46e-07	-9.5688	-8.0091	-8.9351
18	685.3474	4.181069	2.52e-07	-9.5523	-7.9034	-8.8823

*[26]

7.3 Johansen's Cointegration Test between $LnCPI_t$ and LnM_{1t}

The Johansen method of cointegration is based on Maximum-Eigen and Trace statistic value. The following results have been revealed between $LnCPI$ and LnM_{1t} for Johansen approach.

*[26] Indicates significant level

Table 7.2: Test Based on Maximum Eigen Value ($\lambda_{\max}$)

Endogenous Variables: $LnCPI\ and\ LnM_1$ Order of VAR = 5
Trend Assumption: No Deterministic Trend (Restricted Constant)

Null Hypothesis	Alternative Hypothesis	Eigen-values (λ_i)	Max-Eigen Statistics($\lambda_{\max}$)	0.05 Critical Value	Probability
r = 0*	r = 1	0.1231	18.3993	15.8921	0.0198
r ≤ 1	r = 2	0.0478	6.8626	9.1645	0.1338

* Denotes the rejection of the hypothesis at 0.05 levels.

Table-7.3: Test Based on Trace Statistic (λ_{trace})

Endogenous Variables: $LnCPI\ and\ LnM_1$ Order of VAR = 5
Trend Assumption: No Deterministic Trend (Restricted Constant)

Null Hypothesis	Alternative Hypothesis	Eigen-values (λ_i)	Trace Statistics ($\lambda_{\max}$)	0.05 Critical Value	Probability
r = 0*	r = 1	0.1231	25.2620	20.2618	0.0094
r ≤ 1	r = 2	0.0478	6.8626	9.1645	0.1338

Using fifth order VAR of the two variables under investigation, the hypothesis of r = 0 is uniformly rejected in favor of the alternative hypothesis r = 1 employing the maximum Eigen-value test as reported by the 4th column of Table-7.2. The maximum Eigen-value test of r = 1 versus r = 2 fails to reject the null hypothesis of k = 1 implying one cointegrating vector. Thus, on the basis of maximum Eigen-value test, $LnCPI\ and\ LnM_1$ are found to be cointegrated.

Turning to the trace test as reported by Table-7.3, the null hypothesis r ≤ 1 cannot be rejected while the hypothesis r = 0 can be rejected at 5 percent significant level. Moreover, there appears to be single cointegrating vector, that is: $r = 1$. Consequently, this test indicates that $LnCPI_t\ and\ LnM_{1t}$ are cointegrated.

Both maximum Eigen-value test and trace test indicate that $LnCPI\ and\ LnM_1$ are cointegrated to each other, that is, there is found to be long run equilibrium relationship between narrow money supply and price level during the study period from $1976Q_1$ to $2012Q_2$.

7.4 Vector Error Correction Modeling (VECM) [$\boldsymbol{LnCPI_t}$ & $\boldsymbol{LnM_{1_t}}$]

Once the variables $LnCPI\ and\ LnM_1$ are cointegrated, our next job is to employ the VECM to capture the long run equilibrium relationship by allowing the short run shocks. “A vector error correction (VEC) model is a restricted VAR designed for use with nonstationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the *error correction* term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments”. (Quantitative Micro Software, 2009: Eviews 7, User’s Guide II)

Table-7.4 shows the regression results from VECM with $LnCPI$ as dependent variable. The estimated VECM with $LnCPI$ as dependent variable is given by equation (7.1).

$$\begin{aligned} dLnCPI_t = {} & \rho_1 Z_{1_{t-1}} + \alpha_1 dLnM_{1_{t-1}} + \alpha_2 dLnM_{1_{t-2}} + \alpha_3 dLnM_{1_{t-3}} + \alpha_4 dLnM_{1_{t-4}} \\ & + \alpha_{5d} LnM_{1_{t-5}} + \beta_1 dLnCPI_{t-1} + \beta_2 dLnCPI_{t-2} + \beta_3 dLnCPI_{t-3} \\ & + \beta_4 dLnCPI_{t-4} + \beta_5 dLnCPI_{t-5} + \varepsilon_{1t} \end{aligned} \tag{7.1}$$

The coefficients of independent variables, standard error, t-statistic and probability value of equation (7.1) are presented through Table-7.4.

Table-7.4: Results from VECM with $dLnCPI_t$ as Dependent Variable

(Lag:1 to 5)

Trend Assumption: No Deterministic Trend (Restricted Constant:$\gamma = 0$)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Z_{1t-1}	ρ_1 = -0.0085	0.0045	-1.8579	0.0655
LnM_{1t-1}	α_1 = 0.1006	0.0613	1.6403	0.1034
LnM_{1t-2}	α_2 = 0.1404	0.0548	2.5604	0.0116
LnM_{1t-3}	α_3 = 0.0532	0.0591	0.8998	0.3699
LnM_{1t-4}	α_4 =- 0.1136	0.0575	-1.9738	0.0505
LnM_{1t-5}	α_5 = 0.0448	0.0633	0.7072	0.4807
$dLnCPI_{t-1}$	β_1 = 0.0847	0.0873	0.9707	0.3335
$dLnCPI_{t-2}$	β_2 = 0.0191	0.0813	0.2361	0.8137
$dLnCPI_{t-3}$	β_3 = -0.1224	0.0799	-1.5318	0.1280
$dLnCPI_{t-4}$	β_4 = 0.3383	0.0776	4.3578	0.0000
$dLnCPI_{t-5}$	β_5 = -0.2140	0.0818	-2.6152	0.0100

R^2=0.532329 Adj. R^2=0.496076 S.E. of regression= 0.018283 Log likelihood=367.3262
Durbin-Watson stat=1.987960

From the Table-7.4, it is observed that

i) The coefficient of error correction term ($Z_{1_{t-1}}$), ρ_1 =-0.0085 is significant at 10% level, which indicates that the short run shocks significantly affect the long run relationship between the variables $dLnCPIP_t$ and $dLnM_{1_t}$. The speed of convergence of equilibrium of (0.0085) 0.85 % implies that inflations are adjusted by 0.85 % of the past five quarters' deviation from equilibrium.

ii) The negative value of ρ_1 =-0.0085 indicates that $dLnCPI_t$, following any positive short run shocks, declined. Consequently, the short run shocks appeared to pull down the $dLnCPIP_t$ below the long run equilibrium level.

iii) The absolute value of the coefficient of Z_{t-1} to be lower than unity, i.e. $|\rho_1| < 1$, which implies that $dLnCPIP_t$ converged to the long run equilibrium level following a short run shocks. Thus, long run relationship between $dLnCPIP_t$ as dependent variable and $dLnM_{1_t}$ independent variables is found to be stable. Consequently, the short run dynamics defined an 'equilibrium' process.

iv) The coefficient of $dLnM_{1_{t-2}}$ is α_2 =0.1404. It is positive and significant at 5% level implying the current inflation is caused by two period's (quarter) back narrow money supply. More clearly, a ten percent rise of change in M_1 money supply in two periods back causes the change in price level to rise by 1.4%.

v) The coefficient of $dLnM_{1_{t-4}}$ is $\alpha_4 =$ - 0.1136. It is significant at 10% level, but the algebraic sign is negative which violates the theoretical norms of 'Quantity Theory of Money'. So this coefficient is disregarded from the analysis of money-price relation.

vi) The coefficient of $dLnCPI_{t-4}$ is $\beta_4 =$ 0.3383. It is significant at less than 1% level and positive, meaning the change in current price level is positively affected by the change in price level of four periods back. It implies that a 10% rise in change in price of four periods/quarters back has caused the change in current price level by 3.3%.

The values of coefficient of determination and adjusted coefficient of determination of estimated VECM of equation (7.1) are R^2=0.5323, Adj. R^2=0.4960 respectively. This implies that approximately 50% of the variation of dependent variable $dLnCPI_t$ is explained by the set of independent variables. This represents the satisfactory goodness of the fit of VECM with $dLnCPI_t$ as dependent variable. Likewise, the low value of standard error of regression and high value of Log likelihood ratio also represent that the estimated VECM is reasonably fitted. Since, the Durbin-Watson statistic is 1.98 (close to 2), the estimated VECM of equation (7.1) does not suffer from positive autocorrelation problem.

The estimated VECM with $dLnM_{1t}$ as dependent variable is given by equation (7.2) as:

$$\begin{aligned} dLnM_{1t} = \rho_2 Z_{1_{t-1}} &+ \delta_1 dLnM_{1_{t-1}} + \delta_2 dLnM_{1_{t-2}} + \delta_3 dLnM_{1_{t-3}} + \delta_4 dLnM_{1_{t-4}} \\ &+ \delta_5 dLnM_{1_{t-5}} + \theta_1 dLnCPI_{t-1} + \theta_2 dLnCPI_{t-2} + \theta_3 dLnCPI_{t-3} \\ &+ \theta_4 dLnCPI_{t-4} + \theta_5 dLnCPI_{t-5} + \varepsilon_{2t} \end{aligned} \tag{7.2}$$

The coefficients of independent variables, standard error, t-statistic and probability value of equation (7.2) are presented through Table-7.5.

Table-7.5: Results from VECM with $dLnM_{1_t}$ as Dependent Variable (Lag: 1 to 5)

Trend Assumption: No Deterministic Trend (Restricted Constant: $\gamma = 0$)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Z_{2t-1}	ρ_2 = -0.0241	0.0063	-3.7868	0.0002
LnM_{1t-1}	δ_1=0.0192	0.0852	0.2253	0.8221
LnM_{1t-2}	δ_2=-0.3187	0.0762	-4.1794	0.0001
LnM_{1t-3}	δ_3=-0.0424	0.0822	-0.5164	0.6065
LnM_{1t-4}	δ_4=0.4097	0.0800	5.1209	0.0000
LnM_{1t-5}	δ_5=0.0447	0.0880	0.5076	0.6126
$dLnCPI_{t-1}$	θ_1=0.2608	0.1213	2.1493	0.0335
$dLnCPI_{t-2}$	θ_2=0.0750	0.1130	0.6640	0.5079
$dLnCPI_{t-3}$	θ_3=0.1312	0.1110	1.1816	0.2395
$dLnCPI_{t-4}$	θ_4=-0.2969	0.1079	-2.7521	0.0068
$dLnCPI_{t-5}$	θ_5=-0.0599	0.1137	-0.5267	0.5992

R^2=0.6989 Adj. R^2=0.6756 S.E. of regression= 0.0254 Log likelihood=321.2465

Durbin-Watson stat=1. 9781

From the Table-7.5, it is observed that

i) The coefficient of error correction term ($Z_{2_{t-1}}$), ρ_2= -0.0241 significant at less than 1% level, which indicates that the short run shocks significantly affect the long run relationship between the variables $dLnCPI_t$ and $dLnM_{1_t}$. The speed of convergence of equilibrium of (0.0241) 2.4 % implies that money supplies (narrow money) are adjusted by 2.4 % of the past five quarters' deviation from equilibrium.

ii) The negative value of ρ_2 =-0.0241 indicates that $dLnM_{1_t}$, following any positive short run shocks, declined. Consequently, the short run shocks appeared to pull down the $dLnM_{1_t}$ below the long run equilibrium level.

iii) The absolute value of the coefficient of Z_{2t-1} to be lower than unity, i.e. $|\rho_2|<$ 1, which implies that $dLnM_{1_t}$ converged to the long run equilibrium level following a short run shocks. Thus, long run relationship between $dLnM_{1_t}$ as dependent variable and $dLnCPI_t$ independent variables is found to be stable. Consequently, the short run dynamics defined an 'equilibrium' process.

iv) The coefficient of $dLnM_{1_{t-4}}$, $\delta_4 = 0.4097$. It is positive and significant at 1% level implying the current narrow money supply is caused by four period's (quarter) back narrow money supply. More clearly, a ten percent rise of change in M_1 money supply in four periods back causes the change in M_1 money supply level to rise by 4.04%.

v) The coefficient of $dLnCPI_{t-1}$ is $\theta_1 = 0.2608$. It is positive and significant at 5% level. This implies that current M_1 money supply is positively caused by the price level of one period back. A ten percent rise in price level in previous period causes M_1 money supply to rise by 2.6%.

The values of coefficient of determination and adjusted coefficient of determination of estimated VECM of equation (7.2) are R^2=0.6989 Adj. R^2=0.6756 respectively. This implies that more than 65% of the variation of dependent variable dM_{1_t} is explained by the set of independent variables. This represents the satisfactory goodness of the fit of VECM with dM_{1_t} as dependent variable. Likewise, the low value of standard error of regression and high value of Log likelihood ratio also represent that the estimated VECM is reasonably fitted. Since, the Durbin-Watson statistic is 1.97 (close to 2); the estimated VECM of equation (7.2) does not suffer from positive autocorrelation problem.

Thus, the estimated VECMs imply that there is cointegration between M_1 money supply and price level. The long run equilibrium relationship between these two variables imply that there is bi-directional Granger causality between M_1 money supply and price level in Nepalese economy during the study period.

7.4.1 Residuals Diagnostic of VECM

In order to examine the consistency of fitted VECM of equation (7.1), it is necessary to apply Residual Diagnostic through the test such as Correlogram-Q statistic, Correlogram Squared Residuals, Serial Correlation LM Test and Heteroscedasticity Test. With the help of these tests, we can conclude whether or not estimated VECM is consistent.

7.4.1.1 Correlogram –Q-Statistics of Residuals

The Correlogram-Q-statistic of the residuals of estimated VECM of equation (7.1) is presented through Table-7.6. The ACFs and PACFs of correlogram of the 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 fitted VECM of equation (7.1) are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of the VECM of equation (7.1).

Table-7.6: Correlogram-Q-statistics of Residual of VECM Equation (7.1)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.014	-0.014	0.0284	0.866	11	0.069	0.010	14.735	0.195
2	-0.009	-0.009	0.0388	0.981	12	-0.047	0.002	15.074	0.237
3	0.140	0.140	2.8983	0.408	13	0.064	0.016	15.705	0.265
4	-0.119	-0.117	4.9613	0.291	14	-0.111	-0.121	17.644	0.223
5	0.050	0.053	5.3322	0.377	15	-0.057	-0.014	18.162	0.254
6	-0.077	-0.103	6.2100	0.400	16	0.102	0.053	19.828	0.228
7	-0.152	-0.121	9.6500	0.209	17	-0.062	-0.001	20.449	0.252
8	0.148	0.126	12.957	0.113	18	0.024	0.017	20.545	0.303
9	-0.083	-0.058	14.007	0.122	19	-0.049	-0.087	20.940	0.340
10	0.003	0.027	14.008	0.173	20	0.113	0.160	23.045	0.287

7.4.1.2 Correlogram of Squared Residuals

The Correlogram-Q-statistic of the residuals squared of estimated VECM of equation (7.1) is presented through Table-7.7. The ACFs and PACFs of correlogram of the residual squared are nearly zero at all lags and the Q-statistics at all lags are not significant with large p-values. This indicates that there is no evidence of rejecting the null hypothesis of no serial correlation. This implies that the residuals of the fitted VECM of equation (7.1) are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of the VECM of equation (7.1).

Table-7.7: Correlogram-Q-statistics of Squared Residual of VECM Equation (7.1)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.039	-0.039	0.2231	0.866	9	0.006	0.001	3.6192	0.122
2	-0.012	-0.013	0.2434	0.981	10	-0.041	-0.030	3.8746	0.173
3	-0.021	-0.022	0.3075	0.408	11	0.007	0.007	3.8830	0.973
4	0.133	0.131	2.8779	0.291	12	0.010	-0.003	3.8972	0.985
5	0.022	0.032	2.9480	0.377	13	-0.023	-0.028	3.9812	0.991
6	-0.043	-0.039	3.2260	0.400	14	-0.021	-0.011	4.0538	0.995
7	0.005	0.007	3.2293	0.209	15	-0.099	-0.103	5.6008	0.986
8	0.050	0.034	3.6129	0.113	16	-0.034	-0.051	5.7888	0.990

7.4.1.3 Breusch-Godfrey Lagrange Multiplier Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation have been presented through Table-7.8. As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test of Table-7.8, the null hypothesis of no autocorrelation cannot be rejected. The B-G LM test implies that residuals are not serially correlated. Due to the non-presence of serial correlation, the estimated VECM of equation (7.1) is considered as the consistent model for representing the long run equilibrium relationship between M_1 money supply and price level.

Table-7.8: Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.1067	Prob. F(2,127)	0.3338
$T \times R^2$	2.3864	Prob. Chi-Square(2)	0.3032

7.4.1.4 VEC Residuals Heteroscedasticity Test

The null hypothesis of White's (1980) is: H_0: there is homoscedasticity in the residuals. The null hypothesis is not rejected if the F-statistic and χ^2 –statistic are not significant. No rejection of null hypothesis confirms that residuals of estimated VECM do not suffer from heteroscedasticity problem and estimated VECM is claimed to be consistent. Table-7.9 presents the VEC Residual Heteroscedasticity test.

Looking at the individual component (lower part of Table-7.9), R^2 of all dependent variables are not significant as implied by F-statistic and χ^2-statistic not rejecting the null hypothesis. Likewise, the χ^2-statistic of Joint test also implies that the null hypothesis is not rejected, which means residuals are homoscedastic. Thus, the VEC Residual Heteroscedasticity test confirms that there is no heteroscedasticity problem in the residuals of estimated VECM of equation (7.1). Thus, the estimated VEC model is econometrically meaning full and sound

Table-7.9: VEC Residual Heteroscedasticity Test

Joint Test

χ^2	Degree of Freedom	Probability
64.69036	66	0.5226

Individual Components

Dependent	R-squared	F(22,117)	Prob.	Chi-sq(22)
res1×res1	0.1511	0.9469	0.5355	21.1597
res2×res2	0.1383	0.8537	0.6536	19.3656
res2×res1	0.1934	1.2759	0.2023	27.0891

7.4.2 Stability Test

To examine the stability of the estimated VECM of equation (7.1), we apply some test such as Ramsey's RESET test, Recursive Residual test, CUSUM test, CUSUM of Squares test etc.

7.4.2.1 Ramsey's RESET Test

Ramsey (1969)[27] introduced Regression Specification Error Test (RESET) to examine whether the functional form of the regression is appropriate. In this test, we examine whether the relationship between dependent variable and the independent variable in the regression model bears the linear relationship or non-linear relationship is appropriate. The test involves the addition of powers of the fitted values from the regression into a second regression. If the appropriate model was a linear one, then the powers of the fitted values would not be significant in this second regression.

The classical normal linear regression model is estimated as[28]:

[27] Ramsey, J.B. (1969). Tests for specification errors in classical linear least-squares analysis, Journal of the Royal Statistical Society, Series B, 71, 350–371.

[28] See QMS (2009), Eviews 7: User's Guide II.

$$y = X\beta + \varepsilon \qquad (7.3)$$

Where, ε is the white noise error term and it is $iid(0, \sigma^2)$, that is, it follows the multivariate distribution.

The null and alternative hypotheses for Ramsey's RESET are:

$H_0 : \varepsilon \sim N(0, \sigma^2)$ &

$H_1 : \varepsilon \sim N(\mu, \sigma^2) \qquad \mu \neq 0$

The test is based on the augmented regression,

$$y = X\beta + Z_\gamma + \varepsilon \qquad (7.4)$$

The test of specification error evaluates the restriction,

$\gamma = 0$

In equation (7.3) there is no entry of matrix *Z*. So we are very curious that what variables enter the *Z* matrix so that there exists an omitted variable,

$\gamma = 0$

In testing whether the functional form is incorrect, the non-linear part of the regression model will be some function of the regressors included in equation (7.3).

$$y = \beta_0 + \beta_1 X + \varepsilon \qquad (7.3a)$$

&

$$y = \beta_0 + \beta_1 X + \beta_2 X^2 + \varepsilon \qquad (7.3b)$$

So, two regressions are estimated where the latter is the former with squared fitted values obtained from the first regression. Note that the squared fitted values introduce the non-linearity into the specification. We will test for *functional form* with an F-test. The null hypothesis is that "the correct specification is linear"**.** The alternative hypothesis is the correct specification is "non-linear".

If the null hypothesis is not rejected as reported by F-statistic[29], the true specification is linear and the equation passes the Ramsey Reset test. Contrary to this, if null hypothesis is rejected, the specification is not linear and it requires including the squared fitted values to the original model. In such a situation, the model represents non-linear relationship between the variables under study.

[29] t-statistic as well as likelihood ratio can also be used.

Table-7.10 demonstrates the results from Ramsey's RESET test. In the upper part of Table-7.10, f-statistic, t-statistic and likelihood ratio are not significant as reported by the corresponding probability values. The null hypothesis 'correct specification is linear' is not rejected even by including the $Fitted^2$ term in to the VECM of equation (7.1). It means the estimated VECM is linear and there is no need of non-linearity in the estimated VECM (7.1). Likewise, in lower part of Table-7.10, H_0: $\gamma = 0$ is not rejected as reported by the t-statistic. Hence, the Ramsey's RESET test implies that the estimated VECM (7.1) is stable model consisting the properties of linearity and non-misspecification of the model.

Table-7.10: Ramsey's RESET Test of VECM of Equation (7.1)

(a)

Test-statistic	Value	Degree of Freedom	Probability
t-statistic	0.3727	128	0.7099
F-statistic	0.1389	(1, 128)	0.7099
Likelihood ratio	0.1518	1	0.6967

Unrestricted Test Equation (b)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Z_{1t-1}	ρ_1 =-0.0088	0.0046	-1.8879	0.0613
LnM_{1t-1}	α_1 = 0.1082	0.0648	1.6692	0.0975
LnM_{1t-2}	α_2 = 0.1529	0.0644	2.3733	0.0191
LnM_{1t-3}	α_3 = 0.0610	0.0629	0.9698	0.3339
LnM_{1t-4}	α_4 = -0.1262	0.0669	-1.8867	0.0615
LnM_{1t-5}	α_5 = 0.0464	0.0637	0.7287	0.4675
$dLnCPI_{t-1}$	β_1 =0.0903	0.0889	1.0167	0.3112
$dLnCPI_{t-2}$	β_2 =0.0258	0.0835	0.3100	0.7571
$dLnCPI_{t-3}$	β_3 =-0.1359	0.0879	-1.5449	0.1248
$dLnCPI_{t-4}$	β_4 =0.3691	0.1135	3.2520	0.0015
$dLnCPI_{t-5}$	β_5 =-0.2269	0.0890	-2.5469	0.0120
$Fitted^2$	γ =-1.6273	4.3657	-0.3727	0.7099

7.4.2.2 CUSUM Test

"The CUSUM test (Brown, Durbin, and Evans, 1975) is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines". (QMS,2009)

[30]The CUSUM test is based on the statistic:

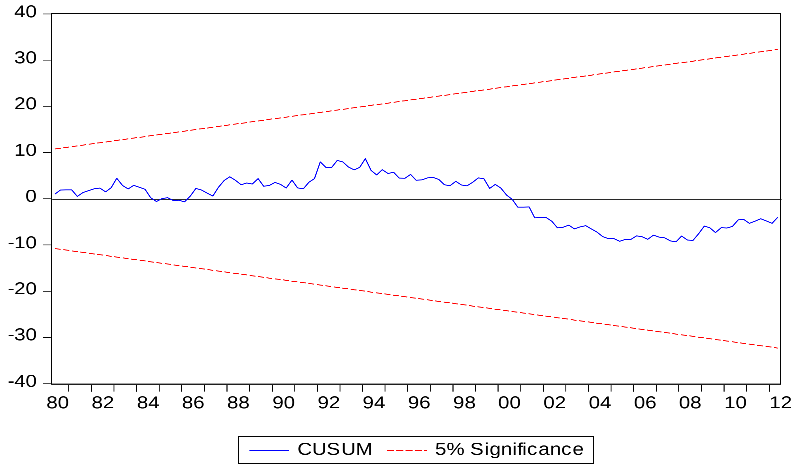
$$W_t = \sum_{r=k+1}^{t} {}^{w_r}/_{s} \tag{7.5}$$

For $t = k + 1, \ldots T,$ where w is the recursive residual defined above, and s is the standard deviation of the recursive residuals w_t. If the β vector remains constant from period to period, $E(W_t = 0)$, but if β changes, W_t will tend to diverge from the zero mean value line. The significance of any departure from the zero line is assessed by reference to a pair of 5% significance lines, the distance between which increases with . The 5% significance lines are found by connecting the points:

$$[k, \pm - 0.948(T - k)^{1/3}] \text{ and, } [T, \pm 3 \times 0.948(T - k)^{1/3}] \tag{7.6}$$

Movement of W_t outside the critical lines is suggestive of coefficient instability. But if W_t lies within the critical lines, there is stability of coefficient of estimated model. In Graph 7.1, W_t line lies within the critical lines. This clearly confirms the stability of coefficient of estimated VECM (7.1).

Figure-7.1: Graphical Presentation of CUSUM Test



[30] See QMS (2009), Eviews 7: User's Guide II.

7.4.2.3 CUSUM of Squared Test

[31]The CUSUM of squares test (Brown, Durbin, and Evans, 1975) is based on the test statistic:

$$S_t = {(\sum_{r=k+1}^{t} w_r^2)} \Big/ {(\sum_{r=k+1}^{T} w_r^2)} \tag{7.7}$$

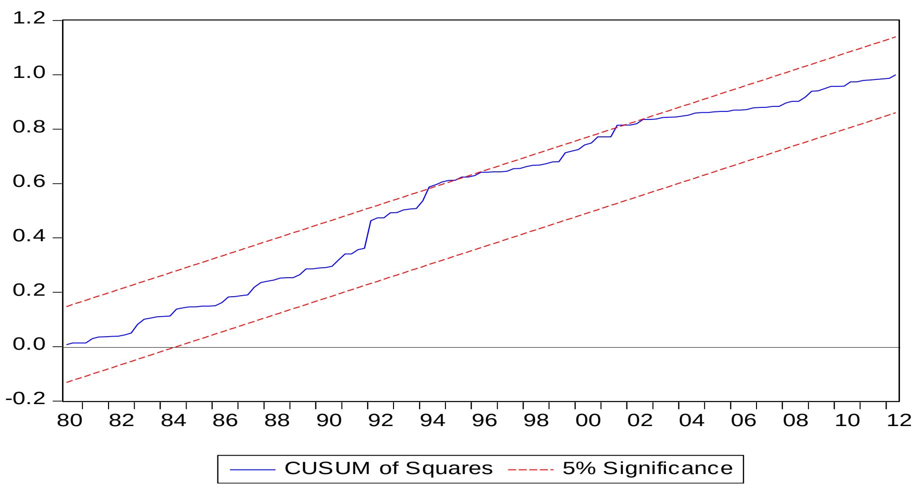
The expected value of S_t under the hypothesis of parameter constancy is:

$$E(S_t) = {(t-k)} \Big/ {(T-k)} \tag{7.8}$$

Which, goes from zero at $t = k$ to unity at $T = k$. The significance of the departure of S_t from its expected value is assessed by reference to a pair of parallel straight lines around the expected value.

The CUSUM of squared test provides a plot of S_t against t and the pair of 5 percent critical lines. As with the CUSUM test, movement outside the critical lines is suggestive of parameter or variance instability. Figure-7.2 shows the graphical presentation of CUSUM of squares test. In the graph, since S_t line lies within the critical lines, the estimated VECM (7.1) has stable parameter and variance.

Figure-7.2: Graphical Presentation of CUSUM of Squared Test



7.4.2.4 Recursive Coefficient Test

This view enables us to "trace the evolution of estimates for any coefficient as more and more of the sample data are used in the estimation. The view will provide a plot

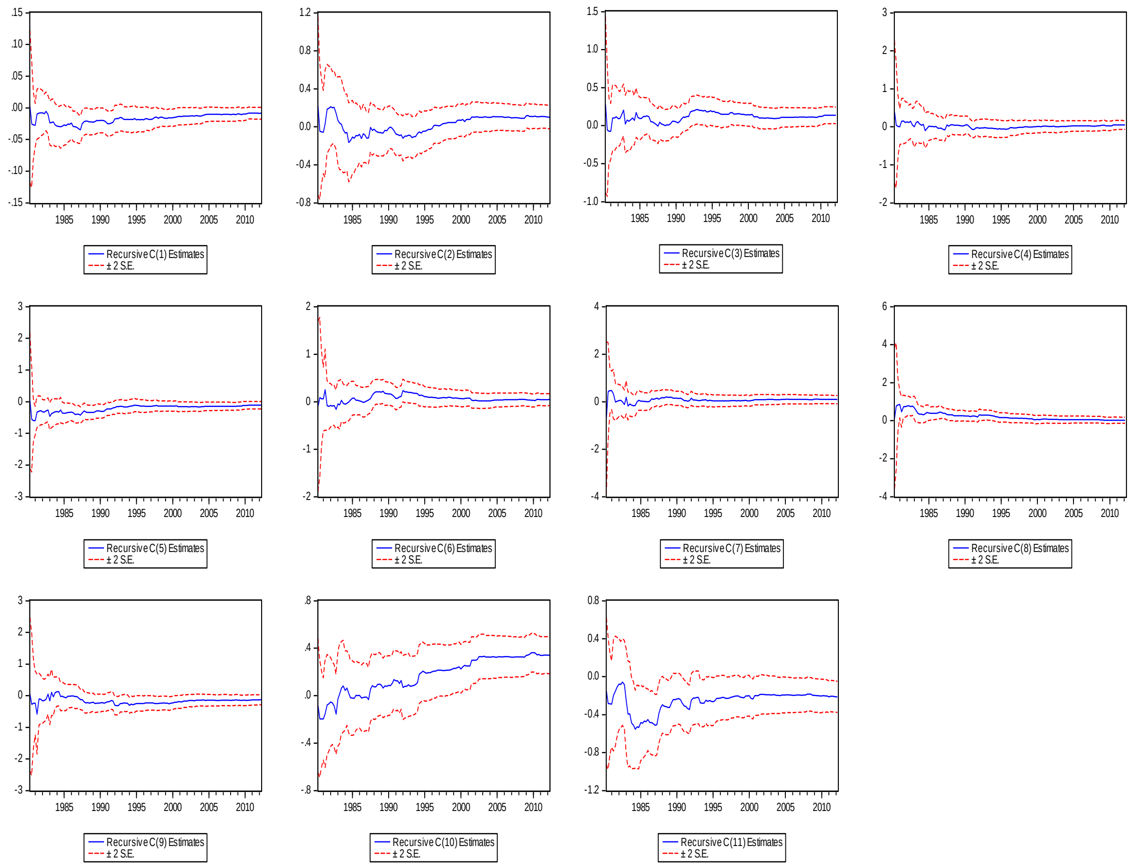
[31] See QMS (2009), Eviews 7: User's Guide II.

of selected coefficients in the equation for all feasible recursive estimations. Also shown are the two standard error bands around the estimated coefficients". (QMS, 2009: Eviews 7)

QMS (2009: Eviews 7), adds that "If the coefficient displays significant variation as more data is added to the estimating equation, it is a strong indication of instability. Coefficient plots will sometimes show dramatic jumps as the postulated equation tries to digest a structural break". Contrary to this, if the coefficient displays no or negligible variation as more data is added to the estimating equation, it can be claimed that there is stability of coefficient of the estimated equation.

Graph-7.3 represents the Recursive Coefficient test of estimated VECM (7.1). The graph of most of the coefficients represents either no or negligible variation with respect to change in time. The slight variation is observed only in case of C(10). But of other coefficients except C(10) have more or less no variation. Thus, the Recursive Coefficient test also represents the stability of coefficients of estimated VECM (7.1).

Graph-7.3: Graphical Presentation of Recursive Coefficients Test



7.5 Johansen's Cointegration Test between $LnCPI_t$ and LnM_{2_t}

Before carrying out the Johansen's Cointegration test between broad money supply and price level, it is necessary to select the suitable lags to be used for each endogenous variable in regression. Table-7.11 shows the selection of suitable lags using different criteria through VAR technique.

From Table-7.11 it is observed that the Schwarz statistics are significant at lags 5 and LR, FPE, HQ and Akaike information statistics are significant at lag 9. Lag 9 is very high lag to use in regression for analyzing the relationship between two endogenous variables. Lag 5 under SC and HQ is somewhat suitable as compared to lag 9. So, we use lag 5 as the suitable lag for each endogenous variable in regression of cointegration and VECM for the endogenous variables $LnCPI$ and LnM_2.

Table-7.11: VAR Lag Order Selection Criteria

Endogenous variables: $LnCPI_t$ & LnM_{2t} Exogenous Variable: constant

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-77.3305	NA	0.011509	1.2111	1.2550	1.2289
1	572.4997	1269.897	6.01e-07	-8.6488	-8.5171	-8.5953
2	576.1597	7.040449	6.04e-07	-8.6436	-8.4241	-8.5544
3	589.3071	24.88982	5.26e-07	-8.7833	-8.4760	-8.6584
4	594.9274	10.46842	5.13e-07	-8.8080	-8.4129	-8.6475
5	628.0603	60.70138	3.29e-07	-9.2528	-8.7699*	-9.0566
6	632.0103	7.115996	3.29e-07	-9.2520	-8.6814	-9.0201
7	634.9120	5.138896	3.35e-07	-9.2352	-8.5768	-8.9677
8	640.2715	9.328061	3.28e-07	-9.2560	-8.5098	-8.9528
9	654.3319	24.04213*	2.82e-07*	-9.4096*	-8.5756	-9.0707*
10	656.3744	3.430251	2.91e-07	-9.3797	-8.4579	-9.0051
11	660.8251	7.338492	2.90e-07	-9.3866	-8.3770	-8.9763
12	663.9000	4.976228	2.94e-07	-9.3725	-8.2751	-8.9265
13	666.8685	4.713289	3.00e-07	-9.3567	-8.1715	-8.8751
14	671.5004	7.213093	2.98e-07	-9.3664	-8.0934	-8.8491
15	671.8438	0.524172	3.16e-07	-9.3105	-7.9498	-8.7576

The Johansen method of cointegration is based on Maximum-Eigen and Trace statistic value. The following results have been revealed between $LnCPI$ and LnM_2 for Johansen approach.

Table 7.12: Test Based on Maximum Eigen Value ($\lambda_{\max}$)

Endogenous Variables: $LnCPI\ and\ LnM_1$ Order of VAR = 5

Trend Assumption: No Deterministic Trend (Restricted Constant)

Null Hypothesis	Alternative Hypothesis	Eigen-values (λ_i)	Max-Eigen Statistics($\lambda_{\max}$)	0.05 Critical Value	Probability
r = 0*	r = 1	0.08837	12.9532	11.2248	0.0246
r $\leq$1	r = 2	0.01976	2.79471	4.1299	0.1118

Table-7.13: Test Based on Trace Statistic (λ_{trace})

Endogenous Variables: $LnCPI\ and\ LnM_1$ Order of VAR = 5

Trend Assumption: No Deterministic Trend (Restricted Constant)

Null Hypothesis	Alternative Hypothesis	Eigen-values (λ_i)	Trace Statistics ($\lambda_{\max}$)	0.05 Critical Value	Probability
r = 0*	r = 1	0.08837	15.7479	12.3209	0.0128
r $\leq$1	r = 2	0.01976	2.7947	4.1299	0.1118

Using fifth order VAR of the two variables under investigation, the hypothesis of r = 0 is uniformly rejected in favor of the alternative hypothesis $r = 1$ employing the maximum Eigen-value test as reported by the 4^{th} column of Table-7.12. The maximum Eigen-value test of $r = 1$ versus $r = 2$ fails to reject the null hypothesis of $k = 1$ implying one cointegrating vector. Thus, on the basis of maximum Eigen-value test, $LnCPI\ and\ LnM_2$ are found to be cointegrated. Turning to the trace test as reported by Table-7.13, the null hypothesis r $\leq$1 cannot be rejected while the hypothesis r = 0 can be rejected at 5 percent significant level. Moreover, there appears to be single cointegrating vector $(r = 1)$. Consequently, this test indicates that $LnCPI\ and\ LnM_2$ are cointegrated.

Both maximum Eigen-value test and trace test indicate that $LnCPI\ and\ LnM_2$ are cointegrated to each other, that is, there is found to be long run equilibrium relationship between broad money supply and price level during the study period from $1976Q_1$ to $2012Q_2$.

7.6 Vector Error Correction Modeling (VECM) [$\boldsymbol{LnCPI_t}$ **and** $\boldsymbol{LnM_{2_t}}$]

After the variables $LnCPI$ and LnM_1 are cointegrated, our next job is to employ the VECM to capture the long run equilibrium relationship by allowing the short run shocks. An error correction model is not a model that corrects the error in another model. Error Correction Models (ECMs) are a category of multiple time series models that directly estimate the speed at which a dependent variable Y returns to equilibrium after a change in an independent variable X. ECMs are theoretically-driven approach useful for estimating both short term and long term effects of one time series on another. Table-7.4 shows the regression results from VECM with $LnCPI$ as dependent variable. The estimated VECM with $LnCPI$ as dependent variable is given by equation (7.9).

$$dLnCPI_t = \rho_1 Z_{1_{t-1}} + \alpha_1 LnM_{2_{t-1}} + \alpha_2 LnM_{2_{t-2}} + \alpha_3 LnM_{2_{t-3}} + \alpha_4 LnM_{2_{t-4}} + \alpha_5 LnM_{2_{t-5}} + \beta_1 LnCPI_{t-1} + \beta_2 LnCPI_{t-2} + \beta_3 LnCPI_{t-3} + \beta_4 LnCPI_{t-4} + \beta_5 LnCPI_{t-5} + \varepsilon_{1t} \quad (7.9)$$

The coefficients of independent variables, standard error, t-statistic and probability value of equation (7.9) are presented through Table-7.14. From the Table-7.14, it is observed that

i) The coefficient of error correction term ($Z_{1_{t-1}}$), ρ_1 =-0.0097 is significant at 5% level, which indicates that the short run shocks significantly affect the long run relationship between the variables $dLnCPIP_t$ and $dLnM_{2_t}$. The speed of convergence of equilibrium of (0.0097) 0.97% implies that inflations are adjusted by 0.97 % of the past five quarters' deviation from equilibrium.

ii) The negative value of ρ_1 =-0.0097 indicates that $dLnCPI_t$, following any positive short run shocks, declined. Consequently, the short run shocks appeared to pull down the $dLnCPIP_t$ below the long run equilibrium level.

iii) The absolute value of the coefficient of Z_{t-1} to be lower than unity, i.e. $|\rho_1| < 1$, which implies that $dLnCPIP_t$ converged to the long run equilibrium level following a short run shocks. Thus, long run relationship between $dLnCPIP_t$ as dependent variable and $dLnM_{2_t}$ independent variables is found to be stable. Consequently, the short run dynamics defined an 'equilibrium' process.

iv) The coefficient of $dLnM_{2_{t-2}}$, α_2 =0.1259. It is positive and significant at 5% level implying the current inflation is caused by two period's (quarter) back broad money supply. More clearly, a ten percent rise of change in M_2 money supply in two periods back causes the change in price level to rise by 1.2%.

v) The coefficient of $dLnM_{2_{t-4}}$ is $\alpha_4 =$ -0.1058. It is significant at 10% level, but the algebraic sign is negative which violates the theoretical norms of 'Quantity Theory of Money'. So, this coefficient is disregarded in the analysis of money-price relation.

vi) The coefficient of $dLnCPI_{t-4}$ is $\beta_4 =$ 0.4873. It is significant at less than 1% level and positive, meaning the change in current price level is positively affected by the change in price level of four periods back. It implies that a 10% rise in change in price of four periods/quarters back has caused the change in current price level by 4.8%. Likewise, the coefficient of $dLnCPI_{t-5}$ is $\beta_5 =$ -0.2562. It is significant at 1% level but negative and nothing can be interpreted with the help of this value.

Table-7.14: Results from VECM with $dLnCPI_t$ as Dependent Variable (Lag:1 to 5)

Trend Assumption: No Deterministic Trend (Restricted Constant:$\gamma = 0$)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Z_{1t-1}	ρ_1 =-0.0097	0.0040	-2.3962	0.0180
LnM_{2t-1}	α_1 =0.0559	0.0579	0.9649	0.3364
LnM_{2t-2}	α_2 =0.1259	0.0575	2.1860	0.0306
LnM_{2t-3}	α_3 =-0.0328	0.0591	-0.5548	0.5800
LnM_{2t-4}	α_4 =-0.1058	0.0582	-1.8166	0.0716
LnM_{2t-5}	α_5 =0.0857	0.0578	1.4815	0.1409
$LnCPI_{t-1}$	β_1 =0.1377	0.0834	1.6510	0.1012
$LnCPI_{t-2}$	β_2 =-0.0754	0.0689	-1.0942	0.2759
$LnCPI_{t-3}$	β_3 =-0.1567	0.0683	-2.2919	0.0235
$LnCPI_{t-4}$	β_4 = 0.4873	0.0654	7.4504	0.0000
$LnCPI_{t-5}$	β_5 =-0.2562	0.0768	-3.3335	0.0011

R^2=0.5145 Adj. R^2=0.4769 S.E. of regression= 0.01828

Log likelihood=364.7136 Durbin-Watson stat=2.077961

The values of coefficient of determination and adjusted coefficient of determination of estimated VECM of equation (7.9) are R^2=0.5145 Adj. R^2=0.4769 respectively. This implies that nearly 50% of the variation of dependent variable $dLnCPI_t$ is explained by the set of independent variables. This represents the satisfactory goodness of the fit of VECM with $dLnCPI_t$ as dependent variable. Likewise, the low value of standard error of regression and high value of Log likelihood ratio also represent that the estimated VECM is reasonably fitted. Since, the Durbin-Watson statistic is 2.07 (approximately 2), the estimated VECM of equation (7.9) does not suffer from positive autocorrelation problem.

The estimated VECM with LnM_{1t} as dependent variable is given by equation (7.10)

$$LnM_{2t} = \rho_2 Z_{1_{t-1}} + \delta_1 LnM_{2_{t-1}} + \delta_2 LnM_{2_{t-2}} + \delta_3 LnM_{2_{t-3}} + \delta_4 LnM_{2_{t-4}} + \delta_5 LnM_{2_{t-5}} + \theta_1 LnCPI_{t-1} + \theta_2 LnCPI_{t-2} + \theta_3 LnCPI_{t-3} + \theta_4 LnCPI_{t-4} + \theta_5 LnCPI_{t-5} + \varepsilon_{2t} \tag{7.10}$$

The coefficients of independent variables, standard error, t-statistic and probability value of equation (7.10) are presented through Table-7.15.

Table-7.15: Results from VECM with $dLnM_{2_t}$ as Dependent Variable (Lag: 1 to 5)

Trend Assumption: No Deterministic Trend (Restricted Constant:$\gamma = 0$)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Z_{2t-1}	ρ_2 =-0.0152	0.0062	-2.4416	0.0160
LnM_{2t-1}	δ_1 =0.1179	0.0883	1.3345	0.1844
LnM_{2t-2}	δ_2 =-0.2122	0.0877	-2.4180	0.0170
LnM_{2t-3}	δ_3 =0.0427	0.0902	0.4735	0.6366
LnM_{2t-4}	δ_4 =0.2084	0.0887	2.3482	0.0204
LnM_{2t-5}	δ_5 =0.1051	0.0882	1.1924	0.2353
$LnCPI_{t-1}$	θ_1 =0.2066	0.1271	1.6248	0.1066
$LnCPI_{t-2}$	θ_2 =0.1966	0.1050	1.8725	0.0634
$LnCPI_{t-3}$	θ_3 =0.1386	0.1041	1.3310	0.1855
$LnCPI_{t-4}$	θ_4 =-0.0311	0.0996	-0.3126	0.7551
$LnCPI_{t-5}$	θ_5 =0.0354	0.1171	0.3022	0.7629

R^2=0.2118 Adj. R^2=0.1507 S.E. of regression= 0.0283
Log likelihood=305.7439 Durbin-Watson stat=1.9764

From the Table-7.15, it is observed that

i) The coefficient of error correction term ($Z_{2_{t-1}}$), ρ_2 =-0.0152 significant at 1% level, which indicates that the short run shocks significantly affect the long run relationship between the variables $dLnCPI_t$ and $dLnM_{2_t}$. The speed of convergence of equilibrium of (0.0152) 1.5 % implies that money supplies (broad money) are adjusted by 1.5 % of the past five quarters' deviation from equilibrium.

ii) The negative value of ρ_2 =-0.0152 indicates that $dLnM_{1_t}$, following any positive short run shocks, declined. Consequently, the short run shocks appeared to pull down the $dLnM_{2_t}$ below the long run equilibrium level.

iii) The absolute value of the coefficient of Z_{2t-1} to be lower than unity, i.e. $|\rho_2|<$ 1, which implies that $dLnM_{2_t}$ converged to the long run equilibrium level following a short run shocks. Thus, long run relationship between $dLnM_{2_t}$as dependent variable and $dLCPI_t$ independent variables is found to be stable. Consequently, the short run dynamics defined an 'equilibrium' process.

iv) The coefficient of $dLnM_{1_{t-4}}$, δ_4 = 0.2084 It is positive and significant at 5% level implying the current broad money supply is caused by four period's (quarter) back broad money supply. More clearly, a ten percent rise of change in M_2 money supply in four periods back causes the change in M_2 money supply level in current time to rise by 2.08%.

v) The coefficient of $LnCPI_{t-2}$, θ_2 =0.1966 is positive and significant at 10% level, implying that a ten percent rise in change of price level in previous second quarter/period causes the change in broad money supply in current period to rise by 1.96%.

The values of coefficient of determination and adjusted coefficient of determination of estimated VECM of equation (7.10) are R^2= 0.2118 and Adj.R^2=0.1507 respectively. This implies that the variation in dependent variable is not so much satisfactorily explained by the set of independent variables. However, the values of standard error of regression, log likelihood ratio and Durbin-Watson statistic imply that VECM of equation (7.10) is reasonably fitted.

Thus, the estimated VECMs imply that there is cointegration between M_2 money supply and price level. The long run equilibrium relationship between these two variables imply that there is bi-directional Granger causality between M_1 money supply and price level in Nepalese economy during the study period.

7.6.1 Residual Diagnostic of VECM of Equation (7.10)

In order to examine the consistency of fitted VECM of equation (7.10), it is necessary to apply Residual Diagnostic through the test such as Correlogram-Q statistic, Correlogram Squared Residuals, Serial Correlation LM Test and Heteroscedasticity Test. With the help of these tests, we can conclude whether or not estimated VECM (7.10) is consistent.

7.6.1.1 Correlogram –Q-Statistics of Residuals

The Correlogram-Q-statistic of the residuals of estimated VECM of equation (7.10) is presented through Table-7.16. The ACFs and PACFs of correlogram of the residual are not nearly zero at all lags. Besides, the Q-statistics up to lag 3 are not significant and above lag 3 these are significant with less p-values. This indicates that there is no evidence of accepting the null hypothesis of no serial correlation. This implies that the residuals of the fitted VECM of equation (7.10) are not uncorrelated with their own lagged values. Hence, there is no evidence of goodness of fit of the VECM of equation (7.10). However, correlogram-Q-statistics alone is not sufficient criterion for diagnostic of residuals. The presence or absence of serial correlation of the residual can be examined with the help of further other tests like Correlogram of Squared Residuals, B-G LM test and Residual Heteroscedasticity test.

Table-7.16: Correlogram-Q-statistics of Residual of VECM Equation (7.10)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.049	-0.049	0.3411	0.559	7	-0.166	-0.102	19.464	0.007
2	0.061	0.059	0.8740	0.646	8	0.176	0.127	24.109	0.002
3	0.188	0.195	6.0284	0.110	9	-0.098	-0.030	25.558	0.002
4	-0.229	-0.222	13.668	0.008	10	-0.047	-0.064	25.899	0.004
5	0.073	0.036	14.460	0.013	11	0.099	0.014	27.413	0.004
6	-0.076	-0.085	15.322	0.018	12	-0.016	0.086	27.451	0.007

7.6.1.2 Correlogram of Squared Residuals

The Correlogram-Q-statistic of the residuals squared of estimated VECM of equation (7.10) is presented through Table-7.17.

Table-7.17: Correlogram-Q-statistics of Residuals Squared of VECM Equation (7.10)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.062	-0.062	0.5557	0.456	7	-0.015	-0.019	1.1873	0.991
2	-0.018	-0.022	0.6000	0.741	8	0.092	0.087	2.4648	0.963
3	0.004	0.002	0.6027	0.896	9	-0.021	-0.012	2.5337	0.980
4	0.054	0.054	1.0310	0.905	10	-0.023	-0.020	2.6142	0.989
5	0.014	0.021	1.0580	0.958	11	-0.009	-0.011	2.6280	0.995
6	-0.025	-0.021	1.1514	0.979	12	-0.019	-0.030	2.6825	0.997

The ACFs and PACFs of correlogram of the residual squared are nearly zero at all lags and the Q-statistics at all lags are not significant with large p-values. This indicates that there is no evidence of rejecting the null hypothesis of no serial correlation. This implies that the residuals of the fitted VECM of equation (7.10) are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of the VECM of equation (7.10).

7.6.1.3 Breusch-Godfrey Lagrange Multiplier Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation have been presented through Table-7.18. As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test of Table-7.18, the null hypothesis of no autocorrelation cannot be rejected at 5% level of significance. The B-G LM test implies that residuals are not serially correlated. Due to the non-presence of serial correlation, the estimated VECM of equation (7.10) is considered as the consistent model for representing the long run equilibrium relationship between M_2 money supply and price level.

Table-7.18: Breusch-Godfrey Serial Correlation LM Test

F-statistic	2.2869	Prob. F(2,127)	0.1057
$T \times R^2$	4.8580	Prob. Chi-Square(2)	0.0881

7.6.1.4 VEC Residuals Heteroscedasticity Test

Table-7.19 presents the VEC Residual Heteroscedasticity test. Looking at the individual component (lower part of Table-7.19), R^2 of all dependent variables are not significant as implied by F-statistic and χ^2-statistic not rejecting the null hypothesis. Likewise, the χ^2-statistic of Joint test also implies that the null hypothesis is not rejected, which means residuals are homoscedastic. Thus, the VEC Residual Heteroscedasticity test confirms that there is no heteroscedasticity problem in the residuals of estimated VECM of equation (7.10). Thus, the estimated VEC model is econometrically meaning full and sound.

Table-7.19: VEC Residual Heteroscedasticity Test

Joint Test

χ^2	Degree of Freedom	Probability
72.6275	66	0.2689

Individual Components

Dependent	R-squared	F(22,117)	Prob.	Chi-sq(22)
res1*res1	0.0860	0.5006	0.9685	12.0457
res2*res2	0.1104	0.6601	0.8694	15.4596
res2*res1	0.3015	2.2959	0.0024	42.2157

7.7 Stability Test

To examine the stability of the estimated VECM of equation (7.10), we apply some test such as Ramsey's RESET test, CUSUM test, CUSUM Squares test, Recursive Residual test etc.

7.7.1 Ramsey's RESET Test

Table-7.20 demonstrates the results from Ramsey's RESET test. In the upper part of Table-7.20, F-statistic, t-statistic and likelihood ratio are not significant as reported by the corresponding probability values. The null hypothesis 'correct specification is linear' is not rejected even by including the $Fitted^2$ in to the VECM of equation (7.10). It means the estimated VECM is linear and there is no need of non-linearity in the estimated VECM (7.10).

Likewise, in lower part of Table-7.10, H_0: $\gamma = 0$ is not rejected as reported by the t-statistic. Hence, the Ramsey's RESET test implies that the estimated VECM (7.10) is stable model containing the properties of linearity and non-misspecification of the model.

Table-7.20: Ramsey's RESET Test of VECM of Equation (7.10)

(a)

Test-statistic	Value	Degree of Freedom	Probability
t-statistic	0.5748	128	0.5664
F-statistic	0.3304	(1, 128)	0.5664
Likelihood ratio	0.3609	1	0.5480

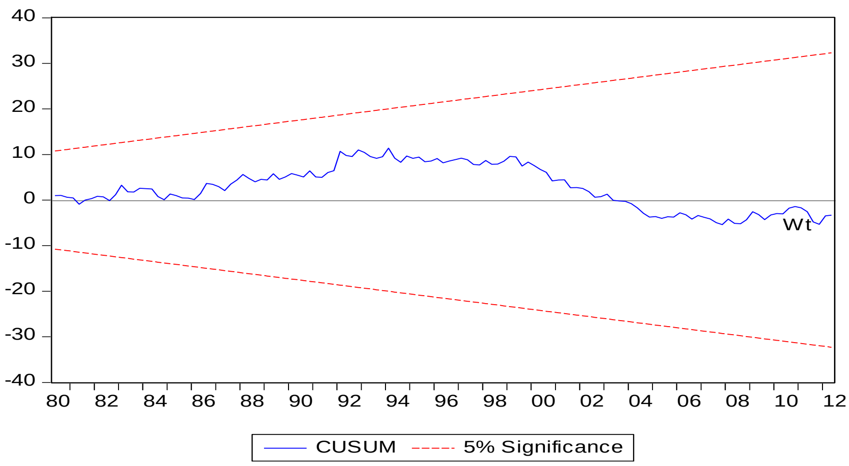
Unrestricted Test Equation (b)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Z_{1t-1}	ρ_1 =-0.0099	0.0041	-2.4175	0.0170
LnM_{1t-1}	α_1 = 0.0595	0.0584	1.0187	0.3102
LnM_{1t-2}	α_2 = 0.1590	0.0816	1.9488	0.0535
LnM_{1t-3}	α_3 = -0.0382	0.0601	-0.6371	0.5252
LnM_{1t-4}	α_4 = -0.1134	0.0599	-1.8944	0.0604
LnM_{1t-5}	α_5 = 0.0965	0.0610	1.5829	0.1159
$LnCPI_{t-1}$	β_1 =0.1535	0.0880	1.7438	0.0836
$LnCPI_{t-2}$	β_2 =-0.0793	0.0694	-1.1427	0.2553
$LnCPI_{t-3}$	β_3 =-0.1919	0.0919	-2.0868	0.0389
$LnCPI_{t-4}$	β_4 =0.5576	0.1387	4.0186	0.0001
$LnCPI_{t-5}$	β_5= 0.2805	0.0878	-3.1921	0.0018
$Fitted^2$	γ =-2.6724	4.6492	-0.5748	0.5664

7.7.2 CUSUM Test

Figure-7.4 shows the graphical presentation of CUSUM test. In the graph, W_t line lies within the critical lines. This clearly confirms the stability of coefficients of estimated VECM (7.10).

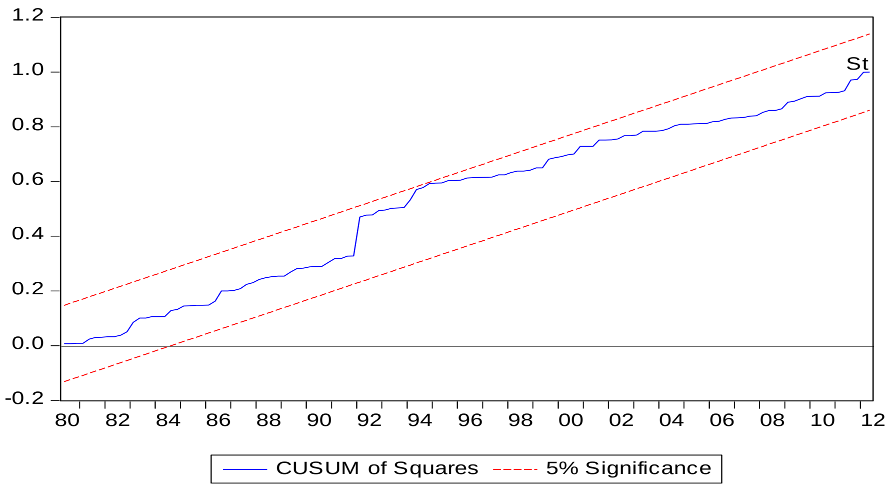
Figure-7.4: Graphical Presentation of CUSUM Test



7.7.3 CUSUM of Squared Test

Figure-7.5 shows the graphical presentation of CUSUM of squares test. In the graph, since S_t line lies within the critical lines, the estimated VECM (7.1) has stable parameter and variance.

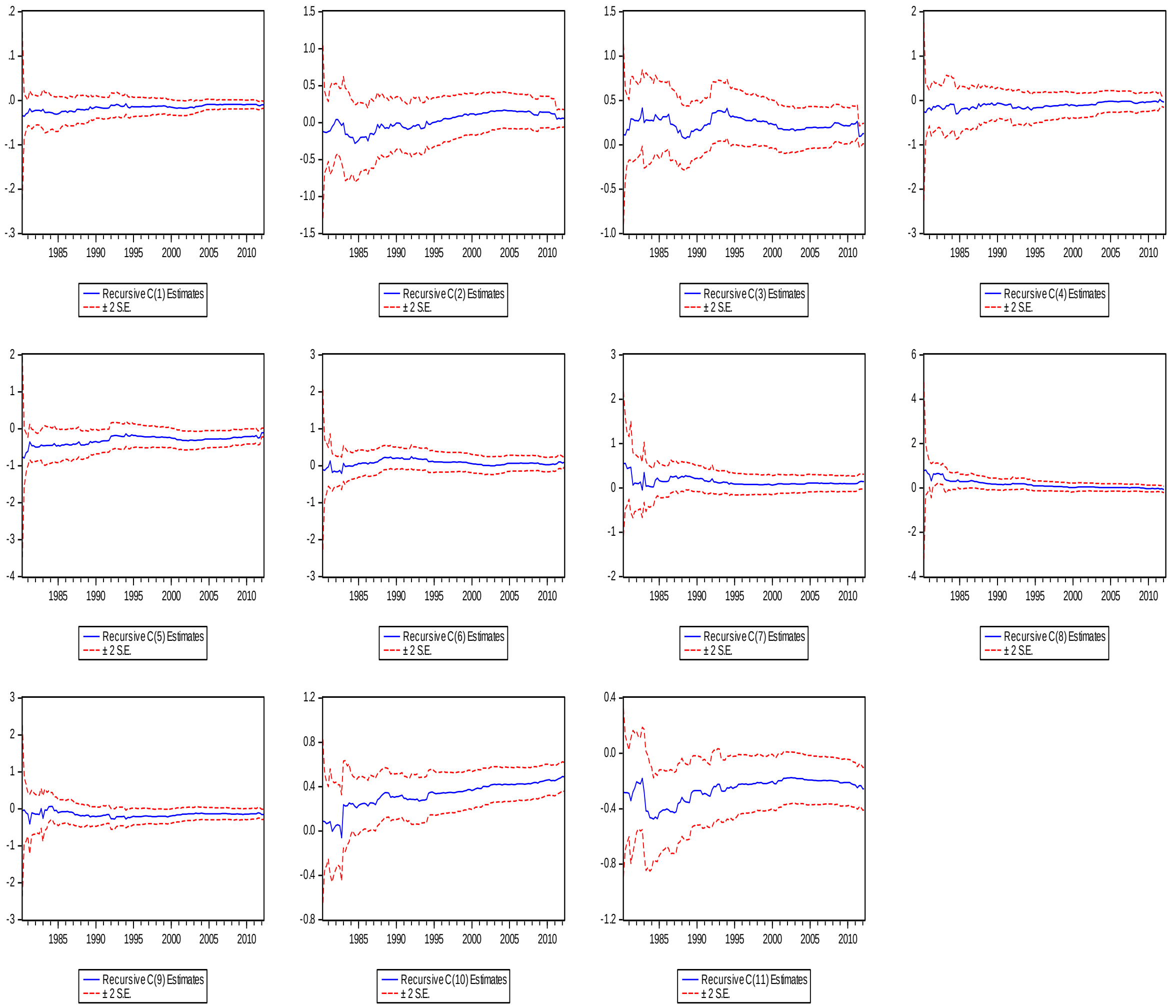
Figure-7.5: Graphical Presentation of CUSUM of Square Test



7.7.4 Recursive Coefficient Test

Figure/Graph-7.6 represents the Recursive Coefficient test of estimated VECM (7.1). The graph of most of the coefficients represents either no or negligible variation with respect to change in time. The slight variation is observed only in case of C(11). But other coefficients except C(10) have more or less no variation. Thus, the Recursive Coefficient test also represents the stability of coefficients of estimated VECM (7.10).

Figure-7.6: Recursive Coefficient Test of VECM (7.10)



7.8 Granger Causality Test

Since the variables ($LnCPI_t$& LnM_{1t}; $LnCPI_t$&LnM_{2t}) under investigation are found to be cointegrated, the Granger causality test can be used to obtain the causal relationship between $LnCPI_t\, and\ LnM_{1t}$ as well as $LnCPI_t\, and\ LnM_{2t}$. The Granger causality test is based on F-statistic and it requires the stationary variables. Therefore, the stationary series $dLnCPI_t and\, dLnM_{1t}$ as well as $dLnCPI_t and\, dLnM_{2t}$ have been used for Granger Causality Test. The results of Granger causality test have been portrayed in following Table=7.21.

Table-7.21: Pair Wise Granger Causality Test

Endogenous variables: $\begin{Bmatrix} dLnCPI_t and\ dLnM_{1t} \\ dLnCPI_t\ and\ dLnM_{2t} \end{Bmatrix}$

Null Hypothesis (H_0:$\alpha = 0$) ($dLnCPI_t and\ dLnM_{1t}$)	Lags	F-statistic	Probability
$dLnM_{1t}$ does not Granger Cause $dLnCPI_t$ $dLnCPI_t$ does not Granger Cause $dLnM_{1t}$	1	10.7724 0.0134	0.0013 0.9080
$dLnM_{1t}$ does not Granger Cause $dLnCPI_t$ $dLnCPI_t$ does not Granger Cause $dLnM_{1t}$	2	25.0991 6.18836	5.E-10 0.0027
$dLnM_{1t}$ does not Granger Cause $dLnCPI_t$ $dLnCPI_t$ does not Granger Cause $dLnM_{1t}$	3	21.6135 10.3106	2.E-11 4.E-06
$dLnM_{1t}$ does not Granger Cause $dLnCPI_t$ $dLnCPI_t$ does not Granger Cause $dLnM_{1t}$	4	8.2210 4.4006	6.E-06 0.0023
$dLnM_{1t}$ does not Granger Cause $dLnCPI_t$ $dLnCPI_t$ does not Granger Cause $dLnM_{1t}$	5	5.2248 3.4992	0.0002 0.0053
$dLnCPI_t$& $dLnM_{2t}$			
$dLnM_{2t}$ does not Granger Cause $dLnCPI_t$ $dLnCPI_t$ does not Granger Cause $dLnM_{2t}$	2	7.1088 3.9165	0.0012 0.0222
$dLnM_{2t}$ does not Granger Cause $dLnCPI_t$ $dLnCPI_t$ does not Granger Cause $dLnM_{2t}$	3	6.5207 3.7888	0.0004 0.0120
$dLnM_{2t}$ does not Granger Cause $dLnCPI_t$ $dLnCPI_t$ does not Granger Cause $dLnM_{2t}$	4	4.0642 1.7163	0.0039 0.1501

Upper part of Table-7.21 displays the Granger causality between narrow money supply (M_1) and price level, and lower part of the table shows the Granger causality between broad money supply (M_2) and price level. In the upper part of the Table-7.21, the null hypothesis "$dLnM_{1t}$ does not Granger cause $dLnCPI_t$" is strongly rejected at lag 1,2,3,4 and 5 at less than 1% level of significance as reported by F-statistic and the corresponding probability values. It means the price level is Granger caused by narrow money supply, i.e. the causality runs from narrow money supply to price level. Likewise, the null hypothesis "$dLnCPI_t$ does not Granger cause $dLnM_{1t}$" is also rejected at lag 2,3,4 and 5 at less than 1% level of significance. It implies that narrow money supply is also Granger caused by price level. It is clearly examined that there is bi-directional Granger causality between narrow money supply and price level. The change in narrow money supply has caused price level to change and change in price level has also caused narrow money supply to change. It means not only price level changes by narrow money supply but also narrow money supply changes due to the change in price level in Nepal during the study period.

From lower part of the Table-7.21, it is observed that the null hypothesis "$dLnM_{2t}$ does not Granger Cause $dLnCPI_t$" is strongly rejected at lag 2,3 and 4 at less than 1% level of significance representing that broad money supply Granger causes price level. The change in broad money supply definitely brings about the change in price level. Likewise, the null hypothesis "$dLnCPI_t$ does not Granger cause $dLnM_{2t}$" is also rejected at lag 2 and 3 at 5% level of significance, which means the change in price level definitely brings about the change in broad money supply. It is examined that not only price level is Granger caused by broad money supply but also broad money supply is Granger caused by price level. This clearly implies that there is bi-directional Granger causality between broad money supply and price level in the economy of Nepal during the study period.

7.9 Conclusion of Chapter Seven

Following conclusions are drawn from Chapter Seven.

- As reported by Johansen's Cointegration test, M_1 money supply and price level have long run equilibrium relationship with one cointegrating vector.
- The VECM with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ with independent variables of equation (7.1) implies that short run shocks significantly affect the long run relationship between M_1 money supply and price level. The inflations are adjusted by 0.85% of the past five quarters' deviation from equilibrium. A ten percent increase in change of M_1 money

supply of two quarters back causes the change in price level to increase by 1.4%.

- Not only M_1 money supply causes price to change but also price is caused by price itself. A ten percent increase in change of price of four periods back causes the change in price of current time to increase by 3.38%.
- The VECM, with $dLnM_{1t}$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables, implies that M_1 money supplies are adjusted by 2.4% of the past five quarters' deviation from equilibrium.
- The change in M_1 money supply at current time is caused by the change in M_1 money supply of four periods back itself. A ten percent increase in change of M_1 money supply of four periods back causes the change in current M_1 money supply by 4.04%.
- A ten percent rise in change of price level of preceding period causes change in M_1 money supply of current period to increase by 2.6%.
- As reported by VECM, there is bi-directional Granger causality between M_1 money supply and price level.
- As reported by various residuals diagnostic tests such as correlogram of squared residuals, B-G LM test and heteroscedasticity test, the VECM with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ with independent variables of equation (7.1) does not suffer serial/autocorrelation and heteroscedasticity problems. There is goodness of fit of the estimated VECM.
- The VECM of equation (7.1) bears the property of stability as reported by Ramsey's RESET test. This VECM is linear with no misspecification while building the model.
- The CUSUM test, CUSUM of squares test and recursive coefficient test imply that the coefficients and parameters of estimated VECM of equation (7.1) are stable.
- The M_2 money supply and price level have the long run equilibrium relationship as confirmed by Johansen's Cointegration test. There is one

cointegrating vector as indicated by maximum Eigen-value test and Trace statistic of Johansen's Cointegration test.

- The VECM with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{2t}$ as independent variables of equation (7.9) implies that short run shocks significantly affect the long run relationship between M_2 money supply and price level. The inflations are adjusted by 0.97% of the past five quarters' deviation from equilibrium. A ten percent increase in change of M_2 money supply of two quarters back causes the change in price level to increase by 1.2%.

- The change in price level is not only affected by the change in M_2 money supply but also by the change in price itself. A ten percent increase in change of price level of four periods back causes the change in price level at current time to increase by 4.87%.

- The VECM, with $dLnM_{2t}$ as dependent variable and lagged $dLnM_{2t}$and $dLnCPI_t$ as independent variables, shows that there is short run as well as long run equilibrium relationship between the variables under study. The short run shocks significantly affect the long run equilibrium relationship between $dLnCPI_t$ and $dLnM_{2t}$. The M_2 money supply is adjusted by 1.5% of the past five quarters' deviation from equilibrium.

- The change in M_2 money supply at current time is affected by the change in M_2 money supply itself. A ten percent increase in change of M_2 money supply at four periods back causes the change in M_2 money supply at current time by 2.08%.

- The change in M_2 money supply at current time is affected by the change in price level of two periods back. A ten percent increase in change of price of two periods back causes the current change in M_2 money supply to increase by approximately 2%.

- The VECM, with $dLnM_{2t}$ as dependent variable of equation (7.10) as reported by residuals diagnostic tests, is efficiently fitted. It does not suffer autocorrelation and heteroscedasticity problems.

- The VECM of equation (7.10) satisfies the parameter stability condition as reported by Ramsey's RESET test, CUSUM test, CUSUM of square test and Recursive coefficient test.
- The Granger causality test implies that there is bi-directional Granger causality between M_1 money supply and price level as well as M_2 money supply and price level.

CHAPTER EIGHT

DISTRIBUTED LAG MODEL FOR MONEY SUPPLY AND PRICE RELATIONSHIP

8.1 Distributed Lag Model[32]

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

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

In linear form,

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

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

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

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

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

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

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

$Y_t = \alpha + \beta_0 X_t$

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

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

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

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

… …

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

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

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

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

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

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

8.2 Almon Approach to Distributed Lag Models

(Polynomial Distributed Lag models)

The general form of distributed lag model is:

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

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

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

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

Then,

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

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

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

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

Hère,

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

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

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

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

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

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

$\beta_i = a_0$

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

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

$\dots$

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

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

8.3 Distributed Lag Models: Price Level and Narrow Money Supply

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

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

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

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

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

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

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

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

8.3.1Redundant Test

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

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

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

Table- 8.2: Redundant Test of Equation (8.7)

Redundant Variables: $dLnM_{1t}$

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

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

8.3.2 Wald Coefficient Restriction Test

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

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

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

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

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

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

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

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

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

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

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

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

8.4.1 Correlogram of Squared Residuals

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

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

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

8.4.2 Breusch-Godfrey Lagrange Multiplier Test for Serial Correlation

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

Table-8.6: Breusch-Godfrey Serial Correlation LM Test

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

8.4.3 Residuals Heteroscedasticity Test

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

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

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

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

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

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

8.5.1 Ramsey's RESET Test

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

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

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

Unrestricted Test Equation

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

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

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

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

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

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

Unrestricted Test Equation

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

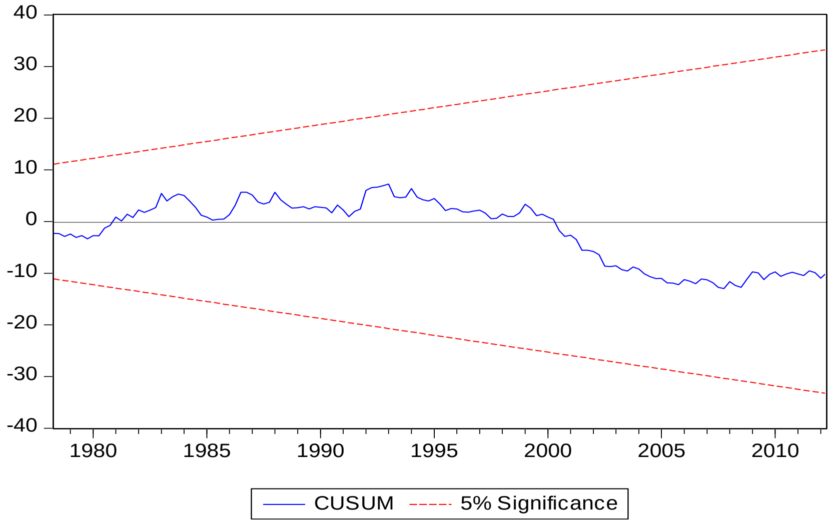
Table-8.9 demonstrates the results from Ramsey's RESET test of regression equation of equation (8.8). In the upper part of the Table, F-statistic, t-statistic and likelihood ratio are not significant. The null hypothesis 'correct specification is linear' is not rejected even if the variable $Fitted^2$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

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

8.5.2 CUSUM Test

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

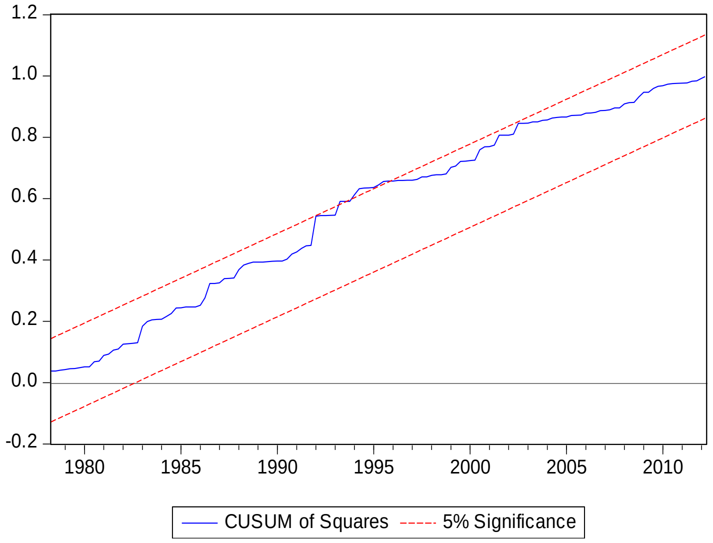
Figure-8.1: Graphical Presentation of CUSUM Test



8.5.3 CUSUM of Squared Test

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

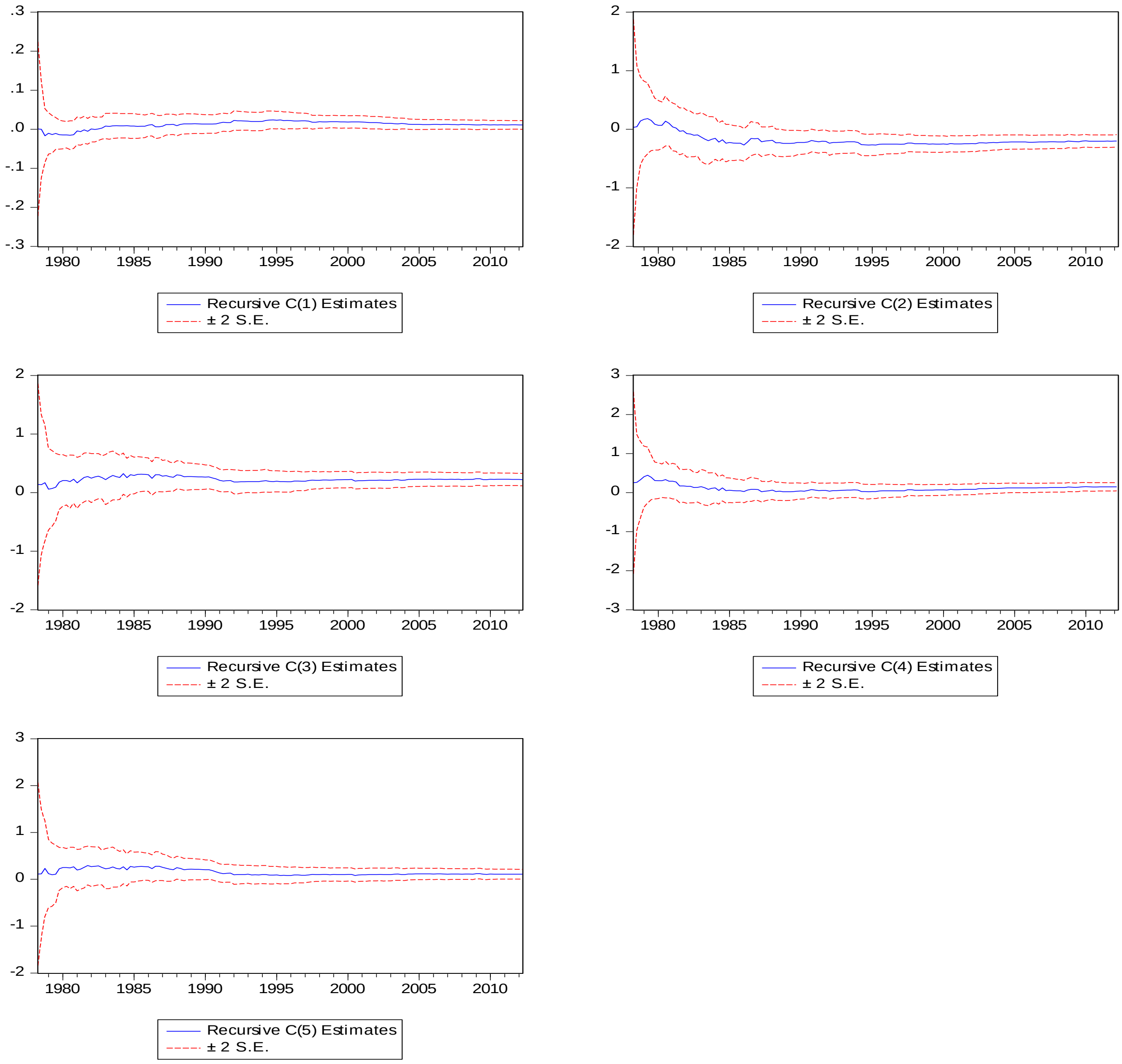
Figure-8.2: Graphical Presentation of CUSUM of Square Test



8.5.4 Recursive Coefficient Test

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

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



8.6 Distributed Lag Models: Price Level and Broad Money Supply

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

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

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

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

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

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

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

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

8.6.1Redundant Test

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

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

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

Table- 8.11: Redundant Test of Equation (8.9)

Redundant Variables: $dLnM_{2t}$

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

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

8.6.2 Wald Coefficient Restriction Test

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

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

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

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

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

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

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

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

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

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

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

8.7.1 Correlogram of Squared Residuals

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

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

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

8.7.2 Breusch-Godfrey LM Test for Serial Correlation

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

Table-8.15: Breusch-Godfrey Serial Correlation LM Test

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

8.7.3 Residuals Heteroscedasticity Test

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

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

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

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

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

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

8.8.1 Ramsey's RESET Test

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

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

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

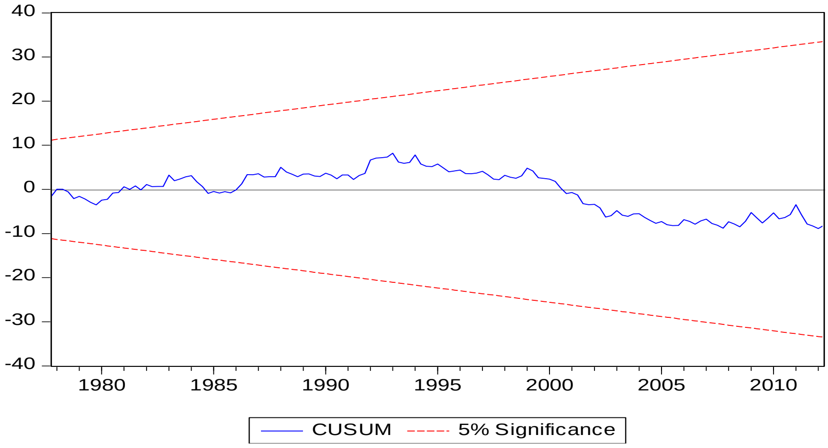
Unrestricted Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	$\alpha = 0.0132$	0.0063	2.0935	0.0381
$dLnM_{2t}$	$\beta_0 = -0.1614$	0.0703	-2.2941	0.0233
$dLnM_{2t-1}$	$\beta_1 = 0.1488$	0.0956	1.5557	0.1220
$dLnM_{2t-2}$	$\beta_2 = 0.1949$	0.1427	1.3656	0.1743
$Fitted^2$	$\gamma = -0.4070$	9.1247	-0.0446	0.9645

8.8.2 CUSUM Test

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

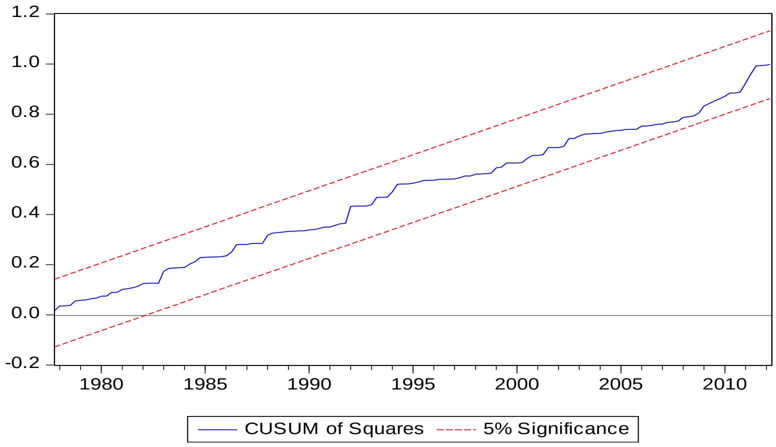
Figure-8.4: Graphical Presentation of CUSUM Test



8.8.3 CUSUM of Squared Test

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

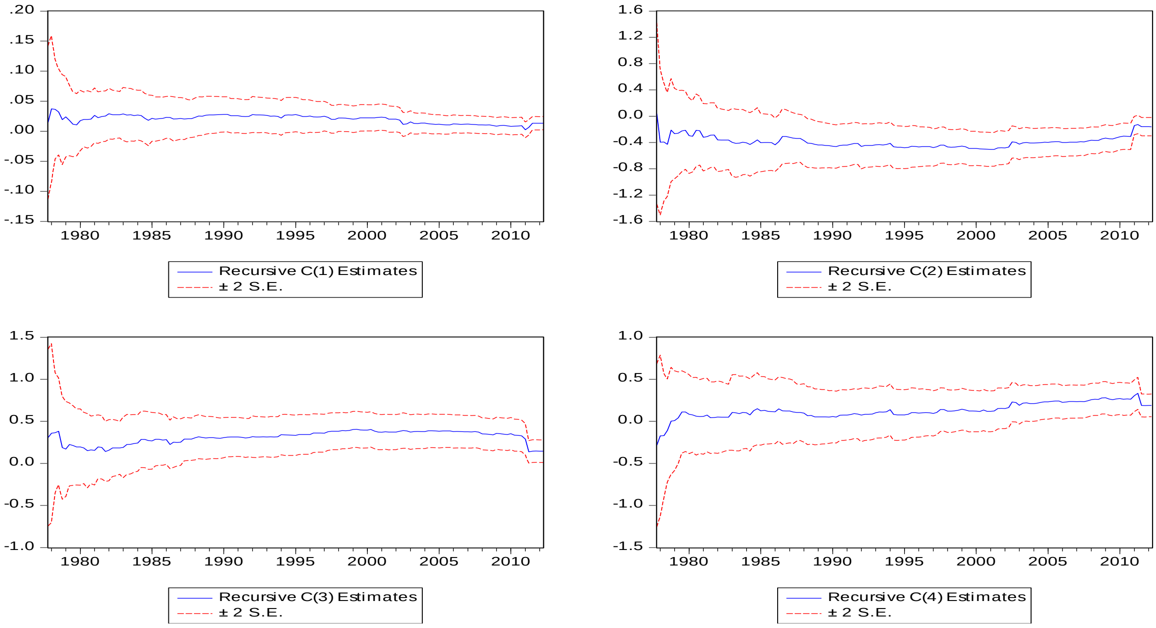
Figure-8.5: Graphical Presentation Squared of CUSUM Test



8.8.4 Recursive Coefficient Test

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

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



8.9 Impact of Indian Inflation on Nepalese Inflation

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

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

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

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

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

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

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

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

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant\ (C)$	α = 0.0091	0.0055	1.6568	0.0998
$dLnM_{1t}$	β_0= -0.1286	0.0604	-2.1275	0.0352
$dLnM_{1t-1}$	$\beta_1 = 0.2012$	0.0526	3.8228	0.0002
$dLnM_{1t-2}$	$\beta_2 = 0.1040$	0.0552	1.8844	0.0616
$dLnM_{1t-3}$	$\beta_3 = 0.0970$	0.0522	1.8581	0.0653
$dLnIWPI_t$	γ = 0.2061	0.0880	2.3398	0.0207

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

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

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

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

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

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

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

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

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

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

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

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

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

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

8.10 Conclusion of Chapter Eight

Following conclusions are drawn from chapter Eight.

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

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

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

CHAPTER NINE

FORECASTING BY VECTOR AUTOREGRESSION MODELS

9.1 Vector Autoregressive (VAR) Models

Vector Autoregression (VAR) models were introduced by the macro- econometrician Christopher Sims (1980) to model the joint dynamics and causal relations among a set of macroeconomic variables. "The vector autoregression (VAR) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The VAR approach sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system". (QMS, 2009: Eviews 7:User's Guide II)

"The vector autoregression (VAR) model is one of the most successful, flexible, and easy to use models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to dynamic multivariate time series. The VAR model has proven to be especially useful for describing the dynamic behavior of economic and financial time series and for forecasting. It often provides superior forecasts to those from univariate time series models and elaborate theory-based simultaneous equations models. Forecasts from VAR models are quite flexible because they can be made conditional on the potential future paths of specified variables in the model". (QMS, 2009: Eviews 7:User's Guide II)

In addition to data description and forecasting, the VAR model is also used for structural inference and policy analysis. In structural analysis, certain assumptions about the causal structure of the data under investigation are imposed, and the resulting causal impacts of unexpected shocks or innovations to specified variables on the variables in the model are summarized. These causal impacts are usually summarized with impulse response functions and forecast error variance decompositions.

Though VAR models in economics were made popular by Sims (1980), the definitive technical reference for VAR models is Lutkepohl (1991), and updated surveys of VAR techniques are given in Watson (1994) and Lutkepohl (1999) and Waggoner and Zha (1999). Applications of VAR models to financial data are given in Hamilton (1994), Campbell, Lo and MacKinlay (1997), Cuthbertson (1996), Mills (1999) and Tsay (2001).

The mathematical representation of a VAR is:

Let $Y_t = (y_{1t}, y_{2t}, \ldots.. y_{nt})$ denote an $(n \times 1)$ vector of time series variables. The basic $\rho -$ lag vector autoregressive (VAR (P)) model has the form:

$$Y_t = c + \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \cdots \ldots \ldots \ldots \ldots \ldots \ldots \ldots + \pi_P Y_{t-P} + \varepsilon_t,\ t = 1, \ldots. T \qquad (9.1)$$

Where, π_i are $(n \times n)$ coefficient matrices and ε_t is an $(n \times 1)$ unobservable zero mean white noise vector process (serially uncorrelated or independent) with time invariant covariance matrix Σ. For example, a bivariate $VAR(2)$ model by equation has the form:

$$\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \begin{pmatrix} \pi_{11}^1 & \pi_{12}^1 \\ \pi_{21}^1 & \pi_{22}^1 \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \end{pmatrix} + \begin{pmatrix} \pi_{11}^2 & \pi_{12}^2 \\ \pi_{21}^2 & \pi_{22}^2 \end{pmatrix} \begin{pmatrix} y_{1t-2} \\ y_{2t-2} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \qquad (9.2)$$

$$Or, y_{1t} = c_1 + \pi_{11}^1 y_{1t-1} + \pi_{12}^1 y_{2t-1} + \pi_{11}^2 y_{1t-2} + \pi_{12}^2 y_{2t-2} + \varepsilon_{1t} \qquad (9.3)$$

$$y_{2t} = c_2 + \pi_{21}^1 y_{1t-1} + \pi_{22}^1 y_{2t-1} + \pi_{21}^2 y_{1t-2} + \pi_{22}^2 y_{2t-2} + \varepsilon_{2t} \qquad (9.4)$$

In the similar fashion, a multi-variate $VAR(P)$ model by equation has the form:

$$\begin{pmatrix} y_{1t} \\ y_{2t} \\ \vdots \\ y_{nt} \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \begin{pmatrix} \pi_{11}^1 & \pi_{12}^1 \cdots & \pi_{1P}^1 \\ \pi_{21}^1 & \pi_{22}^1 & \pi_{2P}^1 \\ \vdots & \vdots & \vdots \\ \pi_{P1}^1 & \pi_{P2}^1 \ldots. & \pi_{PP}^1 \end{pmatrix} \begin{pmatrix} y_{1t-1} \ldots. y_{1t-p} \\ y_{2t-1} \ldots. y_{2t-P} \\ \vdots \\ y_{nt-1} \ldots. y_{nt-P} \end{pmatrix} +$$

$$\begin{pmatrix} \pi_{11}^2 & \pi_{12}^2 \cdots & \pi_{1P}^2 \\ \pi_{21}^2 & \pi_{22}^2 & \pi_{2P}^2 \\ \vdots & \vdots & \vdots \\ \pi_{P1}^2 & \pi_{P2}^2 \ldots. & \pi_{PP}^2 \end{pmatrix} \begin{pmatrix} y_{1t-1} \ldots. y_{1t-p} \\ y_{2t-1} \ldots. y_{2t-P} \\ \vdots \\ y_{nt-1} \ldots. y_{nt-P} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \vdots \\ \varepsilon_{nt} \end{pmatrix}$$

Where, cov$(\varepsilon_{1t}, \varepsilon_{2s})$ = σ_{12} for t = s; 0 otherwise. Notice that each equation has the same regressors - lagged values of y_{1t} and y_{2t}. Hence, the $VAR(P)$ model is just a seemingly unrelated regression (SUR) model with lagged variables and deterministic terms as common regressors.

In lag operator notification, the $VAR(P)$ is written as:

$$\Pi(L)\mathrm{Y_t} = \mathrm{c} + \varepsilon_\mathrm{t} \qquad (9.5)$$

Where, $\Pi(L) = \mathrm{I_n} - \Pi_1 \mathrm{L} - \Pi_\mathrm{P} \mathrm{L^P}$

The $VAR(P)$ is stable if the roots of $det\left(\mathrm{I_n} - \Pi_{1^{z-\cdots-}}\Pi_{p^{z^P}}\right) = 0$ lie outside the complex unit circle (have modulus greater than one), or equivalently if Eigen values of the companion matrix

$F = \begin{pmatrix} \Pi_1 & \Pi_2 & \dots & \Pi_n \\ I_n \ddots 0 & 0 & \dots & 0 \\ 0 \quad \dots & 0 & 0 & 0 \end{pmatrix}$ have modulus less than one.

9.2 Study on Narrow Money Supply and Price Level by VAR Model

To analyze the relationship between narrow money supply and price level by VAR technique, we need the stationary series of the concerned variables. The stationary series of the variables narrow money supply and price level are $dLnM_{1t}$ and $dLnCPI_t$ respectively. Lags 5 are the appropriate lags (according to Schwarz Criterion) of the variables $dLnM_{1t}$ and $dLnCPI_t$ to apply VAR model. Using 5 lags for each endogenous variable, the VAR models with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables is given by equation (9.6), and $dLnM_{1t}$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables is given by equation (9.7).

$$\begin{aligned} dLnCPI_t = \gamma_1 &+ \alpha_1 dLnM_{1_{t-1}} + \alpha_2 dLnM_{1_{t-2}} + \alpha_3 dLnM_{1_{t-3}} + \alpha_4 dLnM_{1_{t-4}} \\ &+ \alpha_{5_d} LnM_{1_{t-5}}\, \beta_1 dLnCPI_{t-1} + \beta_2 dLnCPI_{t-2} + \beta_3 dLnCPI_{t-3} \\ &+ \beta_4 dLnCPI_{t-4} + \beta_5 dLnCPI_{t-5} + \varepsilon_{1t} \end{aligned} \tag{9.6}$$

$$\begin{aligned} dLnM_{2t} = \ &\gamma_2 + \delta_1 dLnM_{2_{t-1}} + \delta_2 dLnM_{2_{t-2}} + \delta_3 dLnM_{2_{t-3}} + \delta_4 dLnM_{2_{t-4}} + \\ &\delta_5 dLnM_{2_{t-5}} + \ \theta_1 dLnCPI_{t-1} + \theta_2 dLnCPI_{t-2} + \theta_3 dLnCPI_{t-3} + \theta_4 dLnCPI_{t-4} \ + \\ &\theta_5 dLnCPI_{t-5} + \varepsilon_{2t} \end{aligned} \tag{9.7}$$

The results from VAR model according to equation (9.6) are presented through Table-9.1.

Table-9.1: Results from VAR with $dLnCPI_t$ as Dependent Variable (Lag:1 to 5)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	$\gamma_1 = 0.0118$	0.0055	2.1455	0.0338
$dLnM_{1t-1}$	$\alpha_1 = 0.0937$	0.0617	1.51880	0.1312
$dLnM_{1t-2}$	$\alpha_2 = 0.1239$	0.0557	2.2236	0.0279
$dLnM_{1t-3}$	$\alpha_3 = 0.0448$	0.0595	0.7532	0.4527
$dLnM_{1t-4}$	$\alpha_4 =$ -0.1185	0.0575	-2.0601	0.0414
$dLnM_{1t-5}$	$\alpha_5 = 0.0363$	0.0635	0.5718	0.5684
$dCPI_{t-1}$	$\beta_1 = 0.0996$	0.0855	1.1650	0.2461
$dCPI_{t-2}$	$\beta_2 = 0.0194$	0.0797	0.2433	0.8081
$dCPI_{t-3}$	β_3 = -0.1169	0.0792	-1.4764	0.1422
$dCPI_{t-4}$	$\beta_4 = 0.3502$	0.0767	4.5636	0.0000
$dCPI_{t-5}$	$\beta_5 =$ -0.2152	0.0804	-2.6750	0.0084

R^2=0.5358 Adj. R^2=0.4960 S.E. of regression= 0.0182
Log likelihood=370.4535 Durbin-Watson stat=1.9881

With $dLnCPI_t$ as the dependent variable of VAR model based on equation (9.6), the coefficient of $dLnM_{1_{t-2}}$ is $\alpha_2 = 0.1239$, which is positive and significant at 5% level. This clearly indicates that $dLnCPI_t$ is Granger caused by the lagged $dLnM_{1_t}$ preceding two periods. That is, current price level is directly caused by the M_1 money supply of two periods/quarters back. This confirms that a ten percent rise of change in M_1 money supply at two quarters back causes the change in price level at current time by 1.23%. This implies that as money supply increases at 2 quarters back, there is expansion of credit. As the commercial banks expand more money, market rate of interest falls. At low rate of interest, people do not want to keep money in bank, rather they withdraw money from banks to purchase bond when its price falls. This further causes money supply to increase in the society. As non-bank public have more money in hands, they are ready to pay still higher and higher price to have the commodities and thereby price further rises and inflation arises.

The coefficient of $dLnM_{1_{t-4}}$ is significant at 10% level but it is negative, which is not desirable in accordance with Quantity Theory of Money. The coefficients of other lagged $dLnM_{1_t}$ are not significant. The coefficient of $dLnCPI_{t-4}$ is $\beta_4 = 0.3502$, which is positive and significant at less than 1% level. This implies that $dLnCPI_t$ is not only caused by lagged $dLnM_{1_t}$ but also by own lagged term of $dLnCPI_t$. It means inflation of four periods back has the influence on current price level positively. For example, if price was high at four quarters back, the suppliers create artificial scarcity of goods with the expectation of further rise in price to earn more profit. As commodities become scarce, price level further rises. In this way, past inflation causes present inflation and same has happened in the economy of Nepal during the study period.

Since the Adjusted R^2 of VAR equation (9.6) is 0.4960, the dependent variable $dLnCPI_t$ is explained approximately 50% by the variation of independent variables the model is not poorly fitted. The value of standard error of regression, log likelihood ratio and D-W statistic also confirm that the estimated VAR model of equation (9.6) possesses the characteristics of goodness of fit.

The results from VAR model based on equation (9.7) are presented through Table-9.2, where $dLnM_{1_t}$ is taken as dependent variable and lagged (1 to 5 lags) $dLnM_{1_t}$ and $dLnCPI_t$ are taken as independent variables.

Table-9.2: Results from VAR with $dLnM_{1t}$ as Dependent Variable (Lag:1 to 5)

Variable	Coefficient	Std. Error	t-statistic	Prob.
$Constant$	γ_2 = 0.0260	0.0078	3.3287	0.0011
$dLnM_{1t-1}$	δ_1 = 0.0198	0.0871	0.2275	0.8204
$dLnM_{1t-2}$	δ_2 = -0.3221	0.0788	-4.0833	0.0001
$dLnM_{1t-3}$	δ_3 = -0.0340	0.0841	-0.4047	0.6863
$dLnM_{1t-4}$	δ_4 = 0.4203	0.0813	5.1696	0.0000
$dLnM_{1t-5}$	δ_5 = 0.0487	0.0897	0.5434	0.5877
$dLnCPI_{t-1}$	θ_1 = 0.2939	0.1214	2.4196	0.0169
$dLnCPI_{t-2}$	θ_2 = 0.1114	0.1131	0.9852	0.3263
$dLnCPI_{t-3}$	θ_3 = 0.1589	0.1118	1.4214	0.1576
$dLnCPI_{t-4}$	θ_4 = -0.2760	0.1087	-2.5385	0.0123
$dLnCPI_{t-5}$	θ_5 = -0.0288	0.1138	-0.2530	0.8007

R^2=0.6919 Adj. R^2=0.6680 S.E. of regression= 0.0257
Log likelihood=319.6362 Durbin-Watson stat=1.9895

In the Table-9.2, the coefficient of $dLnCPI_{t-1}$ is $\theta_1 = 0.2939$, which is positive and significant at 5% level. It means the change in M_1 money supply at current time 't' is caused by the change in price level of preceding time period 't-1'.when there is inflation in the economy, supply of money should be increased to cope with the inflationary pressure. The increase in money supply further causes the price level to rise. The rising price requires increasing money supply further to bring adjustment between demand and supply and rise in money supply as a result of price level is a short term relief from inflationary pressure. In this way, there is circular relationship between price level and money supply. The Quantity Theory of Money states that rise in money supply causes price level to increase, but the VAR model of equation (9.7) states that not only rise in money supply causes price to rise but rise in price also causes money supply to rise. Thus, the coefficient of $dLnCPI_{t-1}$ implies that a 10% rise of change in price level at preceding time period requires to increase the change of M_1 money supply at current time by 2.93%.

Next, the coefficient of $dLnCPI_{t-4}$ is $\theta_4 =$ -0.2760, which is negative though it is significant. This negative coefficient is not desirable to analyze the relationship between M_1 money supply and price level. The coefficient of $dLnM_{1_{t-4}}$ is $\delta_4 =$ 0.4203, which is positive and significant at less than 1% level implying that change in current money supply is affected not only by price level but also by the change in money supply of four periods back. This clearly indicates that rise in money supply in the previous periods brings about the rise in money supply at current time. For example, when there is increase in money supply to cope with inflation the credit expands in the society. Non-bank public has more money in hands. The consumers are ready to pay higher price to have commodity rather than go without commodity. Consumers afford more and more not only for necessities but also for comforts and luxuries because they have no crisis of money. The quantity of money is increasing but value of money continues to fall. The falling value of money requires to increase quantity of money further. Hence, the increase in money supply in the past periods causes money supply to increase in the current time as well.

So far as the robustness of the VAR model of equation (9.7) is concerned, the Adjusted R^2 is 0.6680, which explains 66% of the dependent variable $dLnM_{1t}$ with the variation of independent variables. This model represents goodness of fit satisfactorily. Likewise, the standard error of regression, log likelihood ratio and D-W statistic also prove that the estimated VAR model of equation (9.7) is claimed to be robust.

9.3 Residuals Diagnostic of VAR Models
($dLnCPI_t$ Regressed on Lagged $dLnM_{1t}$)

In order to examine the consistency of estimated VAR model of equation (9.6), we have tested Residual Diagnostic through Correlogram Squared Residuals, Serial Correlation LM Test and Heteroscedasticity Test. With the help of these tests, we can conclude whether or not estimated regression equation (9.6) is consistent.

9.3.1 Correlogram of Squared Residuals

The Correlogram-Q-statistic of the residuals squared of estimated regression equation (9.6) is presented through Table-9.3. The ACFs and PACFs of correlogram of the residual squared are nearly zero at all lags and the Q-statistics at all lags are not significant with large p-values. This indicates that there is no evidence of rejecting the null hypothesis of no serial correlation. This implies that the residuals of the estimated VAR model of equation (9.6) are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of the estimated VAR model of equation (9.6).

Table-9.3: Correlogram of Squared Residuals of Equation (9.6)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	0.125	0.123	2.6276	0.622	9	0.014	0.002	3.8352	0.986
2	0.023	0.034	2.7051	0.745	10	-0.026	-0.029	3.9408	0.992
3	-0.044	-0.041	2.9904	0.810	11	-0.023	-0.011	4.0263	0.995
4	0.003	0.004	2.9914	0.886	12	-0.097	-0.103	5.5399	0.986
5	0.054	0.041	3.4379	0.904	13	-0.029	-0.049	5.6765	0.991
6	-0.003	-0.008	3.4395	0.944	14	0.125	0.123	2.6276	0.622
7	-0.046	-0.037	3.7586	0.958	15	0.023	0.034	2.7051	0.745
8	0.017	0.017	3.8042	0.975	16	-0.044	-0.041	2.9904	0.810

9.3.2 Breusch-Godfrey Lagrange Multiplier Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation have been presented through Table-9.4. As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test of Table-9.4, the null hypothesis of no autocorrelation cannot be rejected. The B-G LM test implies that residuals are not serially correlated. Due to the non-presence of serial correlation, the estimated VAR model of equation (9.6) is considered as the consistent model for representing the relationship between M_1 money supply and price level.

Table-9.4: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.3516	Prob. F(1,129)	0.5542
$T \times R^2$	0.3832	Prob. Chi-Square(1)	0.5359

9.3.3 Residuals Heteroscedasticity Test

The null hypothesis of White's (1980) is H_0: there is homoscedasticity in the residuals. The null hypothesis is not rejected if the F-statistic and χ^2statistic are not significant. No rejection of null hypothesis confirms that residuals of estimated regression do not suffer from heteroscedasticity problem and estimated regression is claimed to be consistent. Table-9.5 presents the Residual Heteroscedasticity test of estimated VAR model of equation (9.6).

From the Table-9.5, it is observed that F-statistic and $T \times R^2$ value are not significant as reported by the probability values of the fourth column. There is no evidence of rejecting the null hypothesis that residuals are homoscedastic. It means, the residuals of estimated VAR model of equation (9.6) do not suffer heteroscedastic problem. Hence, it is claimed that the estimated VAR model of equation (9.6) representing the relationship between narrow money supply and price level is consistent model.

Table-9.5: White Heteroscedasticity of Residuals of Equation (9.6)

Test Summary	Value	Degree of Freedom	Probability
F-statistic	1.0911	Prob. F(65,75)	0.3562
$T \times R^2$	68.5309	Prob. Chi-suare(65)	0.3585

9.4 Stability Test of Estimated VAR Models

($dLnCPI_t$ Regressed on Lagged $dLnM_{1t}$)

To examine the stability of the estimated regression equation (9.6), we apply some test such as Inverse Roots of Characteristic Polynomials; Ramsey's RESET test and Coefficient Variance Decomposition (coefficient diagnostic) test.

9.4.1 Inverse Roots of Characteristic Polynomials

The Inverse Roots of Characteristic Polynomials of Estimated VAR model of equation (9.6) is presented through Table-9.6. In the table, the modulus value of all roots does not exceed one, which means no root lies outside the unit circle. Thus, the estimated VAR model of equation (9.6) satisfies the stability condition, i.e. the estimated VAR model is stable.

Table-9.6: Inverse Roots of Characteristic Polynomials of Equation (9.6)

Root	Modulus
0.0012 - 0.9657i	0.9657
0.0012 + 0.9657i	0.9657
-0.9333	0.9333
0.7341	0.7341
-0.0600 - 0.7060i	0.7086
-0.0600 + 0.7060i	0.7086
0.5757 - 0.2502i	0.6277
0.5757 + 0.2502i	0.6277
-0.6058	0.6058
-0.1192	0.1192

9.4.2 Ramsey's RESET Test

Table-9.7 demonstrates the results from Ramsey's RESET test of estimated VAR model of equation of equation (9.6).

In the upper part of the Table-9.7, F-statistic, t-statistic and likelihood ratio are not significant as reported by the corresponding probability values. The null hypothesis 'correct specification is linear' is not rejected even if the variable $Fitted^2$ term is included in to the regression equation (9.6). It means the estimated VAR model of equation (9.6) does not avoid the property of linearity. Likewise, in lower part of Table-9.7, H_0: $\gamma = 0$, is not rejected as reported by the t-statistic. Hence, the Ramsey's RESET test implies that the estimated regression equation (9.6) is stable model containing the properties of linearity and it is not misspecified model.

Table-9.7: Ramsey's RESET Test of VAR Equation (9.6)

Test-statistic	Value	Degree of Freedom	Probability
t-statistic	0.0229	129	0.9817
F-statistic	0.0005	(1, 129)	0.9817
Likelihood ratio	0.0005	1	0.9808

Unrestricted Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	$\gamma_1 = 0.0118$	0.0055	2.1334	0.0338
$dLnM_{1t-1}$	$\alpha_1 = 0.0943$	0.0664	1.4192	0.11582
$dLnM_{1t-2}$	$\alpha_2 = 0.1247$	0.0663	1.8798	0.0624
$dLnM_{1t-3}$	$\alpha_3 = 0.0454$	0.0651	0.6981	0.4863
$dLnM_{1t-4}$	$\alpha_4 = -0.1193$	0.0662	-1.8001	0.0742
$dLnM_{1t-5}$	$\alpha_5 = 0.0365$	0.0641	0.5690	0.5703
$dCPI_{t-1}$	$\beta_1 = 0.1001$	0.0880	1.1373	0.2575
$dCPI_{t-2}$	$\beta_2 = 0.0198$	0.0820	0.2415	0.8095
$dCPI_{t-3}$	$\beta_3 = -0.1178$	0.0876	-1.3437	0.1814
$dCPI_{t-4}$	$\beta_4 = 0.3523$	0.1175	2.9960	0.0033
$dCPI_{t-5}$	$\beta_5 = -0.2160$	0.0875	-2.4669	0.0149
$Fitted^2$	$\rho = -0.1057$	4.6019	-0.0229	0.9817

9.4.3 Coefficient Variance Decomposition

Intriligator[37](1978) opines that since most aggregate economic time series are highly correlated with their own previous values and with present and past values of other time series, multi-colinearity can become a serious problem as more and more series and lagged values of series are added to the model. As the system expands, it can become very difficult to separate the effects of the explanatory variables, and the parameter estimates can become highly sensitive to the combination of variables used in the model.

37 Intriligator, Michael D. (1978). *Econometric Models, Techniques, and Applications.* Englewood Cliffs, NJ: Prentice- Hall

Therefore, it is necessary to examine whether or not any colinearity exists in the estimated VAR model. If colinearity is detected, the estimated coefficients are not reliable and they do not represent the concrete relationship between dependent variable and lagged regressors in the VAR model.

The Coefficient Variance Decomposition view of an equation provides information on the Eigen vector decomposition of the coefficient covariance matrix. This decomposition is a useful tool to help diagnose potential colinearity problems amongst the regressors. The decomposition calculations follow those given in Belsley, Kuh and Welsch (BKW) (1980). Note that although BKW use the singular-value decomposition as their method to decompose the variance-covariance matrix, since this matrix is a square positive semi-definite matrix, using the Eigen value decomposition will yield the same results. (QMS, 2009: Eviews 7: User's Guide II)

For simple linear least squares regression, the coefficient variance-covariance matrix can be decomposed as given by:

$$Var(\hat{\beta}) = \sigma^2 (X'X)^{-1} = \sigma^2 V S^{-1} V' \tag{9.8}$$

Where S is the diagonal matrix containing the Eigen values of $X'X$, and V is a matrix whose columns are equal to the corresponding Eigen vectors.

The variance of an individual coefficient estimate is then:

$$Var(\hat{\beta}_i) = \sigma^2 \sum_j v_{ij}^2 \tag{9.9}$$

where, μ_i is the jth Eigen values and v_{ij} is the ('i j')th condition number of the covariance matrix, k_j:

$$k_j = \frac{min\,(\mu_m)}{\mu_j} \tag{9.10}$$

If we let,

$$\phi_{ij} = \frac{v_{ij}^2}{\mu_j} \tag{9.11}$$

and

$$\phi_i = \sum_j \phi_{ij}' \tag{9.12}$$

$$\pi_{ji} = \frac{\phi_{ij}}{\phi_i} \tag{9.13}$$

(Source: QMS, 2009: Eviews 7: User's Guide II)

These proportions, together with the condition numbers, can then be used as a diagnostic tool for determining colinearity between each of the coefficients.

Belsley, Kuh and Welsch recommend the following procedure:

Check the condition numbers of the matrix. A condition number smaller than 1/900 (0.001) could signify the presence of colinearity. Note that BKW use a rule of any number greater than 30, but base it on the condition numbers of X , rather than $X'X^{-1}$ .If there are one or more small condition numbers, then the variance-decomposition proportions should be investigated. Two or more variables with values greater than 0.5 associated with a small condition number indicate the possibility of colinearity between those two variables. (QMS,2009: Eviews 7: User's Guide II)

The results from Coefficient Variance Decomposition based on VAR model of equation (9.6) are presented through Annex-IV. The top line of the Annex-IV shows the Eigen values, sorted from largest to smallest, with the condition numbers below. Note that the final condition number is always equal to 1. None of the ten Eigen values have condition numbers smaller than 0.001, with the smallest condition number being: 0.023767, which would indicate no colinearity between and among the regressors.

The second section of the table displays the decomposition proportions. The proportions associated with the smallest condition number are located in the first column. Only two of these ten values are larger than 0.5, but they are not very close to 1. This indicates that there is more or less no colinearity between those ten regressors.

Since the regressors are not collinear, the estimated coefficients of VAR model of equation (9.6) are claimed to be reliable and stable that bear consistent positive relationship between M_1 money supply and price level in the economy of Nepal during the study period.

9.5 Study on Broad Money Supply and Price Level by VAR Model

To analyze the relationship between broad money supply and price level by VAR technique, we need the stationary series of the concerned variables. The stationary series of the variables broad money supply and price level are $dLnM_{2t}$ and $dLnCPI_t$

respectively. Lags 4 are the appropriate lags (according to Schwarz Criterion) of the variables $dLnM_{2t}$ and $dLnCPI_t$ to apply VAR model. Using 4 lags for each endogenous variable, the VAR models with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{2t}$ as independent variables is given by equation (9.14), and $dLnM_{2t}$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{2t}$ as independent variables is given by equation (9.15).

$$\begin{aligned} dLnCPI_t = {} & \gamma_1 + \alpha_1 dLnM_{2_{t-1}} + \alpha_2 dLnM_{2_{t-2}} + \alpha_3 dLnM_{2_{t-3}} + \alpha_4 dLnM_{2_{t-4}} + dLnCPI_{t-1} \\ & + \beta_2 dLnCPI_{t-2} + \beta_3 dLnCPI_{t-3} + \beta_4 dLnCPI_{t-4} + \varepsilon_{1t} \end{aligned} \tag{9.14}$$

$$\begin{aligned} dLnM_{2t} = {} & \gamma_2 + \delta_1 dLnM_{2_{t-1}} + \delta_2 dLnM_{2_{t-2}} + \delta_3 dLnM_{2_{t-3}} + \delta_4 dLnM_{2_{t-4}} \\ & + \theta_1 dLnCPI_{t-1} + \theta_2 dLnCPI_{t-2} + \theta_3 dLnCPI_{t-3} + \theta_4 dLnCPI_{t-4} + \varepsilon_{2t} \end{aligned} \tag{9.15}$$

The results from VAR model based on equation (9.14) are presented through Table-9.8. With $dLnCPI_t$ as the dependent variable of VAR model based on equation (9.14), the coefficient of $dLnM_{2_{t-2}}$ is $\alpha_2 = 0.1265$, which is positive and significant at 5% level. This clearly indicates that $dLnCPI_t$ is Granger caused by the lagged $dLnM_{2_t}$ of preceding two periods. That is, current price level is directly caused by the M_2 money supply of two periods/quarters back. This confirms that a ten percent rise of change in M_2 money supply at two quarters back causes the change in price level at current time by 1.26%. This implies that as money supply increases at 2 quarters back, there is expansion of credit. As money supply of commercial banks increases, market rate of interest falls. At low rate of interest, people do not want to keep money in bank, rather they withdraw money from banks to purchase bond when its price falls. This further causes money supply to increase in the society. As non-bank public have more money in hands, they are ready to pay still higher and higher price to have the commodities and thereby price further rises and inflation arises.

Table-9.8: Results from VAR with $dLnCPI_t$ as Dependent Variable (Lag:1 to 4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	$\gamma_1 = 0.0129$	0.0054	2.3924	0.0181
$dLnM_{2t-1}$	$\alpha_1 = 0.0844$	0.0590	1.4307	0.1548
$dLnM_{2t-2}$	$\alpha_2 = 0.1265$	0.0597	2.1169	0.0361
$dLnM_{2t-3}$	$\alpha_3 =$ - 0.0388	0.0610	-0.6366	0.5255
$dLnM_{2t-4}$	$\alpha_4 = -0.1312$	0.0576	-2.2768	0.0244
$dLnCPI_{t-1}$	$\beta_1 = -0.0336$	0.0715	-0.4704	0.6388
$dLnCPI_{t-2}$	$\beta_2 = -0.0450$	0.0710	-0.6341	0.5270
$dLnCPI_{t-3}$	$\beta_3 = -0.1007$	0.0677	-1.4865	0.1395
$dLnCPI_{t-4}$	$\beta_4 = 0.5042$	0.0675	7.4618	0.0000

R^2=0.4607 Adj. R^2=0.4282 S.E. of regression= 0.0195
Log likelihood=362.0368 Durbin-Watson stat=1.625

The coefficient of $dLnM_{1_{t-4}}$ is significant at 5% level but it is negative, which is not desirable in accordance with Quantity Theory of Money. The coefficients of other lagged $dLnM_{2_t}$are not significant. The coefficient of $dLnCPI_{t-4}$ is $\beta_4 = 0.5042$, which is positive and significant at less than 1% level. This implies that $dLnCPI_t$ is not only caused by lagged $dLnM_{2_t}$ but also by own lagged term of $dLnCPI_t$. It means inflation of four periods back has the influence on current price level positively. For example, if price was high at four quarters back, the suppliers create artificial scarcity of goods with the expectation of further rise in price to earn more profit. As commodities become scarce, price level further rises. In this way, past inflation causes present inflation and same has happened in the economy of Nepal during the study period.

Since the Adjusted R^2 of VAR equation (9.14) is 0.4282, the dependent variable $dLnCPI_t$ is explained approximately 42% by the variation of independent variables, the model is not so satisfactorily fitted. The value of standard error of regression and log likelihood ratio indicate that the VAR model is appropriately fitted. However, D-W statistic is only 1.625886, which implies that there is the possibility of positive serial correlation.

The results from VAR model based on equation (9.15) are presented through Table-9.9, where $dLnM_{2_t}$ is taken as dependent variable and lagged (1 to 4 lags) $dLnM_{2_t}$ and $dLnCPI_t$ are taken as independent variables.

Table-9.9: Results from VAR with $dLnM_{2t}$ as Dependent Variable (Lag:1 to 4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	γ_2 =0.0265	0.0077	3.3992	0.0009
$dLnM_{2t-1}$	δ_1=0.1379	0.0849	1.6244	0.1067
$dLnM_{2t-2}$	δ_2= -0.2068	0.0860	-2.4024	0.0177
$dLnM_{2t-3}$	δ_3=0.0148	0.0877	0.1696	0.8655
$dLnM_{2t-4}$	δ_4=0.2311	0.0829	2.7870	0.0061
$dLnCPI_{t-1}$	θ_1=0.1844	0.1031	1.7891	0.0759
$dLnCPI_{t-2}$	θ_2=0.1660	0.1022	1.6236	0.1068
$dLnCPI_{t-3}$	θ_3=0.1225	0.0975	1.2565	0.2111
$dLnCPI_{t-4}$	θ_4=-0.0375	0.0973	-0.3853	0.7006

In the Table-9.9, the coefficient of $dLnCPI_{t-1}$ is θ_1 = 0.1844, which is positive and significant at 10% level. It means the change in M_2 money supply at current time 't' is caused by the change in price level of preceding time period 't-1'.when there is inflation in the economy, supply of money should be increased to cope with the inflationary pressure. The increase in money supply further causes the price level to rise. The rising price requires increasing money supply further to bring adjustment between demand and supply and rise in money supply as a result of price level is a short term relief from inflationary pressure. In this way, there is circular relationship between price level and money supply. The Quantity Theory of Money states that rise in money supply causes price level to increase, but the VAR model of equation (9.15) states that not only rise in money supply causes price to rise but rise in price also causes money supply to rise. Thus, the coefficient of $dLnCPI_{t-1}$ implies that a 10% rise of change in price level at preceding time period requires to increase the change of M_2 money supply at current time by 1.84%.

Next, the coefficients of $dLnM_{2_{t-2}}$ is: δ_2= -0.2068, which is negative though significant at 5% level. This negative coefficient is not desirable for direct relationship between money supply and price level. The coefficient $dLnM_{2_{t-4}}$ is δ_4=

0.2311, which is positive and significant at less than 1% level implying that change in current money supply is affected not only by price level but also by the change in money supply at 4 periods back. This clearly indicates that rise in money supply in the previous four-period back brings about the rise in money supply at current time. For example, when there is increase in money supply to cope with inflation the credit expands in the society. Non-bank public has more money in hands. The consumers are ready to pay higher price to have commodity rather than go without commodity. Consumers afford more and more not only for necessities but also for comforts and luxuries because they have no crisis of money. The quantity of money is increasing but value of money continues to fall. The falling value of money requires increasing quantity of money further. Hence, the increase in money supply in the past periods causes money supply to increase in the current time as well.

9.6 Residuals Diagnostic of VAR Models
($dLnCPI_t$ Regressed on Lagged $dLnM_{2t}$)

In order to examine the consistency of estimated VAR model of equation (9.14), we have tested Residual Diagnostic through Correlogram Squared Residuals, Serial Correlation LM Test and Heteroscedasticity Test. With the help of these tests, we can conclude whether or not estimated regression equation (9.14) is consistent.

9.6.1 Correlogram of Squared Residuals

The Correlogram-Q-statistic of the squared residuals of estimated regression equation (9.14) is presented through Table-9.10. The ACFs and PACFs of correlogram of the residual squared are nearly zero at all lags and the Q-statistics at all lags are not significant with large p-values. This indicates that there is no evidence of rejecting the null hypothesis of no serial correlation. This implies that the residuals of the estimated VAR model of equation (9.14) are not correlated with their own lagged values. Hence, there is strong evidence of goodness of fit of the estimated VAR model of equation (9.14).

Table-9.10: Correlogram of Squared of Residuals of Equation (9.14)

Lag	AC	PAC	Q-Stat	Prob	Lag	AC	PAC	Q-Stat	Prob
1	-0.046	-0.046	0.3134	0.576	9	-0.032	-0.035	3.3897	0.947
2	-0.013	-0.015	0.3384	0.844	10	-0.024	-0.041	3.4784	0.968
3	0.005	0.003	0.3414	0.952	11	-0.063	-0.062	4.0949	0.967
4	0.023	0.023	0.4168	0.981	12	-0.027	-0.043	4.2073	0.979
5	0.125	0.128	2.7449	0.739	13	-0.042	-0.055	4.4870	0.985
6	-0.037	-0.025	2.9548	0.814	14	-0.021	-0.016	4.5598	0.991
7	0.022	0.023	3.0295	0.882	15	-0.069	-0.066	5.3262	0.989
8	0.037	0.037	3.2341	0.919	16	-0.009	-0.000	5.3396	0.994

9.6.2 Breusch-Godfrey LM Test for Serial Correlation

The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation have been presented through Table-9.11. As reported by F-statistic and $T \times R^2$ value and their corresponding probabilities of B-G LM test of Table-9.11, the null hypothesis of no autocorrelation is strongly rejected. The B-G LM test implies that residuals of equation (9.14) are serially correlated. Due to the presence of serial correlation, the estimated VAR model of equation (9.14) is not considered as the consistent model for representing the relationship between M_2 money supply and price level. However, the residuals of VAR model of equation (9.14) are free from serial correlation problem based on Correlogram of Squared of Residuals.

Table-9.11: Breusch-Godfrey Serial Correlation LM Test of Equation (9.14)

F-statistic	14.82834	Prob. F(1,132)	0.0002
$T \times R^2$	14.34072	Prob. Chi-Square(1)	0.0002

Now, we test serial correlation of residuals of VAR model of equation (9.15) using B-G LM test in order to confirm whether there is any need of remodeling of VAR between M_2 money supply and price level. The results of Breusch-Godfrey Lagrange Multiplier test for serial correlation based on equation (9.15) have been presented through Table-9.12.

Table-9.12: Breusch-Godfrey Serial Correlation LM Test of Equation (9.15)

F-statistic	0.823678	Prob. F(2,130)	0.4411
$T \times R^2$	1.764388	Prob. Chi-Square(2)	0.4139

The value of F-statistic and $T \times R^2$ based on the corresponding probability suggest that there is no evidence of rejecting the null hypothesis of serial correlation (Table-9.12). This clearly indicates that the residuals of VAR model of equation (9.15) are not serially correlated representing the robustness of the model, no need of remodeling of VAR model of relationship between M_2 money supply and price level.

9.6.3 Residuals Heteroscedasticity Test

The null hypothesis of White's (1980) is H_0: there is homoscedasticity in the residuals. The null hypothesis is not rejected if the F-statistic and χ^2 –statistic are not significant. No rejection of null hypothesis confirms that residuals of estimated regression do not suffer from heteroscedasticity problem and estimated regression is claimed to be consistent. Table-9.13 presents the Residual Heteroscedasticity test of estimated VAR model of equation (9.14).

From the Table-9.13, it is observed that F-statistic and $T \times R^2$ value are not significant as reported by the probability values of the fourth column. There is no evidence of rejecting the null hypothesis that residuals are homoscedastic. It means, the residuals of estimated VAR model of equation (9.14) do not suffer heteroscedastic problem. Hence, it is claimed that the estimated VAR model of equation (9.14) representing the relationship between broad money supply and price level is consistent model.

Table-9.13: White Heteroscedasticity Test of Residuals of Equation (9.14)

Test Summary	Value	Degree of Freedom	Probability
F-statistic	0.503655	Prob. F(44,97)	0.9938
$T \times R^2$	26.40832	Prob. Chi-square(44)	0.9835

9.7 Stability Test of Estimated VAR Models
($dLnCPI_t$ Regressed on Lagged $dLnM_{2t}$)

To examine the stability of the estimated regression equation (9.14), we apply some test such as Inverse Roots of Characteristic Polynomials; Ramsey's RESET test and Coefficient Variance Decomposition (coefficient diagnostic) test.

9.7.1 Inverse Roots of Characteristic Polynomials

The Inverse Roots of Characteristic Polynomials of Estimated VAR model of equation (9.14) is presented through Table-9.14. In the table, the modulus value of all roots does not exceed one, which means no root lies outside the unit circle. Thus, the estimated VAR model of equation (9.14) satisfies the stability condition, i.e. the estimated VAR model is stable.

Table-9.14: Inverse Roots of Characteristic Polynomials of Equation (9.14)

Root	Modulus
0.0064 - 0.9104i	0.9104
0.0064+ 0.9104i	0.9104
-0.8777	0.8777
0.7347 - 0.0254i	0.7352
0.7347 + 0.0254i	0.7352
0.0362 - 0.6981i	0.6990
0.0362 + 0.6981i	0.6990
-0.5769	0.5769
0.0064 - 0.9104i	0.9104
0.0064 + 0.9104i	0.9104

9.7.2 Ramsey's RESET Test

Table-9.15 demonstrates the results from Ramsey's RESET test of estimated VAR model of equation of equation (9.14).

In the upper part of the Table-9.15, F-statistic, t-statistic and likelihood ratio are not significant as reported by the corresponding probability values. The null hypothesis 'correct specification is linear' is not rejected even if the variable $Fitted^2$ term is included in to the regression equation (9.14). It means the estimated VAR model of equation (9.14) does not avoid the property of linearity. Likewise, in lower part of Table-9.15, H_0: $\gamma = 0$, is not rejected as reported by the t-statistic. Hence, the Ramsey's RESET test implies that the estimated regression equation (9.14) is stable model containing the properties of linearity and it is not misspecified model.

Table-9.15: Ramsey's RESET Test of VAR Equation (9.14)

Test-statistic	Value	Degree of Freedom	Probability
t-statistic	0.5376	132	0.5918
F-statistic	0.2890	(1, 132)	0.5918
Likelihood ratio	0.3105	1	0.5773

Unrestricted Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$Constant$	γ_1 = 0.0130	0.0054	2.3950	0.0180
$dLnM_{2t-1}$	α_1 = 0.0952	0.0625	1.5240	0.1299
$dLnM_{2t-2}$	α_2 = 0.1605	0.0870	1.8433	0.0675
$dLnM_{2t-3}$	α_3 = - 0.0450	0.0622	-0.7223	0.4713
$dLnM_{2t-4}$	α_4 = -0.1404	0.0602	-2.3300	0.0213
$dLnCPI_{t-1}$	β_1 = -0.0379	0.0721	-0.5254	0.6001
$dLnCPI_{t-2}$	β_2 = -0.0466	0.0713	-0.6541	0.5142
$dLnCPI_{t-3}$	β_3 = -0.1314	0.0887	-1.4809	0.1410
$dLnCPI_{t-4}$	β_4 = 0.5790	0.1547	3.7421	0.0003
$Fitted^2$	ρ =-2.7708	5.1540	-0.5376	0.5918

9.7.3 Coefficient Variance Decomposition

The results from Coefficient Variance Decomposition based on VAR model of equation (9.14) are presented through Annex-V.

The top line of the Annex-V shows the Eigen values, sorted from largest to smallest, with the condition numbers below. Note that the final condition number is always equal to 1. None of the ten Eigen values have condition numbers smaller than 0.001, with the smallest condition number being: 0.0350, which would indicate no colinearity amongst the regressors.

The second section of the table displays the decomposition proportions. The proportions associated with the smallest condition number are located in the first column. None these ten values are larger than 0.5. This indicates that there is no colinearity between those ten regressors.

Since the regressors are not collinear, the estimated coefficients of VAR model of equation (9.14) are claimed to be reliable and stable that bear consistent positive relationship between M_2 money supply and price level in the economy of Nepal during the study period.

9.8 Conclusion of Chapter Nine

Chapter Nine has the following conclusions.

- The VAR model, with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables, implies that a ten percent increase in change of M_1 money supply of two periods back causes the change in price level of current time to increase by 1.23%.
- The change in price in current time is caused by the change in price itself of four periods back. A ten percent increase in change of price of four periods back causes the change in price of current time to increase by 3.5%.
- The VAR model, with $dLnM_{1t}$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables, implies that a ten percent increase in change of price level of preceding period causes the change in M_1 money supply of current time to increase by approximately 3%.
- The change in M_1 money supply is not only affected by the change in price level but also by the change in M_1 money supply itself. A ten percent rise in change of M_1 money supply of four periods back causes the change in M_1 money supply of current time to increase by 4.2%.
- The estimated VAR model, with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables, is reasonably fitted. It is because it does not suffer autocorrelation and heteroscedasticity problems. This model satisfies the property of linearity and all the parameters are stable and no colinearity problem emerges so that this model is claimed to be

suitable for forecasting of inflation with the help of price and M_1 money supply in the economy of Nepal.

- The VAR model, with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{2t}$ as independent variables, implies that the change in M_2 money supply of two periods back causes the change in price level of current time. A ten percent rise in change of M_2 money supply of two periods back causes the change in current price level to increase by 1.26%.
- A ten percent increase in change of price itself of four periods back causes the change in M_2 money supply of current time to increase by approximately 5%.
- The estimated VAR model, with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{2t}$ as independent variables, is claimed to be suitable model for forecasting of inflation with the help of price level and M_2 money supply since it does not suffer autocorrelation and heteroscedasticity problems. It is the stable model containing the property of linearity and all parameters are also stable, and no colinearity problem is detected.
- The VAR model, with $dLnM_{2t}$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{2t}$ as independent variables, implies that the change in M_2 money supply of current time is caused by the change in M_2 money supply itself of four periods back. However, the change in M_2 money supply of current time is not affected by the change in price level.

CHAPTER TEN

ANALYSIS OF MONEY SUPPLY AND PRICE LEVEL BY IMPULSE RESPONSE FUNCTION AND VARIANCE DECOMPOSITION

10.1 Impulse Response Function

The impulse response function (IRF) as new powerful and analytical tool is offered by the methodology of VAR. the IRFs are designed to follow the response of variable/s to impulse of the shocks. Sim (1980) has provided the clear literature regarding the applications of IRFs once the VARs are estimated. The New Palgrave Dictionary of Economics (2008) has provided the definition of IRF given by Lutkepohl (1990). Lutkepohl (1991) [38] defines, “Impulse response functions are useful for studying the interactions between variables in a vector autoregressive model. They represent the reactions of the variables to shocks hitting the system. It is often not clear; however, which shocks are relevant for studying specific economic problems. Therefore structural information has to be used to specify meaningful shocks. Structural vector autoregressive models and the estimation of impulse responses are discussed and extensions to models with cointegrated variables or nonlinear features are considered”. Generally an impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables.

Regarding IRF, Sarode (2012) argues that “VAR is estimated and its dynamic structure is characterized using impulse response function. The impulse response can do this by showing how shocks to any one variable filter through the model to affect every other variable and eventually lead back to the original variable itself”.

Impulse Response Function (IRF), of a dynamic system is its output when presented with a brief input signal, called an impulse. More generally, an impulse response refers to the reaction of any dynamic system in response to some external change. In

[38] Lutkepohl, H(1991). Introduction to multiple time series analysis, 2nd ed. Springer-Verlag: Retrieved from http://www.dictionaryofeconomics.com/article?id=pde2008_I000283

both cases, the impulse response describes the reaction of the system as a function of time (or possibly as a function of some other independent variable that parameterizes the dynamic behavior of the system).

Structural VAR embeds economic theory within time series models, providing a convenient and powerful framework for policy analysis. Impulse response function tracks the impact of any variable on others in the system. It is an essential tool in empirical causal analysis and policy effectiveness analysis.

[39]For a set of n time series variables $y_t = (y_{1t}, y_{2t,}\cdots,y_{nt})'$, a VAR model of order p (VAR (p)) can be written as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + u_t \tag{10.1}$$

Where the A_i 's are(nxn) coefficient matrices and $u_t = (u_{1t}, u_{2t}, \ldots, u_{nt})'$ is an unobservable $(i.i.d.)$ zero mean error term.

Consider a two-variable VAR(1) with k=2.

$$y_t = b_{10} - b_{12} z_t + c_{11} y_{t-1} + c_{12} z_{t-1} + \varepsilon_{yt} \tag{10.2}$$

$$z_t = b_{20} - b_{21} y_t + c_{21} y_{t-1} + c_{22} z_{t-1} + \varepsilon_{zt} \tag{10.3}$$

with $\varepsilon_{it} \sim i.i.d(0, \sigma_{\varepsilon i}^2)$ and $\mathrm{cov}(\varepsilon_y, \varepsilon_z) = 0$

In matrix form:

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

More simply,

$$BX_t = \Gamma_0 + \Gamma_1 X_{t-1} + \varepsilon_t \tag{10.4}$$

Equation (10.4) is called Structural VAR (SVAR).

To normalize the LHS vector, we need to multiply the equation by inverse B:

$B^{-1}BX_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 X_{t-1} + B^{-1}\varepsilon_t$, thus:

$$X_t = \mathrm{A}_0 + \mathrm{A}_1 X_{t-1} + e_t \tag{10.5}$$

Equation (10.5) represents VAR in standard form (unstructured VAR=UVAR).

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39 Enders, Walter (2003). *Applied Econometric Time Series* (2nd ed.). John Wiley & Sons. pp. 239–318. ISBN 0-471-23065-0

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \tag{10.6}$$

These error terms are composites of the structural innovations from the primitive system.

For (IRF), we have to trace out the time path of the effect of structural shocks on the dependent variables of the model. For this, we first need to transform the VAR into a VMA representation.

Rewriting the UVAR more compactly:

$$X_t = A_0 + A_1 X_{t-1} + e_t \Rightarrow X_t = \frac{A_0}{I - A_1 L} + \frac{e_t}{I - A_1 L}$$

First, consider the first component on the RHS:

$$\frac{A_0}{I - A_1} = (I - A_1)^{-1} A_0 = \frac{(I - A_1)^a A_0}{|I - A_1|} = \frac{\begin{bmatrix} 1 - a_{11} & -a_{12} \\ -a_{21} & 1 - a_{22} \end{bmatrix} A_0}{\begin{vmatrix} 1 - a_{11} & -a_{12} \\ -a_{21} & 1 - a_{22} \end{vmatrix}} = \frac{\begin{bmatrix} 1 - a_{22} & a_{21} \\ a_{12} & 1 - a_{22} \end{bmatrix} \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix}}{(1 - a_{11})(1 - a_{22}) - a_{21} a_{12}}$$

$$= \frac{1}{\Delta} \begin{bmatrix} (1 - a_{22}) a_{10} + a_{21} a_{20} \\ a_{12} a_{10} + (1 - a_{22}) a_{20} \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix}$$

Stability requires that the roots of $I - A_1 L$ lie outside the unit circle. We will assume that it is the case. Then, we can write the second component as:

$$\frac{e_t}{I - A_1 L} = \sum_{i=0}^{\infty} A_1^i e_{t-i} = \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} e_{1,t-i} \\ e_{2,t-i} \end{bmatrix} \tag{10.7}$$

The errors in equation (10.7) are the composite errors consisting of the structural innovations and these $e's$ are replaced by $\varepsilon's$. Therefore,

$$e_t = \frac{1}{|\,|} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \varepsilon_t \tag{10.8}$$

Thus, $\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \underbrace{\frac{A^i}{1 - b_{12} b_{21}} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}}_{\Phi_i} \begin{bmatrix} \varepsilon_{y,t-i} \\ \varepsilon_{z,t-i} \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \Phi_{11}^{(i)} & \Phi_{12}^{(i)} \\ \Phi_{21}^{(i)} & \Phi_{22}^{(i)} \end{bmatrix}^i \begin{bmatrix} \varepsilon_{y,t-i} \\ \varepsilon_{z,t-i} \end{bmatrix}$

$$= \bar{X} + \sum_{i=0}^{\infty} \Phi_i \varepsilon_{t-i} \tag{10.9}$$

In IRF the Impact Multipliers trace the impact effect of a one unit change in a structural innovation. For example, to find the impact effect of $\varepsilon_{z,t}$ on y_t and z_t :

$$\frac{dy_t}{d\varepsilon_{z,t}} = \Phi_{12}(0) \qquad \frac{dz_t}{d\varepsilon_{z,t}} = \Phi_{22}(0)$$

Lets trace the effect one period ahead on y_{t+1} and z_{t+1}

$$\frac{dy_{t+1}}{d\varepsilon_{z,t}} = \Phi_{12}(1) \qquad \frac{dz_{t+1}}{d\varepsilon_{z,t}} = \Phi_{22}(1)$$

Note that this is the same effect on y_t and z_t of a structural innovation one period ago:

$$\frac{dy_t}{d\varepsilon_{z,t-1}} = \Phi_{12}(1) \qquad \frac{dz_t}{d\varepsilon_{z,t-1}} = \Phi_{22}(1)$$

Impulse response functions are the plots of the effect of $\varepsilon_{z,t}$ on current and all future y and z. IRs show how $\{y_t\}$ or $\{z_t\}$ react to different shocks.

Impulse response function of y to a one unit change in the shock to z

$= \Phi_{12}(0)$**,** $\Phi_{12}(1)$ **,** $\Phi_{12}(2)$ **, …**

Cumulated effect is the sum over IR functions: $\sum_{i=0}^{n} \Phi_{12}(i)$.

Long-run cumulated effect: $\lim_{n\to\infty} \sum_{i=0}^{n} \Phi_{12}(i)$

In practice we cannot calculate these effects since the SVAR is under identified. So we must impose additional restrictions on the VAR to identify the impulse responses.

If we use the Cholesky decomposition and assume that y does not have a contemporaneous effect on z, then $b_{12} = 0$. Thus the error structure becomes lower triangular:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix} \qquad (10.10)$$

The ε_y shock doesn't affect z directly but it affects it indirectly through its lagged effect in VAR.

10.1.1 Analysis of Impulse Response Function

(M_1 Money Supply and Price Level)

The relevant impulse response function (IRF) based on the VAR model with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables as well as $dLnM_{1t}$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables with VAR order 1 to 5 has been analyzed with the help of Figures from 10.1 to 10.4 and Table-10.1 (A and B).

Figure-10.1 presents the response of the price level ($dLnCPI_t$) to an impulse transmitted through price channel. Following a price impulse,

(a) Price level responds immediately by moving up above the long run equilibrium base line.

(b) Price level displays a declining trend for $2 \le t \le 3$.

(c) Price level falls below the long run base line for fourth period and for $6 \le t \le 8$.

(d) Price level displays damped oscillations around the long run equilibrium base line for $t > 4$.

(e) The damped oscillations of price level are short-lived since these fail to change the price level at long run base level.

Figure-10.1: Response of $dLnCPI_t$ to $dLnCPI_t$

$Response\ to\ Cholesky\ One\ S.D. Innovations\ \pm\ 2SE$

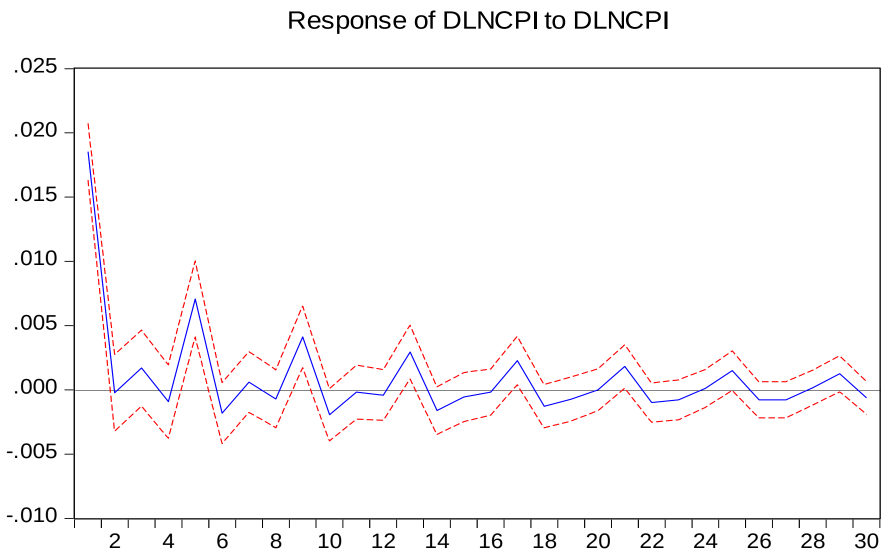


Figure-10.2 exhibits the response of price level to an impulse transmitted through M_1 money supply channel. Following a monetary (M_1 money supply) impulse,

(a) Price level displays a delayed response moving up above the long run equilibrium base line at $t = 2$.

(b) Falls below the base line at $t = 5$.

(c) Price level displays damped oscillations around the long run equilibrium base line for $t > 1$.

(d) The price variations are not experienced to be short-lived and monetary impulses fail to change the price level at long run base level.

Thus, the response of price by price impulse and M_1 monetary impulse are found to be almost counteracting each other resulting the stability in price level in short run.

Figure-10.2: Response of $dLnCPI_t$ to $dLnM_{1t}$

$Response\ to\ Cholesky\ One\ S.D.Innovations\ \pm\ 2SE$

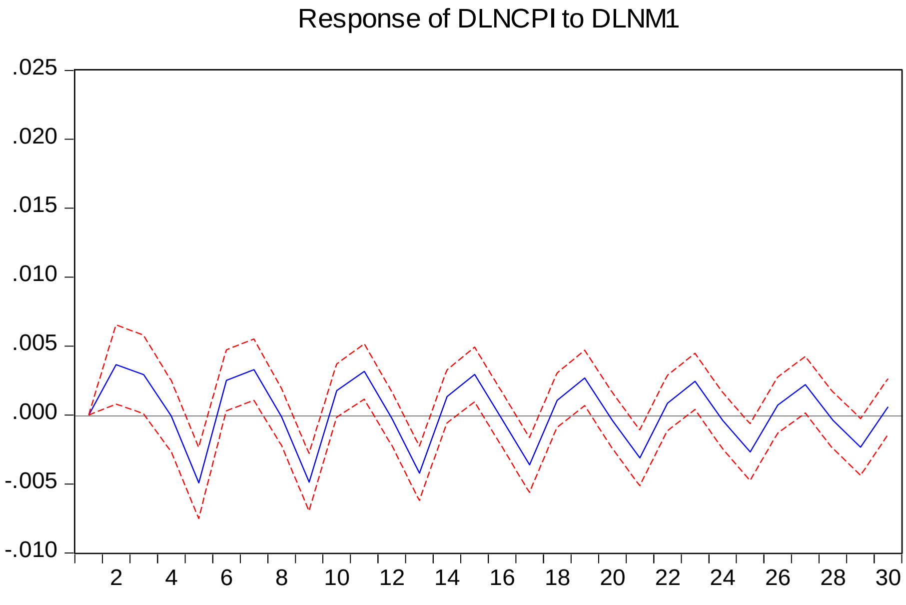


Figure-10.3 shows the response of M_1 money supply to impulse transmitted through price channel. From this figure, it is observed that

(a) M_1 money supply exhibits immediate response falling below long run equilibrium base line at $t = 1$.

(b) M_1 money supply exhibits moving up above the long run base line for $2 \leq t \leq 4$.

(c) M_1 money supply variations collapse on the long run base line at $t = 5,7,9,10$ etc.

(d) M_1 money supply exhibits damped oscillations around long run base line for $t > 1$.

(e) The short run variations in money M_1 supply fail to change the long-run base and, therefore, these variations are short-lived without having permanent impact on M_1 money supply.

Figure-10.3: Response of $dLnM_{1t}$ to $dLnCPI_t$

$Response\ to\ Cholesky\ One\ S.D. Innovations\ \pm\ 2SE$

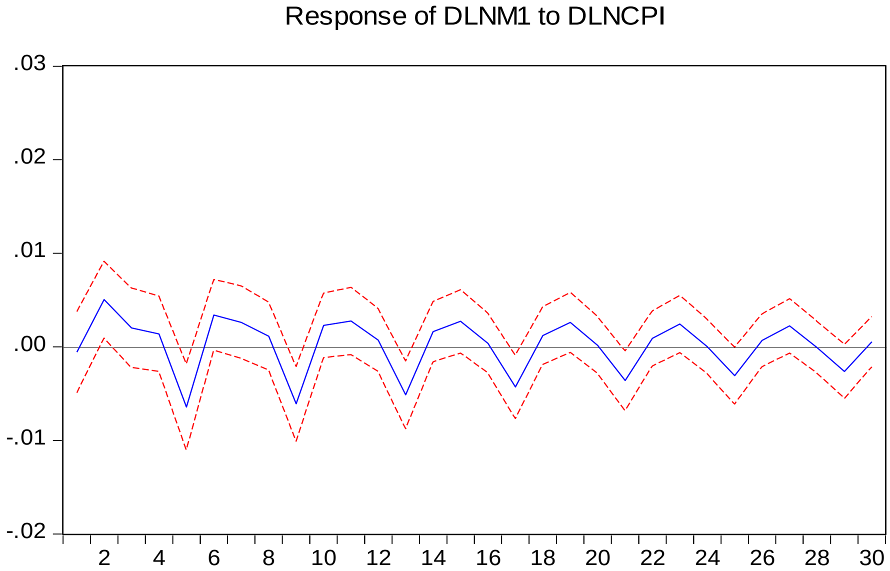


Figure-10.4 shows the response of M_1 money supply to impulse transmitted through M_1 monetary channel. From this figure and Table-10.1, it is observed that

(a) M_1 money supply exhibits immediate response rising above the long run base line at $t = 1$.

(b) It starts falling from period 2 and falls below the long run base line at $t = 3$.

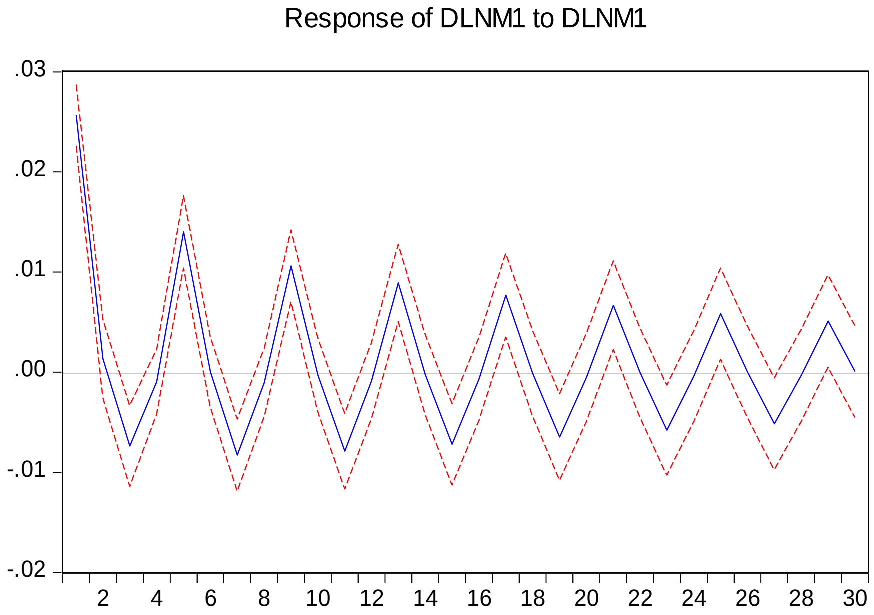
(c) M_1 money supply lies above the long run base line for $4 \leq t \leq 6$.

(d) It exhibits damped oscillations around the long run base line for $t \geq 1$.

(e) M_1 money supply displays the variations, and it fails to change the equilibrium base level. These variations are short-lived without having permanent impact on M_1 money supply.

Figure-10.4: Response of $dLnM_{1t}$ to $dLnM_{1t}$

$Response\ to\ Cholesky\ One\ S.D.Innovations\ \pm\ 2SE$



Annex-VI shows the response of $dLnCPI_t$ to an impulse transmitted through price and M_1 monetary channels based on VAR model with VAR order 1 to 5, with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables. From the table it is observed that the response of price through price channel are more volatile than the responses of price through M_1 monetary channel. It means the variations in price are more sensitive to price than the monetary phenomenon.

Annex-VII shows the response of dM_{1t} to an impulse transmitted through price and M_1 monetary channels based on VAR model with VAR order 1 to 5, with $dM1_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables. From the table it is observed that the responses of M_1 money supply through M_1 monetary channel are more volatile than the responses of price through price channel. It means the variations in M_1 money supply are more sensitive to M_1 money supply than the price mechanism.

Thus, from Figures (10.3 and 10.4 and Annex-VI & VII), it is observed that M_1 money supply responses to price innovations are less volatile than those to M_1 monetary shocks. It is because the cycles of M_1 monetary response to price level are relatively smaller than those of the M_1 monetary response to M_1 money supply.

Additionally, M_1 monetary variations, following the price innovations, appear to counteract those due to monetary shocks for other periods. As a result, the money supply remains stable without significant variations around the long run base level during the study periods.

10.1.2 Analysis of Impulse Response Function

(M_2 Money Supply and Price Level)

The relevant impulse response function (IRF) based on the VAR model with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{2t}$ with VAR order 1 to 4 has been analyzed with the help of Figures from 10.5 to 10.8 and Table-10.2.

Figure-10.5 displays the response of price level to one standard deviation innovation in its own residuals. It shows that, following a shock transmitted through price channel,

(a) Price level responds immediately at $t = 1$, rising above the base level.

(b) Price level exhibits a trend of decline at $t = 2$ and it continues to $t = 4$.

(c) Price level remains more or less constant below the long run equilibrium base line for $2 \leq t \leq 4$.

(d) Price level shows upward and downward deviations around the base line and deviations are decaying for $t > 4$ and collapse for $t > 30$.

(e) Short run price deviations display damped oscillations around the long run base line. Price level are short-lived since these fail to change the price level at long run base level.

Figure-10.5: Response of $dLnCPI_t$ to $dLnCPI_t$

$Response\ to\ Cholesky\ One\ S.D.Innovations\ \pm\ 2SE$

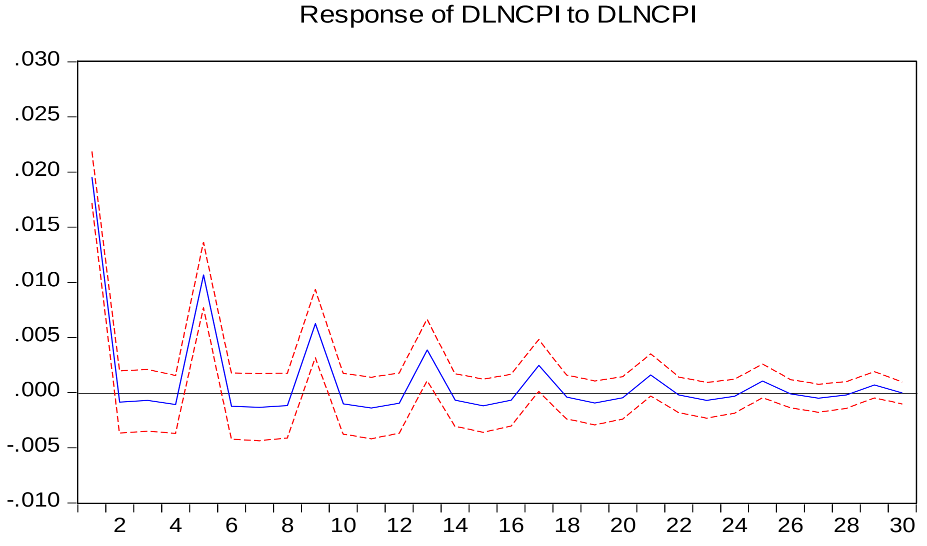


Figure-10.6 shows the response of price level to an impulse transmitted through M_2 money supply channel. Following a M_2 monetary impulse,

(a) Price level displays a delayed response moving up above the long run equilibrium base line at $t = 2$.

(b) Price level shows damped oscillations around the long run base line for $t > 2$.

(c) Price deviations are short-lived since M_2 monetary impulses fail to change the long run base line.

From the joint study of Figures 10.5 and 10.6, it can be concluded that the monetary shocks (M_2 money) fail to generate significant variations in price level around its long run equilibrium base line. The short run price variations are not monetary phenomenon. The shocks transmitted through price and money channels are short-lived and they fail to change the long run equilibrium bases of price and M_2 money supply.

Figure-10.6: Response of $dLnCPI_t$ to $dLnM_{2t}$

$Response\ to\ Cholesky\ One\ S.D. Innovations\ \pm\ 2SE$

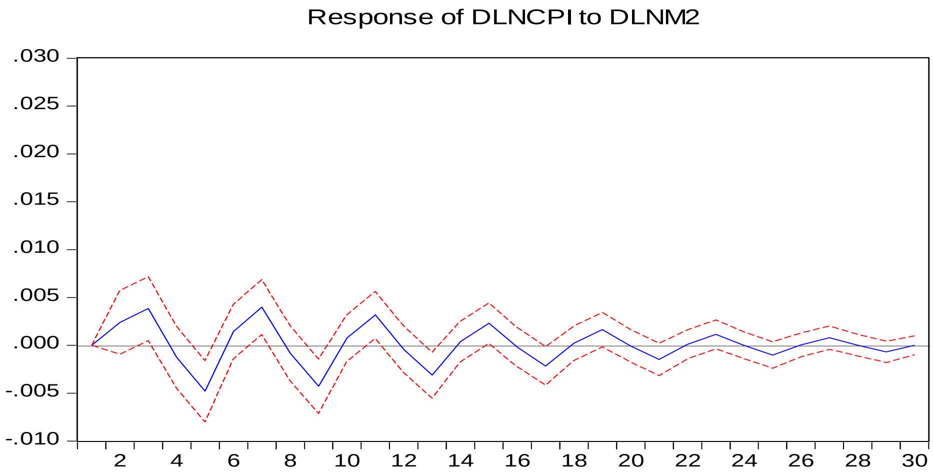


Figure-10.7 exhibits the responses of M_2 money supply to shocks transmitted through price channel. From this figure, it is observed that

(a) M_2 money supply exhibits delayed response by rising above the long run equilibrium base line for $2 \leq t \leq 3$. However, the M_2 money supply falls below the long run base line at $t = 1$.

(b) M_2 money supply exhibits damped oscillations around the long run base line for $3 \leq t \leq 20$.

(c) The oscillations of M_2 money supply more or less collapse on the long run base after period 20.

(d) The impact of price shocks on money supply appears to be very short-lived without having any permanent impact on M_2 money supply.

Figure-10.7: Response of $dLnM_{2t}$ to $dLnCPI_t$

$Response\ to\ Cholesky\ One\ S.D. Innovations\ \pm\ 2SE$

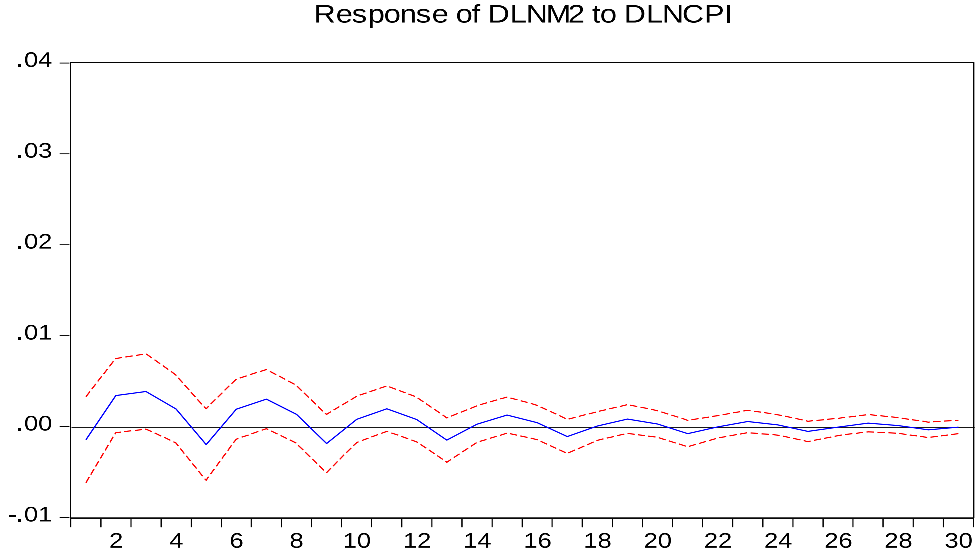


Figure-10.8 shows that M_2 money supply, following shocks transmitted through M_2 monetary channel,

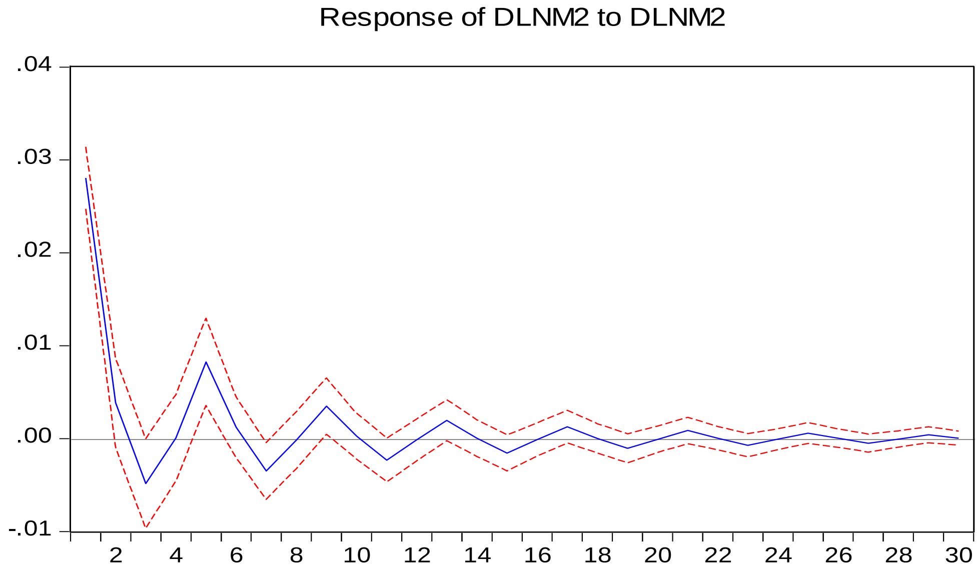
(a) Exhibits an immediate response by rising above the long run equilibrium base line at $t = 1$.

(b) Exhibits downswings below the base level and upswings above the base line for $2 \leq t \leq 28$. These ups and downs in price responses are gradually declining and collapse on long run base after $t = 28$.

(c) Exhibits the damped oscillations around the long run base line.

Figure-10.8: Response of $dLnM_{2t}$ to $dLnM_{2t}$

$Response\ to\ Cholesky\ One\ S.D. Innovations\ \pm\ 2SE$



Annex-VIII shows the response of $dLnCPI_t$ to an impulse transmitted through price and M_2 monetary channels based on VAR model with VAR order 1 to 4, with $dLnCPI_t$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{2t}$ as independent variables. From the table it is observed that the response of price through price channel are more explosive than the responses of price through M_2 monetary channel. It means the variations in price are more sensitive to price than the monetary phenomenon.

Annex-IX shows the response of dM_{2t} to an impulse transmitted through price and M_2 monetary channels based on VAR model with VAR order 1 to 4, with $dLnM_{2t}$ as dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables. From the table it is observed that the responses of M_2 money supply through M_2 monetary channel are more volatile than the responses of price through price channel. It means the variations in M_2 money supply are more sensitive to M_2 money supply than the price mechanism.

Thus, while comparing Figure-10.7 and 10.8 and Annex-VIII & IX, we can conclude that short run variations in M_2 money supply occur mainly due to shocks transmitted through M_2 monetary channel rather than price channel.

10.2 Variance Decomposition

"The Variance Decomposition also referred to as the Forecast Variance Decomposition, essentially denotes the breakdown of the forecast error variance for a particular time horizon. Explicitly, the Variance Decomposition separates the variation in an endogenous variable into the component shocks to the VAR/VECM. In essence, this analysis provides information about the relative importance of each random innovation in affecting the variables in the VAR/VECM (Ludi & Ground, 2006; Georgantopoulos, 2012). Also, the Variance Decomposition can reveal which variables in the model has short term or long term impacts on another variable of interest (http://espin086.wordpress.com/2011/04/).Therefore, the main reason to conduct the Variance Decomposition is to obtain information about the relative significance of each random innovation in affecting the variables in the estimated model. Pesaran and Shin (1998) sustained that the Variance Decomposition analysis is very sensitive to the ordering of variables". (Meniago, 2013)

It tells how much of a change in a variable is due to its own shock and how much due to shocks to other variables. In the SR most of the variation is due to own shock. But as the lagged variables' effect starts kicking in, the percentage of the effect of other shocks increases over time. While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR[40].

To see this consider the VMA representation of VAR in equation (10.9),

$$x_t = \begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \underbrace{\frac{A^i}{1-b_{12}b_{21}} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}^i}_{\Phi_i} \begin{bmatrix} \varepsilon_{y,t-i} \\ \varepsilon_{z,t-i} \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \Phi_{11}^{(i)} & \Phi_{12}^{(i)} \\ \Phi_{21}^{(i)} & \Phi_{22}^{(i)} \end{bmatrix}^i \begin{bmatrix} \varepsilon_{y,t-i} \\ \varepsilon_{z,t-i} \end{bmatrix}$$

That is, $x_t = \overline{X} + \sum_{i=0}^{\infty} \Phi_i \varepsilon_{t-i}$ (10.11)

We want to calculate the n-period forecast error of x in order to find that of say, y_t.

[40] Retrieved from: http://userhome.booklyn.cuny.edu/economics/muctum/econometricsG/VAR.

Start from 1 period:

$$x_{t+1} = \overline{X} + \Phi_0 \varepsilon_{t+1} + \Phi_1 \varepsilon_t + \Phi_2 \varepsilon_{t-1} + \dots \tag{10.12}$$

$$E_t x_{t+1} = \overline{X} + \Phi_1 \varepsilon_t + \Phi_2 \varepsilon_{t-1} + \dots \tag{10.13}$$

One -period forecast error $x_{t+1} - Ex_{t+1} = \Phi_0 \varepsilon_{t+1}$ (10.14)

Proceed in the same way and get 2-period forecast error:

$$x_{t+2} - Ex_{t+2} = \Phi_0 \varepsilon_{t+2} + \Phi_1 \varepsilon_{t+1} \tag{10.15}$$

Three-period forecast error:

$$x_{t+3} - Ex_{t+3} = \Phi_0 \varepsilon_{t+3} + \Phi_1 \varepsilon_{t+2} + \Phi_2 \varepsilon_{t+1} \tag{10.16}$$

n-period forecast error:

$$x_{t+n} - Ex_{t+n} = \Phi_0 \varepsilon_{t+n} + \Phi_1 \varepsilon_{t+n-1} + \Phi_2 \varepsilon_{t+n-2} + \dots + \Phi_{n-1} \varepsilon_{t+1} = \sum_{i=0}^{n-1} \varepsilon_{t+n-i} \tag{10.17}$$

Now consider y, the first element of the x matrix. Its n-step-ahead forecast error is:

$$\begin{aligned} y_{t+n} - Ey_{t+n} = {} & (\phi_{11,0}\varepsilon_{y,t+n} + \phi_{11,1}\varepsilon_{y,t+n-1} + .. + \phi_{11,n-1}\varepsilon_{y,t+1})(\phi_{21,0}\varepsilon_{z,t+n} \\ & + \phi_{21,1}\varepsilon_{z,t+n-1} + .. + \phi_{21,n-1}\varepsilon_{z,t+1}) \end{aligned} \tag{10.18}$$

The variance of its n-step-ahead forecast error is:

$$\sigma_{y,n}^2 = \underbrace{\sigma_y^2(\Phi^2{}_{11,0} + \Phi^2{}_{11,1} + \dots + \Phi^2{}_{11,n-1})}_{\substack{\textit{proportion of variance} \\ \textit{due to own shock} \\ \textit{Decreases over time}}} + \underbrace{\sigma_z^2(\Phi^2{}_{21,0} + \Phi^2{}_{21,1} + \dots + \Phi^2{}_{21,n-1})}_{\substack{\textit{proportion of variance} \\ \textit{due to a z shock} \\ \textit{Grows over time}}} \tag{10.19}$$

- If ε_z can explain none of the forecast error variance of the sequence $\{y_t\}$ at all forecast horizons ($\partial\sigma_{y,n}^2 / \sigma_z^2 \approx 0$), then $\{y_t\}$ is exogenous.
- If ε_z can explain most of the forecast error variance of the sequence $\{y_t\}$ at all forecast horizons ($\partial\sigma_{y,n}^2 / \sigma_z^2 \approx 0.9$ for ex.), then $\{y_t\}$ is endogenous.

10.2.1 Variance Decomposition Results Analysis

(M_1 Money Supply and Price Level)

The results of Variance Decomposition of $dLnCPI_t$ and $dLnM_{1t}$ based on VAR with order 1 to 5 taking $dLnCPI_t$ as dependent and lagged $dLnCPI_t$ and $dLnM_{1t}$ as independent variables as well as $dLnM_{1t}$ dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ independent variables are analyzed with the help of Figure-10.9 and Annex-X and Annex-XI.

Part (A) of Figure-10.9 shows the graphical presentation of Variance Decomposition of $dLnCPI_t$. It represents the percentile decompositions of variance of $dLnCPI_t$ with respect to $dLnCPI_t$ and $dLnM_{1t}$. On the other hand, Table-10.3 exhibits the numerical percentile decompositions of $dLnCPI_t$ contributed by two variables $dLnCPI_t$ and $dLnM_{1t}$. From Annex-X and Figure-10.9 (part 'A'), it is observed that

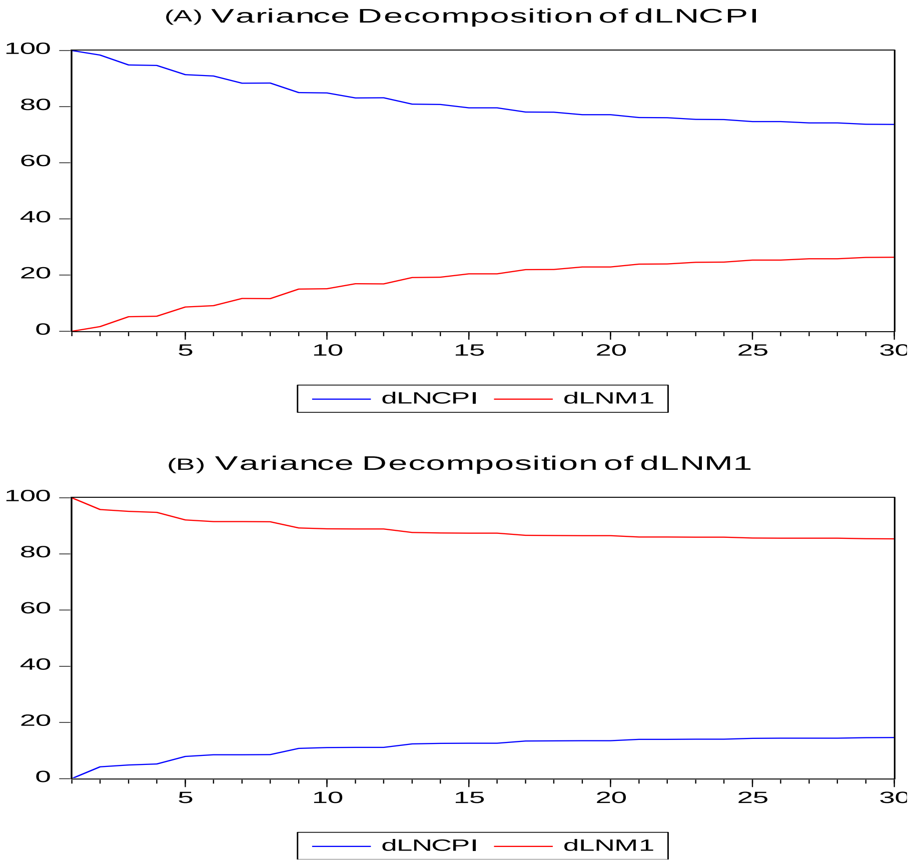
(a) Variations in price level for $1 \leq t \leq 2$ are almost entirely by shocks transmitted through price channel.

(b) M_1 money supply shocks account 5% of price variations at $t = 3$.

(c) Price shocks occupy 74% of total variations in price level for $3 < t \leq 30$.

(d) Shocks transmitted through M_1 money supply channel, account for at least 26% of the total variations in price for $3 < t \leq 30$.

Figure-10.9: Variance Decomposition of $dLnCPI_t$ and $dLnM_{1t}$



Part (B) of Figure-10.9 shows the graphical presentation of Variance Decomposition of $dLnM_{1t}$. It represents the percentile decompositions of variance of $dLnM_{1t}$ with respect to $dLnCPI_t$ and $dLnM_{1t}$. On the other hand, Table-10.4 exhibits the numerical percentile decompositions of $dLnM_{1t}$ contributed by two variables $dLnCPI_t$ and $dLnM_{1t}$. From Annex-XI and Figure-10.9 (part 'B'), it is observed that

(a) Variations in M_1 supply for $t = 1$ are almost entirely by shocks transmitted through M_1 monetary channel.

(b) M_1 money supply shocks account 95% of M_1 monetary variations at $t = 3$ and rest 5% is accounted for price shocks.

(c) M_1 money supply shocks occupy 85% of total variations in M_1 money supply for $3 < t \leq 30$.

(d) Shocks transmitted through price channel, account for at most 15% of the total variations in M_1 money supply for $3 < t \leq 30$.

10.2.2 Variance Decomposition Results Analysis

(M_2 Money Supply and Price Level)

The results of Variance Decomposition of $dLnCPI_t$ and $dLnM_{2t}$ based on VAR with order 1 to 4 taking $dLnCPI_t$ as dependent and lagged $dLnCPI_t$ and $dLnM_{2t}$ as independent variables as well as $dLnM_{2t}$ dependent variable and lagged $dLnCPI_t$ and $dLnM_{1t}$ independent variables are analyzed with the help of Figure-10.10 and Annex-XII and Annex-XIII.

Part (A) of Figure-10.10 shows the graphical presentation of Variance Decomposition of $dLnCPI_t$. It represents the percentile decompositions of variance of $dLnCPI_t$ with respect to $dLnCPI_t$ and $dLnM_{2t}$. On the other hand, Annex-XII exhibits the numerical percentile decompositions of $dLnCPI_t$ contributed by two variables $dLnCPI_t$ and $dLnM_{2t}$. From Annex-XII and Figure-10.10 (part 'A'), it is observed that

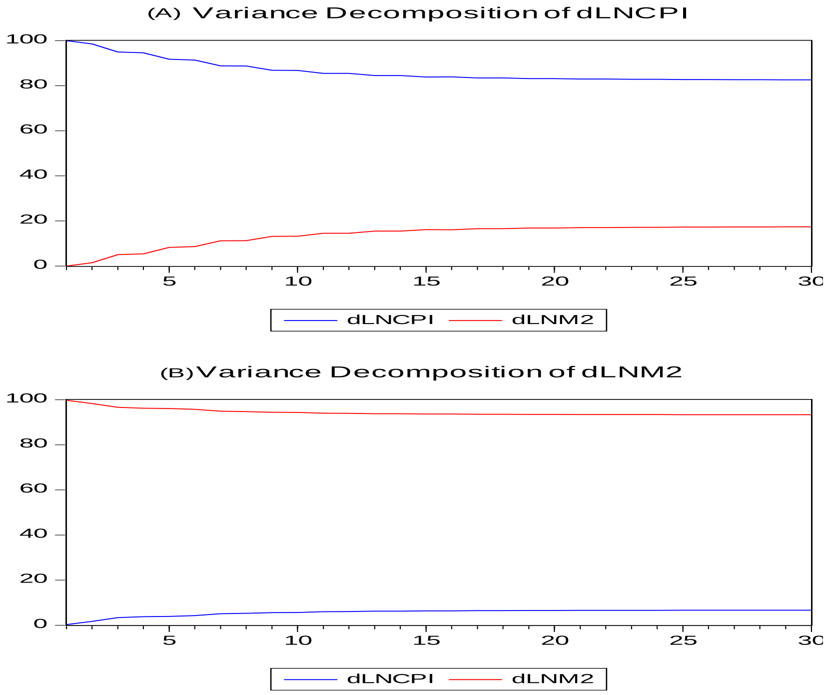
(a) Variations in price level for $t = 1$ are almost entirely by shocks transmitted through price channel.

(b) M_2 money supply shocks account 3% of price variations at $t = 3$.

(c) Price shocks occupy 83% of total variations in price level for $3 < t \leq 30$.

(d) Shocks transmitted through M_2 money supply channel, account for at most 17% of the total variations in price for $3 < t \leq 30$.

Figure-10.10: Variance Decomposition of $dLnCPI_t$ and $dLnM_{2t}$



Part (B) of Figure-10.10 shows the graphical presentation of Variance Decomposition of $dLnM_{2t}$. It represents the percentile decompositions of variance of $dLnM_{2t}$ with respect to $dLnCPI_t$ and $dLnM_{2t}$. On the other hand, Annex-XIII exhibits the numerical percentile decompositions of $dLnM_{2t}$ contributed by two variables $dLnCPI_t$ and $dLnM_{2t}$. From Annex-XIII and Figure-10.10 (part 'B'), it is observed that

(a) Variations in M_2 money supply for $t = 1$ are almost entirely by shocks transmitted through M_2 money supply channel.

(b) M_2 money supply shocks account 97% of M_2 money supply variations at $t = 3$.

(c) Price shocks occupy 7% of total variations in M_2 money supply for $3 < t \leq 30$.

(d) Shocks transmitted through M_2 money supply channel, account for least 93% of the total variations in M_2 money supply for $3 < t \leq 30$.

10.3 Conclusion of Chapter Ten

The following are the conclusions of Chapter Ten.

(Impulse Response Function)

- The responses of price to price innovations are reverse to the price responses to monetary impulses.
- The short run price variations are not appeared through monetary channels. In other words, the monetary shocks do not significantly cause the price variations.
- The shocks transmitted through price and monetary channels are of short term nature. These cannot change the long run price and money supply.
- The short run variations in money supply (both M_1 and M_2) are generated by the shocks transmitted through M_1 and M_2 money supply respectively.
- The price variations are generated through non-monetary factors rather than monetary factors.
- The variations in money supply are negligibly generated through price shocks.

(**Variance Decomposition)**

- Of the total variations in price, the shocks accounted by price are 74 % and by M_1 money supply are 26%. Likewise, between price level and M_2 money supply, of the total variations in price, the price shocks accounted for 83% and M_2 money supply accounted for 17%. This implies that price shocks play vital role to cause price change in Nepal.
- The monetary shocks, rather than price shocks, play crucial role in monetary variations.
- Between two types of money supplies, M_1 money supply generates more variations in price than M_2 money supply. In other words, M_1 money supply better explains the variations in price than M_2 money supply in the economy of Nepal during the study period.

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.

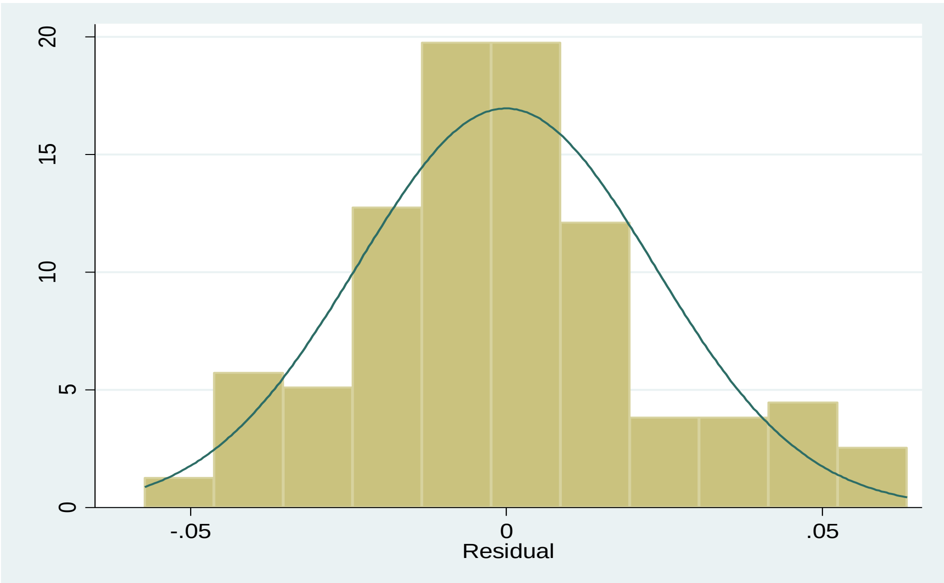
Table-11.3: Breusch-Godfrey Serial Correlation LM Test for M_1

F-statistic	1.380904	Prob. F(2,138)	0.2548
T×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,

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

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:

$$dLnCPI_t = \alpha + \beta AM_{1t} \qquad (11.4)$$

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}	β = 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,

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

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.

CHAPTER TWELVE

SUMMARY, CONCLUSION AND POLICY IMPLICATION

12.1 Summary

The present study consists of twelve chapters. The summary of the whole study from chapter one to chapter eleven is presented below.

Chapter One includes to 'Introduction' consisting the general background of Nepalese economy with some political and socio-economic scenario. The monetary background with reference to banking and financial institutions and, price and inflationary situation of Nepalese economy are focused in this chapter. Besides, statement of the problem, importance of the study and objectives are mentioned clearly. 'To examine the relationship between money supply and price level in Nepal' is the general objective of the present study. Hypothesis, limitations, scope for future research and plan of the present study as the requisites of the study are also mentioned clearly.

Chapter Two is associated with the review and analysis of some important theoretical and empirical studies relating to money-price relationship. Important findings and conclusions of different past studies are reviewed thoroughly.

Chapter Three presents the 'Research Methodology' as very important part of the present study. Nature and sources of data required to accomplish the present study are clearly mentioned. So far as the nature and source of data are concerned, the present study has utilized the secondary data relating to money supply, price level, Indian price, remittance and population. The money supply, price level and Indian price level are the quarterly data from 1976Q_1 to 2012Q_2. However, the data associated with remittance and population are annual from FY 1974/75 to 20111/12. The annual data of price level to show the relationship between remittance and inflation is also utilized in accordance with the objectives of the study. Some key econometric tools used in the present study are also highlighted in this chapter. However, other necessary econometric tools have been presented in the related chapters and sections.

Chapter Four analyzes the forecasting of inflation in Nepal by employing ARMA/ARIMA and ARCH/GARCH models. From the analysis, inflation of Nepal is found to be long-range fluctuating and ARMA {(4,5,6,8),1} model is found to be more efficient than GARCH (1,2) model for forecasting inflation in Nepal.

Chapter Five endeavors the impact of remittance along with the population growth and political instability on Nepalese inflation. The inflation, remittance, population growth and political instability have long run equilibrium relationship. There is little economic significance between inflation and remittance. The remittance of previous period is found causing inflation to increase in the current time. It means the remittance the remittance is also one of the responsible factors to cause inflation in Nepal.

Chapter Six analyzes the unit root test on money supply and price level by employing various 'unit root tests'. The price level and money supply (both M_1 and M_2) transformed at logarithmic form are found to be non-stationary at levels and they are stationary at their first differences.

Chapter Seven analyzes the relationship between money supply and price level using the techniques of Johansen's cointegration test, VECM and Granger causality test. The M_1 money supply and price level as well as M_2 money supply and price level have long run equilibrium relationship. The M_1 money supply has caused price level and M_1 money supply is also caused by price level directly. Likewise, same relationship (as of price and M_1 money supply) holds between M_2 money supply and price level. Bi-directional Granger causality is found between M_1 money supply and price level as well as M_2 money supply and price level.

Chapter Eight analyzes the relationship between money supply and price level employing the distributed lag models. There is direct but non-proportional relationship between M_1 money supply and price level and, M_2 money supply and price level. A ten percent increase in M_1 money supply has caused price level to increase by 2.76%, that is, M_1 money supply contributes 27.6% of total inflation of Nepal. On the other hand, M_2 money supply contributes 20.4% of the total inflation in Nepal. This clearly indicates that M_1 money supply is more powerful than M_2 money supply to explain the relationship between money supply and price level. The Indian wholesale price along with M_1 money supply covers 20.6% of the total inflation.

However, the Indian wholesale price alone (excluding M_1 money supply) covers nearly 50% of the total inflation in Nepal. The Indian wholesale price along with M_2 money supply covers 42.6% of the total inflation. Thus, it can be claimed that Indian inflation plays vital role in Nepalese inflation.

Chapter Nine is devoted to forecasting money supply and price level by the technique of VARs. So far as the relationship between money supply and price level by VAR model is concerned, M_1 money supply and price level as well as M_2 money supply and price level are directly related. The estimated VAR models between M_1 money supply and price level and, M_2 money supply and price level are stable as reported by various tests.

Chapter Ten analyzes the relationship between money supply and price level by the techniques of impulse response function and variance decomposition. As reported by impulse response function, the short run price variations are not appeared through monetary channels. Likewise, the variations in money supplies are negligibly generated through price shocks. The price variations are mostly generated by price shocks and monetary variations are mostly generated by monetary shocks. As reported by variance decomposition, of the total variations in price, the shocks accounted by price are 74% and by M_1 money supply 26%. Likewise, between M_2 money supply and price level, the variations in price by M_2 money supply accounts 17% and rest 83% is accounted by price shocks. It is, therefore, M_1 money supply is more powerful than M_2 money supply to explain the relationship between money supply and price level in the economy of Nepal.

Chapter Eleven examines the relationship between money supply and price level through invariance proposition of rational expectations. Under this chapter, first the suitable models associated with M_1 and M_2 money supply are built using ARIMA model and with the help of such ARIMA models, the anticipated part of both M_1 and M_2 money supply are estimated. Finally, the regressions of price on anticipated money supplies are run to examine whether anticipated money supplies cause inflation in Nepal. The suitable ARIMA models for both M1 and M2 money supply are found to be ARMA (2,1,2). With the help of ARIMA (2,1,2) models, anticipated part of both M_1 and M_2 money supply are estimated. When the regression of price on M_1 anticipated money supply is run without including M_1 money supply, 40% of the total inflation is caused by M_1 anticipated part of money supply. However, the anticipated part of M_2 money supply has no role to cause inflation in Nepal.

12.2 Conclusion and Policy Implication

From the present study, it is found that ARMA{(4,5,6,8),1} and GARCH(1,2) models are the estimated models for forecasting inflation in Nepal. However, the ARMA{(4,5,6,8),1} model is the suitable model of forecasting inflation in Nepal. It is because the ARMA{(4,5,6,8),1} has smaller Theil inequality coefficient (0.28) than that of Theil inequality coefficient (0.5) of GARCH(1,2) model.

The present study has bridged the research gap in the sense that very few studies are found in the economic literature regarding the impact of remittance on inflation so far. This research gap has been attempted to bridge by the present study by examining the impact of remittance on inflation in Nepal. In underdeveloped countries like Nepal, there is a large amount of remittance inflow from foreign countries. But unfortunately, the income recipients from remittance use the funds in unproductive activities like purchase of vehicles (motorcycle and car), luxurious goods and again there is imitative and emulative nature of consumption. In the absence of production, a high rate of consumption automatically brings inflationary pressure in the society. The present study has found that remittance along with population growth and political instability causes inflation to occur.

The present study has utilized the distributed lag models to identify the extent of relationship between money supply and price level. Additionally, the objective of applying distributed lag models is to verify the 'Quantity Theory of Money' in Nepalese context. There is direct but non-proportional relationship between money supply and price level in Nepal. This implies that monetarists' view on money and price is not applicable in Nepal. However, the Keynesian view of money-price relationship holds in Nepal. Next, not only Nepalese money supply but also Indian price is responsible to cause inflation in Nepal.

The cointegration, VECM and Granger causality test also support the direct relationship between money supply and price level. There is bi-directional Granger causality between money supply (both M_1 and M_2) and price level. This means, price is caused by money supply and money supply is also caused by price. When money supply increases, the price level rises due to the fall in value of money. In the situation of falling of value of money, the society still needs more money to purchase expensive commodities. As a result, the monetary authority is compelled to bring expansionary monetary policy for the temporary relief. Thus, higher price invites more money in the society.

From VAR, impulse response function and variance decomposition, it is found that although there is direct relationship between money supply and price level, the variations in price is mostly due to price shocks and variations in money supply is mostly due to monetary channel. The money supply has negligible effect on inflation. Although monetary shocks have negligible effect on price level, of the two monetary aggregates, M_1 money supply has better explained price in Nepal.

All the models like ARMA,VECM, distributed lag, VAR, ARIMA etc used in the present study are stable and robust as reported by different types of test like residuals diagnostic test (autocorrelation, heteroscedasticity) stability test (Ramsey's RESET, CUSUM, CUSUM of squares etc) to explain the relationship between the variables under study.

Finally, the selection of suitable ARIMA model for money supply to estimate the anticipated money supply indicates that ARIMA(2,1,2) model for both M_1 and M_2 money supply is appropriate as reported by different types of tests. While running the regression of price level on anticipated money supply, it is observed that the price level is caused by the rational expectations of money supply. That is, the expected money supply is also responsible to cause inflation in Nepal. However, the anticipated part of M_2 money supply has no role to cause inflation in Nepal.

The present study is very important in the policy perspectives. Since remittance along with the population growth and political instability causes inflation, the government should immediately induce the remittance recipients to invest their funds in productive activities through remittance investment policies so that level of output can be increased. The growing population should be controlled through further effective population control policies. The political instability of the country should be removed through quick issue of the Constitution of Republican Democratic Nepal. As new constitution is issued, political chaos would be minimized through stable government. As there is political stability, domestic as well as foreign investment may increase due to the investment friendly environment. The increase in investment plays dual role: output generation and employment opportunity. Increase in output reduces import as well as crisis of commodities, and thereby growing inflation is automatically checked.

In Nepal, the price of goods and services are mounting due to the petroleum price hike in international market. The electricity is very important substitute of petroleum substances. So investment in hydropower should be increased. For this, the central bank of Nepal, NRB should formulate the increasing investment policy in hydropower in Nepal. As electricity is adequately available, the number of industries automatically increases and national output increases and thereby growing inflation would be controlled. While doing so, higher imports from India can be reduced.

Of the two monetary aggregates, M_2 money supply is less responsible than M_1 money supply to cause inflation. Nepal Rastra Bank should formulate the policy so as to increase quasi money. For this, higher interest rates can be offered for the time deposits of non-bank public by commercial banks. As amount of quasi money increases, the quantity of M_1 money supply reduces and thereby there would be relief from higher inflation to some extent.

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Annexes

Annex-I: Annual Data on Remittance, Population & CPI and Their Log Transformation[43]

FY	Remittance(nominal)	Remittance (real)	Pop	CPI	LnCPI	$LnREMITTANCE$ (real)	$LnPOP$
1974/75	9.07	101.9101	12.59	8.9	2.186051	4.6240911	2.532903
1975/76	9.77	105.0538	12.87	9.3	2.230014	4.6544726	2.554899
1976/77	12.54	139.3333	13.16	9	2.197225	4.9368689	2.577182
1977/78	12	120	13.45	10	2.3025851	4.7874917	2.598979
1978/79	14.63	136.729	13.75	10.7	2.3702437	4.9180009	2.621039
1979/80	15.02	134.1071	14.06	11.2	2.4159138	4.8986387	2.643334
1980/81	21.68	168.062	14.38	12.9	2.5572273	5.124333	2.665838
1981/82	20.55	143.7063	14.72	14.3	2.6602595	4.9677716	2.689207
1982/83	29.26	182.875	15.06	16	2.7725887	5.2088029	2.712042
1983/84	28.01	154.7514	15.42	18.1	2.8959119	5.04182	2.735665
1984/85	27.54	150.4918	15.78	18.3	2.9069011	5.0139086	2.758743
1985/86	34.67	175.101	16.14	19.8	2.9856819	5.165363	2.781301
1986/87	47.87	200.2929	16.51	23.9	3.1738785	5.2997808	2.803966
1987/88	58.98	222.566	16.89	26.5	3.2771447	5.4052237	2.826722
1988/89	60.21	212.7562	17.27	28.3	3.3428618	5.3601469	2.848971
1989/90	67.68	216.9231	17.68	31.2	3.4404181	5.3795429	2.872434
1990/91	54.96	163.5714	18.11	33.6	3.5145261	5.0972496	2.896464
1991/92	42.36	107.2405	18.57	39.5	3.6763007	4.675074	2.921547
1992/93	54.97	118.7257	19.05	46.3	3.835142	4.7768158	2.947067
1993/94	22.3	44.6	19.55	50	3.912023	3.7977339	2.972975
1994/95	290.67	546.3722	20.07	53.2	3.9740584	6.3033004	2.999226
1995/96	266.02	459.4473	20.59	57.9	4.0587174	6.1300242	3.024806
1996/97	293.8	465.6101	21.12	63.1	4.1447208	6.1433486	3.05022
1997/98	408.42	605.9644	21.65	67.4	4.210645	6.4068212	3.075005
1998/99	652.06	865.9495	22.18	75.3	4.3214801	6.7638266	3.099191
1999/00	603.14	755.8145	22.69	79.8	4.3795235	6.627796	3.121924
2000/01	979.76	1215.583	23.18	80.6	4.3894986	7.1029791	3.14329
2001/02	1458.98	1759.928	23.66	82.9	4.4176351	7.4730282	3.163786
2002/03	4163	4818.287	24.1	86.4	4.4589877	8.4801737	3.182212
2003/04	5662.98	6223.055	24.53	91	4.5108595	8.7360162	3.199897
2004/05	6178.48	6629.27	24.92	93.2	4.5347477	8.79925	3.215671
2005/06	9274.86	9274.86	25.29	100	4.6051702	9.1350628	3.230409
2006/07	10741.74	10279.18	25.63	104.5	4.6491871	9.2378758	3.243764
2007/08	13942.15	12628.76	25.95	110.4	4.7041101	9.443732	3.256172
2008/09	19421.56	15725.96	26.25	123.5	4.8162412	9.6630681	3.267666

[43] Remittance in NRs 10 million ,population in million

2009/10	21399.89	15746.79	26.54	135.9	4.9119193	9.6643918	3.278653
2010/11	23296.32	15645.61	26.85	148.9	5.0032749	9.6579456	3.290266
2011/12	33336.68	20796.43	27.16	160.3	5.0770471	9.9425366	3.301745

Annex-II: Quarterly Data on CPI, IWPI, Narrow Money Supply and Broad Money Supply and Their Log Transformation[44]

$Time$	CPI	$M1$	$M2$	$IWPI$	$LnCPI$	$LnM1$	$LnM2$	$LnIWPI$
1976Q1	9.159868	1308.7	2121.73	29.51141	2.214832	7.17679	7.659987	3.384777
1976Q2	8.930872	1385	2383.77	29.32366	2.189514	7.233455	7.776439	3.378395
1976Q3	8.587377	1461.1	2401.37	28.64092	2.150293	7.286945	7.783795	3.354836
1976Q4	8.530127	1476.7	2505.73	29.0847	2.143604	7.297565	7.826335	3.370212
1977Q1	8.873622	1477.2	2608.1	31.44015	2.183083	7.297904	7.866377	3.448086
1977Q2	8.759124	1627.4	2802.5	31.14998	2.170096	7.394739	7.938267	3.438814
1977Q3	9.159868	1882.9	3115.47	30.48431	2.214832	7.540568	8.044135	3.417212
1977Q4	9.388865	1919.3	3253.27	31.06464	2.239524	7.559716	8.087416	3.43607
1978Q1	9.961357	1831.7	3248.5	34.06869	2.298713	7.513	8.085949	3.528379
1978Q2	10.07586	1917.7	3389.23	33.72733	2.310142	7.558882	8.128358	3.518308
1978Q3	10.07586	2144.8	3701	32.46426	2.310142	7.670802	8.216358	3.48014
1978Q4	10.07586	2147.2	3812.27	33.35182	2.310142	7.67192	8.24598	3.507112
1979Q1	10.4766	2043.5	3833.3	38.16513	2.349144	7.622419	8.251481	3.641922
1979Q2	10.41935	2174.5	4044.3	37.70428	2.343665	7.684554	8.305064	3.629774
1979Q3	10.3621	2387.4	4284.9	35.75847	2.338155	7.77796	8.362852	3.576787
1979Q4	10.41935	2489.9	4467.27	37.02154	2.343665	7.819998	8.404533	3.6115
1980Q1	10.93459	2457.5	4556.53	43.02965	2.391931	7.8069	8.424317	3.761889
1980Q2	11.16359	2541.5	4719.9	42.60294	2.412658	7.84051	8.459543	3.751923
1980Q3	11.62158	2839.7	5112.57	40.96436	2.452864	7.951454	8.539457	3.712702
1980Q4	11.96508	2917.5	5314.07	42.19329	2.481992	7.978482	8.578113	3.742261
1981Q1	12.76657	2750.9	5320.2	47.604	2.54683	7.919683	8.579266	3.862917
1981Q2	12.76657	2882.2	5543.06	46.88713	2.54683	7.966309	8.620302	3.847743
1981Q3	13.11006	3230	6007.93	45.31683	2.57338	8.080237	8.700836	3.813678
1981Q4	13.16731	3284.8	6311.97	46.42628	2.577737	8.097061	8.750203	3.837866
1982Q1	14.0833	3083.3	6323.57	50.14721	2.64499	8.033756	8.752039	3.914963
1982Q2	14.14055	3236.2	6601.87	49.48153	2.649046	8.082155	8.795108	3.9016
1982Q3	14.25505	3595.4	7127.4	48.4745	2.657111	8.187411	8.871702	3.881038
1982Q4	14.65579	3662.9	7446.8	49.54981	2.684835	8.20601	8.91554	3.902978
1983Q1	16.14427	3513.7	7602.6	51.52974	2.781565	8.164425	8.936246	3.942159
1983Q2	15.91527	3736.9	7994.4	51.25666	2.767279	8.226012	8.986497	3.936846
1983Q3	16.31602	4111.3	8507.5	50.24962	2.792147	8.321495	9.048703	3.917003
1983Q4	16.88851	4267.5	9007	50.96649	2.826633	8.358783	9.105757	3.931168
1984Q1	17.69	4047.8	9151.76	53.73157	2.872999	8.305929	9.121701	3.984001
1984Q2	17.40375	4355.5	9569.36	53.33903	2.856686	8.379195	9.166322	3.976668

[44] M_1 and M_2 in NRs 10 million. The data on CPI, M1 and M2 are sourced to Quarterly economic bulletin, NRB (various issues) and IWPI is sourced to Reserve Bank of India.

1984Q3	17.232	4804.2	10071.06	52.588	2.846768	8.477246	9.217421	3.962488
1984Q4	17.06025	4985.7	10427.93	53.11711	2.836751	8.514329	9.252243	3.972499
1985Q1	17.91899	4730.8	10369.96	55.47256	2.885861	8.46185	9.246668	4.015888
1985Q2	17.86174	4959.1	10856.56	55.26774	2.882661	8.50898	9.292525	4.012189
1985Q3	18.03349	5463.4	11734.2	54.49965	2.892231	8.605827	9.370263	3.998194
1985Q4	18.43424	5562.9	12333.03	55.08002	2.91421	8.623875	9.420036	4.008787
1986Q1	19.63647	5243.2	12284.16	56.36015	2.977388	8.564687	9.416066	4.031762
1986Q2	20.38071	5676.8	13038.26	56.41136	3.014589	8.644143	9.475643	4.032671
1986Q3	21.46844	6647.8	14387.56	55.76274	3.066584	8.802041	9.574119	4.021106
1986Q4	22.21268	7066.3	15205.36	55.96756	3.100663	8.863092	9.629403	4.024772
1987Q1	23.58666	6537.1	14871	58.83507	3.160681	8.785249	9.607168	4.074738
1987Q2	23.30042	7021.3	15578.76	58.37422	3.148471	8.856704	9.653664	4.066874
1987Q3	23.64391	7758.8	16467.3	57.41836	3.163106	8.956583	9.709132	4.050364
1987Q4	24.2164	8103.5	17367.66	58.10114	3.18703	9.000051	9.762365	4.062185
1988Q1	26.39187	7993	17822.1	61.27588	3.273056	8.986321	9.788195	4.115386
1988Q2	25.99113	8714	19033.5	60.84913	3.257755	9.072686	9.853956	4.108398
1988Q3	26.27737	9411.7	20187.1	59.6714	3.268708	9.149709	9.912799	4.088853
1988Q4	26.62087	9632.4	21247.16	60.42243	3.281695	9.172888	9.963979	4.10136
1989Q1	27.99485	9301.8	21748.43	64.04097	3.33202	9.137963	9.987297	4.159523
1989Q2	28.28109	9902.9	23155.6	63.68253	3.342194	9.200583	10.04999	4.15391
1989Q3	28.39559	10856.4	24867.76	62.64132	3.346234	9.29251	10.12133	4.137425
1989Q4	29.08258	11706.5	26369.73	63.54597	3.370139	9.3679	10.17997	4.151764
1990Q1	30.85731	11083.8	26846.8	67.89843	3.429374	9.31324	10.1979	4.218013
1990Q2	31.02905	11694	28052.4	67.42053	3.434924	9.366831	10.24183	4.21095
1990Q3	31.0863	12710.5	29354.46	65.81606	3.436767	9.450184	10.2872	4.186864
1990Q4	32.40303	13786.5	30863.03	66.48173	3.478252	9.531445	10.33731	4.196927
1991Q1	33.14727	14082.9	32473.07	70.18562	3.50096	9.552717	10.38817	4.251144
1991Q2	33.37627	14293.3	33507.2	70.03201	3.507845	9.567546	10.41952	4.248952
1991Q3	34.63575	15369.2	35384.76	69.12736	3.544886	9.640121	10.47404	4.235951
1991Q4	35.83798	16117.6	37216.63	69.60526	3.579008	9.687667	10.52451	4.24284
1992Q1	39.95993	15994	38224.73	72.37036	3.687877	9.679969	10.55124	4.281797
1992Q2	40.70416	17600.2	41003.16	72.02902	3.70633	9.775666	10.6214	4.277069
1992Q3	41.73465	19183.2	43738.9	71.24384	3.731332	9.86179	10.68599	4.266108
1992Q4	43.45213	19774.1	45389.63	71.75589	3.77166	9.892128	10.72304	4.27327
1993Q1	45.5131	19874.8	47402.3	74.35032	3.818	9.897208	10.76643	4.308788
1993Q2	44.31086	20637.9	49821.63	74.11134	3.79123	9.934884	10.8162	4.305569
1993Q3	44.82611	22097	52957.06	73.51398	3.802791	10.0032	10.87724	4.297476
1993Q4	45.91384	23537.1	56826.2	73.90652	3.826767	10.06633	10.94775	4.302801
1994Q1	49.52054	23384.1	59545.73	76.44974	3.902387	10.05981	10.9945	4.336634
1994Q2	48.26106	25522.6	62908.73	76.05715	3.876625	10.14732	11.04944	4.331485
1994Q3	48.6618	28296.5	66836.3	75.32322	3.884894	10.25049	11.11	4.321788
1994Q4	50.26478	29003.4	69330.6	75.76702	3.917305	10.27517	11.14664	4.327663
1995Q1	52.66924	29168.8	71058.1	78.48091	3.964032	10.28085	11.17125	4.362855
1995Q2	52.4975	30903.7	74302.3	78.07126	3.960765	10.33863	11.2159	4.357622
1995Q3	52.55474	32061.4	77493.23	77.52506	3.961855	10.37541	11.25795	4.350601
1995Q4	54.10047	33398.1	80825.93	78.03711	3.990843	10.41625	11.30005	4.357184

1996Q1	56.61944	31984.1	81289.03	80.80221	4.036352	10.37299	11.30577	4.392004
1996Q2	56.21869	33863.5	84684.26	80.49497	4.029249	10.43009	11.34669	4.388195
1996Q3	57.13468	36088.8	88821.73	79.69274	4.045411	10.49374	11.39439	4.378178
1996Q4	59.0239	36794	92004.69	80.2731	4.077942	10.51309	11.42959	4.385435
1997Q1	62.05811	34797.3	92326.13	82.54319	4.128071	10.4573	11.43308	4.413322
1997Q2	61.77186	36145.6	95109.33	82.25301	4.123448	10.49531	11.46278	4.4098
1997Q3	61.31387	37842.3	98686.39	81.89457	4.116006	10.54118	11.4997	4.405433
1997Q4	62.4016	39190.2	102770.9	82.08234	4.133591	10.57618	11.54026	4.407723
1998Q1	66.2373	37659.8	103990.6	83.80628	4.193244	10.53635	11.55206	4.428508
1998Q2	65.95105	39513.7	109827.3	83.55025	4.188913	10.5844	11.60666	4.425448
1998Q3	66.75254	42564.2	116204	83.05525	4.200992	10.65877	11.6631	4.419506
1998Q4	69.21426	44448.3	123280.7	83.46489	4.237207	10.70208	11.72222	4.424426
1999Q1	74.48118	44247.6	128704.6	85.8886	4.310546	10.69756	11.76528	4.453051
1999Q2	74.88192	45657	136070.4	85.49606	4.315913	10.72891	11.82093	4.44847
1999Q3	73.39344	49521.7	145706.6	84.60846	4.295835	10.81017	11.88935	4.438034
1999Q4	75.91241	51497.7	151331.3	85.18882	4.32958	10.84929	11.92723	4.44487
2000Q1	78.43137	49952.5	154088.4	88.84146	4.362224	10.81883	11.94528	4.486853
2000Q2	77.40089	55540.4	165392	88.227	4.348998	10.92487	12.01607	4.479913
2000Q3	76.19865	58777.5	176187.9	87.44186	4.333344	10.98151	12.07931	4.470974
2000Q4	76.77115	59778.6	182343	88.19284	4.340829	10.9984	12.11364	4.479526
2001Q1	79.69085	60665.3	186784.4	91.06035	4.378155	11.01313	12.13771	4.511522
2001Q2	79.63361	63604.9	195744.8	90.32642	4.377436	11.06045	12.18457	4.50343
2001Q3	77.62988	66956.2	203773.5	90.27521	4.351952	11.11179	12.22476	4.502863
2001Q4	79.34736	69992.3	210367.1	91.00914	4.373835	11.15614	12.25661	4.51096
2002Q1	81.98082	69382.2	213426.4	92.68187	4.406485	11.14739	12.27105	4.529173
2002Q2	81.80907	73182.1	219122.2	92.05035	4.404388	11.20071	12.29738	4.522336
2002Q3	79.91985	76029.4	219455.4	91.55535	4.381024	11.23888	12.2989	4.516944
2002Q4	81.75182	76980.1	221189.2	92.13566	4.403688	11.2513	12.30677	4.523262
2003Q1	84.84328	74738.8	225455.5	94.69593	4.440806	11.22175	12.32588	4.550671
2003Q2	84.04179	77380	229791	93.96201	4.431314	11.25648	12.34493	4.542891
2003Q3	84.72878	79311.2	235423.9	94.06442	4.439455	11.28113	12.36914	4.54398
2003Q4	87.30499	81437.7	241357.3	94.06442	4.469408	11.30759	12.39403	4.54398
2004Q1	89.42321	79344.9	243826.4	97.34157	4.49338	11.28156	12.40421	4.578226
2004Q2	88.39273	81420.1	252642	96.69295	4.48179	11.30738	12.43973	4.57154
2004Q3	87.76299	86970.6	264459	95.85661	4.47464	11.37333	12.48544	4.562853
2004Q4	88.85072	90070.7	270822.1	96.98313	4.486958	11.40835	12.50922	4.574537
2005Q1	91.71318	89936	277060.4	101.4551	4.518666	11.40685	12.53199	4.619616
2005Q2	91.48418	93492.2	284988.3	99.86769	4.516166	11.44563	12.5602	4.603846
2005Q3	92.80092	97782.4	290453.6	98.94599	4.530457	11.4905	12.5792	4.594574
2005Q4	94.51839	98596.3	295899.2	99.73117	4.548794	11.49879	12.59777	4.602478
2006Q1	98.81208	98096.2	303673.2	103.8788	4.59322	11.4937	12.62371	4.643225
2006Q2	98.86933	102853.6	315909.5	102.684	4.593799	11.54106	12.66321	4.631656
2006Q3	99.44182	106701.2	325899.2	102.4109	4.599573	11.57779	12.69434	4.628993
2006Q4	102.8768	111645.1	339503.5	103.93	4.633532	11.62308	12.73524	4.643718
2007Q1	105.8537	111824.1	353145.2	106.7366	4.662058	11.62468	12.77463	4.670364
2007Q2	106.14	115984.7	361896	106.2733	4.664759	11.66121	12.79911	4.666014

2007Q3	106.0255	120231.3	381973.6	105.0628	4.663679	11.69717	12.85311	4.654559
2007Q4	107.743	122382.9	386719.5	106.6098	4.679748	11.71491	12.86545	4.669175
2008Q1	112.8381	125391.4	405931.1	111.7033	4.725954	11.7392	12.91394	4.715846
2008Q2	112.3801	133056.2	431176.6	108.1686	4.721887	11.79853	12.97427	4.683691
2008Q3	113.9259	138554.2	448816.3	109.2458	4.735548	11.83902	13.01437	4.6936
2008Q4	119.3645	149653.2	480897	111.8687	4.782182	11.91608	13.08341	4.717326
2009Q1	128.1237	149217.8	511240.9	110.6003	4.852996	11.91316	13.1446	4.705923
2009Q2	128.4672	163097.9	539931.1	109.8224	4.855673	12.00211	13.1992	4.698864
2009Q3	128.6389	173194.4	563002.4	108.9212	4.857009	12.06217	13.24104	4.690624
2009Q4	133.9631	187707	604016.2	110.0747	4.897564	12.14264	13.31136	4.701159
2010Q1	140.7185	195225.6	651481.2	111.8774	4.946761	12.18191	13.387	4.717404
2010Q2	142.6077	202521.9	667158.6	111.7421	4.960098	12.2186	13.41078	4.716193
2010Q3	148.4	206053.1	673769.6	111.3515	4.999911	12.23589	13.42064	4.712692
2010Q4	152	213122.2	699664.8	111.6542	5.023881	12.26962	13.45836	4.715406
2011Q1	153.6	222285.3	944721.5	116.0409	5.034352	12.31172	13.75865	4.753943
2011Q2	156	228536.3	1002055	114.7216	5.049856	12.33945	13.81756	4.742508
2011Q3	161.9	238119	1036614	114.3046	5.086979	12.38053	13.85147	4.738866
2011Q4	163.5	251813.9	1093309	115.6574	5.096813	12.43645	13.90472	4.750632
2012Q1	164.6	257362.2	1141845	118.3022	5.103518	12.45824	13.94816	4.773242
2012Q2	171.7	266199.3	1178327	117.1729	5.145749	12.492	13.97961	4.763651

Annex-III: Anticipated Part of M_1 and M_2 Money Supply[45]

$Time$	$AM1t$	$AM2t$	$Time$	$AM1t$	$AM2t$
1976Q1	-	-	1985Q3	-0.02735	0.065571
1976Q2	-	-	1985Q4	0.048016	0.040143
1976Q3	0.072981	0.085439	1986Q1	0.099471	0.021055
1976Q4	0.017614	-0.02728	1986Q2	0.026057	0.045859
1977Q1	0.072981	0.078319	1986Q3	-0.02423	0.066937
1977Q2	0.017614	0.059961	1986Q4	0.047447	0.04002
1977Q3	0.020718	0.066564	1987Q1	0.096336	0.018279
1977Q4	0.053504	0.026504	1987Q2	0.026916	0.045555
1978Q1	0.127923	0.018057	1987Q3	-0.02058	0.070787
1978Q2	0.021102	0.058525	1987Q4	0.046996	0.041272
1978Q3	-0.05184	0.069426	1988Q1	0.092561	0.01807
1978Q4	0.052344	0.029999	1988Q2	0.027288	0.044591
1979Q1	0.123684	0.016843	1988Q3	-0.01739	0.067365
1979Q2	0.021777	0.056429	1988Q4	0.046468	0.040687
1979Q3	-0.04798	0.069987	1989Q1	0.090006	0.020872
1979Q4	0.051512	0.031031	1989Q2	0.027946	0.045267
1980Q1	0.119843	0.01861	1989Q3	-0.01508	0.065052
1980Q2	0.022747	0.054602	1989Q4	0.045632	0.040313
1980Q3	-0.04436	0.067337	1990Q1	0.087533	0.021999
1980Q4	0.050933	0.034041	1990Q2	0.028552	0.045041
1981Q1	0.11661	0.019315	1990Q3	-0.01251	0.06445
1981Q2	0.023056	0.052142	1990Q4	0.045515	0.041925
1981Q3	-0.04101	0.068106	1991Q1	0.084811	0.024486
1981Q4	0.05049	0.035801	1991Q2	0.028584	0.044243
1982Q1	0.112884	0.018582	1991Q3	-0.0099	0.059758
1982Q2	0.023613	0.049766	1991Q4	0.045538	0.043582
1982Q3	-0.03731	0.068709	1992Q1	0.08294	0.027989
1982Q4	0.049847	0.03777	1992Q2	0.028204	0.042736
1983Q1	0.109191	0.018339	1992Q3	-0.00815	0.058441
1983Q2	0.024263	0.048424	1992Q4	0.045602	0.042013
1983Q3	-0.03374	0.06751	1993Q1	0.080951	0.028408
1983Q4	0.049221	0.038429	1993Q2	0.028886	0.045145
1984Q1	0.105878	0.02049	1993Q3	-0.00607	0.056816
1984Q2	0.025002	0.046843	1993Q4	0.04477	0.041392
1984Q3	-0.03057	0.065946	1994Q1	0.079011	0.030126
1984Q4	0.048665	0.040264	1994Q2	0.029171	0.043186
1985Q1	0.10264	0.02272	1994Q3	-0.00432	0.05503
1985Q2	0.025658	0.046873	1994Q4	0.044791	0.042754
1995Q1	0.077179	0.031757	2005Q1	0.061107	0.036125
1995Q2	0.02961	0.044514	2005Q2	0.032953	0.047063

[45] Anticipated Money Supply of $dLnM1$ and $dLnM2$

1995Q3	-0.00219	0.055236	2005Q3	0.013319	0.051473
1995Q4	0.044004	0.042341	2005Q4	0.040802	0.041299
1996Q1	0.075192	0.032963	2006Q1	0.059831	0.038053
1996Q2	0.030113	0.044471	2006Q2	0.033095	0.047169
1996Q3	-0.00084	0.055578	2006Q3	0.014384	0.049515
1996Q4	0.043657	0.042659	2006Q4	0.040415	0.040356
1997Q1	0.073412	0.032233	2007Q1	0.058747	0.03889
1997Q2	0.030448	0.044706	2007Q2	0.033556	0.046335
1997Q3	0.001162	0.056397	2007Q3	0.015378	0.047756
1997Q4	0.043128	0.043292	2007Q4	0.040302	0.042229
1998Q1	0.071321	0.032311	2008Q1	0.057829	0.038744
1998Q2	0.030794	0.04374	2008Q2	0.033568	0.046806
1998Q3	0.003061	0.055703	2008Q3	0.016276	0.047205
1998Q4	0.042931	0.042285	2008Q4	0.040037	0.039117
1999Q1	0.069595	0.031466	2009Q1	0.057151	0.04028
1999Q2	0.031081	0.043245	2009Q2	0.03404	0.045329
1999Q3	0.005026	0.054111	2009Q3	0.016986	0.04488
1999Q4	0.042725	0.042648	2009Q4	0.040118	0.040866
2000Q1	0.067982	0.031987	2010Q1	0.056201	0.042225
2000Q2	0.03113	0.044516	2010Q2	0.034233	0.043671
2000Q3	0.006679	0.055523	2010Q3	0.018104	0.042058
2000Q4	0.042638	0.040377	2010Q4	0.039959	0.04466
2001Q1	0.066112	0.031116	2011Q1	0.055487	0.047146
2001Q2	0.031905	0.046809	2011Q2	0.033908	0.042731
2001Q3	0.008297	0.055849	2011Q3	0.018414	0.020799
2001Q4	0.041669	0.040126	2011Q4	0.039849	0.042862
2002Q1	0.064933	0.032554	2012Q1	0.055207	0.064322
2002Q2	0.032319	0.04722	2012Q2	0.033934	0.04317
2002Q3	0.009411	0.055287	2012Q3	0.018909	0.024746
2002Q4	0.041513	0.041299	2012Q4	0.040028	0.044531
2003Q1	0.063618	0.035959			
2003Q2	0.032528	0.047972			
2003Q3	0.010587	0.051897			
2003Q4	0.041013	0.041175			
2004Q1	0.062267	0.037282			
2004Q2	0.03285	0.046806			
2004Q3	0.011795	0.051385			
2004Q4	0.040825	0.04098			

Annex IV: Coefficient Variance Decomposition Test on VAR Model of Equation (9.6)

Eigen values	0.0103	0.0082	0.008	0.0074	0.0058	0.0047	0.0022	0.0006	0.00045	0.00024
Condition	0.0237	0.0296	0.030	0.0328	0.0417	0.0517	0.1105	0.3923	0.54300	1.00000

	Associated Eigen value									
Variable	1	2	3	4	5	6	7	8	9	10
$dLnM_{1_{t-1}}$	0.049791	0.202262	3.48E-07	0.044832	0.156582	0.486801	0.023001	0.000153	0.021257	0.015321
$dLnM_{1_{t-2}}$	0.002218	0.072731	0.308669	0.006209	0.347023	0.060475	0.088382	0.096124	0.005363	0.012806
$dLnM_{1_{t-3}}$	0.089273	0.456832	0.061552	0.044683	0.084242	0.001254	0.189092	0.000642	0.065790	0.006641
$dLnM_{1_{t-4}}$	0.080330	0.035486	0.498328	0.112893	0.056561	0.004883	0.098201	0.099843	0.001894	0.011581
$dLnM_{1_{t-5}}$	0.005465	0.002095	0.004620	0.560256	1.05E-05	0.376946	0.015557	4.12E-05	0.020667	0.014343
$dLnCPI_{t-1}$	0.659583	8.32E-05	0.086485	0.072587	0.142640	0.012686	0.019012	0.000269	0.005640	0.001015
$dLnCPI_{t-2}$	0.002287	0.875699	0.015408	0.004838	0.004887	0.055765	0.031762	0.006952	0.000786	0.001616
$dLnCPI_{t-3}$	0.045710	0.000525	0.756706	0.054032	0.085161	0.007150	0.046998	0.000330	0.000991	0.002396
$dLnCPI_{t-4}$	0.154882	0.021740	0.000949	0.636945	0.022834	0.120549	0.033807	0.006182	4.80E-05	0.002064
$dLnCPI_{t-5}$	0.552415	0.027168	0.003535	0.000277	0.347621	0.033661	0.027989	0.000141	0.006155	0.001039

Annex-V: Coefficient Variance Decomposition Test on VAR Model of Equation (9.14)

Eigen values	0.007807	0.006091	0.005259	0.004500	0.004079	0.001925	0.001892	0.000273
Condition	0.035008	0.044872	0.051968	0.060740	0.067010	0.141966	0.144449	1.000000

	Associated Eigen value							
Variable	1	2	3	4	5	6	7	8
$dLnM_{1_{t-1}}$	0.132048	0.171018	0.072496	0.249897	0.131418	0.201683	0.023273	0.018167
$dLnM_{1_{t-2}}$	0.016774	0.555894	0.046579	0.027503	0.150245	0.013083	0.172629	0.017294
$dLnM_{1_{t-3}}$	0.347460	0.181786	0.143523	0.031489	0.090953	0.176485	0.012096	0.016209
$dLnM_{1_{t-4}}$	0.032225	0.149439	0.290071	0.134636	0.119472	0.018837	0.235779	0.019541
$dLnCPI_{t-1}$	0.387306	0.193212	0.142705	0.127028	0.083211	0.063981	1.51E-06	0.002556
$dLnCPI_{t-2}$	0.425177	0.139298	0.164185	0.086343	0.127935	0.000652	0.053889	0.002521
$dLnCPI_{t-3}$	0.132235	0.221032	0.326705	0.108785	0.147159	0.060760	0.000665	0.002659
$dLnCPI_{t-4}$	0.298881	0.001963	0.112291	0.350500	0.174799	0.000425	0.058526	0.002614

Annex-VI: Results from Impulse Response Function Based on VAR with $dLnCPI_t$ as Dependent Variable and Lagged $dLnCPI_t$ and dM_{1t} as Independent Variables

(Order of VAR: 1 to 5) $Response\ to\ Cholesky\ One\ S.D.Innovations\ \pm\ 2SE$

Response of $dLnCPI_t$			Response of $dLnCPI_t$		
period	$dLnCPI_t$	$dLnM_{1t}$	period	$dLnCPI_t$	$dLnM_{1t}$
1	0.018207 (0.00109)	0.000000 (0.00000)	18	-0.001903 (0.00109)	0.001140 (0.00106)
2	0.001578 (0.00158)	0.002351 (0.00159)	19	-0.000358 (0.00102)	0.002596 (0.00102)
3	0.001062 (0.00149)	0.003554 (0.00143)	20	-0.000242 (0.00100)	-0.000351 (0.00103)
4	-0.001031 (0.00148)	0.000860 (0.00143)	21	0.002210 (0.00100)	-0.003070 (0.00104)
5	0.006826 (0.00151)	-0.004149 (0.00128)	22	-0.001520 (0.00102)	0.000939 (0.00106)
6	-0.003704 (0.00150)	0.001928 (0.00142)	23	-0.000427 (0.00095)	0.002299 (0.00103)
7	-0.000627 (0.00128)	0.003528 (0.00112)	24	-0.000113 (0.00092)	-0.000336 (0.00104)
8	-0.001330 (0.00113)	3.22E-05 (0.00111)	25	0.001823 (0.00093)	-0.002640 (0.00104)
9	0.004210 (0.00118)	-0.004600 (0.00106)	26	-0.001221 (0.00093)	0.000773 (0.00106)
10	-0.003159 (0.00123)	0.001618 (0.00114)	27	-0.000461 (0.00088)	0.002032 (0.00103)
11	-0.000263 (0.00110)	0.003253 (0.00100)	28	-2.32E-05 (0.00085)	-0.000311 (0.00103)
12	-0.000701 (0.00111)	-0.000256 (0.00101)	29	0.001512 (0.00085)	-0.002273 (0.00103)
13	0.003356 (0.00113)	-0.004126 (0.00102)	30	-0.000985 (0.00085)	0.000637 (0.00104)
14	-0.002403 (0.00115)	0.001374 (0.00106)			
15	-0.000258 (0.00108)	0.002923 (0.00101)			
16	-0.000416 (0.00106)	-0.000338 (0.00102)			
17	0.002706 (0.00107)	-0.003569 (0.00103)			

(Standard Errors in Parentheses and Response of the variables in non-parentheses)

Annex-VII: Results from Impulse Response Function Based on VAR with dM_{1t} as Dependent Variable and Lagged $dLnCPI_t$ and dM_{1t} as Independent Variables

(Order of VAR: 1 to 5) $Response\ to\ Cholesky\ One\ S.D.Innovations\ \pm\ 2SE$

Response of $dLnM_{1t}$			Response of $dLnM_{1t}$		
period	$dLnCPI_t$	$dLnM_{1t}$	period	$dLnCPI_t$	$dLnM_{1t}$
1	-0.000598 (0.00217)	0.025696 (0.00154)	18	0.001345 (0.00182)	0.000566 (0.00220)
2	0.005341 (0.00223)	0.000510 (0.00224)	19	0.002576 (0.00172)	-0.006269 (0.00218)
3	0.002792 (0.00217)	-0.007577 (0.00208)	20	0.000388 (0.00170)	-0.001082 (0.00221)
4	0.001738 (0.00217)	0.000118 (0.00210)	21	-0.003940 (0.00171)	0.006411 (0.00223)
5	-0.006258 (0.00240)	0.014251 (0.00185)	22	0.001061 (0.00171)	0.000549 (0.00227)
6	0.002538 (0.00238)	0.000762 (0.00210)	23	0.002340 (0.00163)	-0.005496 (0.00225)
7	0.002610 (0.00208)	-0.008548 (0.00186)	24	0.000261 (0.00161)	-0.000950 (0.00227)
8	0.001056 (0.00200)	-0.000968 (0.00192)	25	-0.003348 (0.00161)	0.005540 (0.00228)
9	-0.006356 (0.00209)	0.010534 (0.00186)	26	0.000835 (0.00162)	0.000528 (0.00230)
10	0.002022 (0.00211)	0.000626 (0.00203)	27	0.002110 (0.00154)	-0.004807 (0.00228)
11	0.002882 (0.00192)	-0.007966 (0.00192)	28	0.000173 (0.00152)	-0.000831 (0.00229)
12	0.000819 (0.00190)	-0.001247 (0.00198)	29	-0.002851 (0.00152)	0.004793 (0.00228)
13	-0.005463 (0.00193)	0.008715 (0.00199)	30	0.000657 (0.00152)	0.000501 (0.00229)
14	0.001687 (0.00194)	0.000585 (0.00210)			
15	0.002795 (0.00182)	-0.007112 (0.00206)			
16	0.000574 (0.00180)	-0.001205 (0.00211)			
17	-0.004642 (0.00182)	0.007441 (0.00213)			

(Standard Errors in Parentheses and Response of the variables in non-parentheses)

Annex-VIII: Results from Impulse Response Function Based on VAR with $dLnCPI_t$as Dependent Variable and Lagged $dLnCPI_t$ and dM_{2t} as Independent Variables

(Order of VAR: 1 to 4) $Response\ to\ Cholesky\ One\ S.D.Innovations\ \pm\ 2SE$

Response of $dLnCPI_t$			Response of $dLnCPI_t$		
period	$dLnCPI_t$	$dLnM_{2t}$	period	$dLnCPI_t$	$dLnM_{2t}$
1	0.019547 (0.00116)	0.000000 (0.00000)	18	-0.000406 (0.00100)	0.000214 (0.00090)
2	-0.000858 (0.00141)	0.002387 (0.00166)	19	-0.000942 (0.00100)	0.001636 (0.00090)
3	-0.000706 (0.00140)	0.003839 (0.00167)	20	-0.000478 (0.00096)	-7.26E-05 (0.00085)
4	-0.001074 (0.00131)	-0.001260 (0.00162)	21	0.001604 (0.00096)	-0.001481 (0.00084)
5	0.010663 (0.00149)	-0.004795 (0.00160)	22	-0.000219 (0.00081)	0.000105 (0.00076)
6	-0.001231 (0.00150)	0.001437 (0.00143)	23	-0.000705 (0.00081)	0.001142 (0.00075)
7	-0.001330 (0.00152)	0.003995 (0.00144)	24	-0.000326 (0.00077)	-1.68E-05 (0.00070)
8	-0.001176 (0.00147)	-0.000831 (0.00144)	25	0.001057 (0.00076)	-0.001013 (0.00069)
9	0.006251 (0.00155)	-0.004275 (0.00142)	26	-0.000105 (0.00064)	4.39E-05 (0.00062)
10	-0.001023 (0.00138)	0.000767 (0.00122)	27	-0.000514 (0.00064)	0.000791 (0.00061)
11	-0.001398 (0.00139)	0.003171 (0.00123)	28	-0.000222 (0.00060)	9.16E-06 (0.00056)
12	-0.000952 (0.00136)	-0.000419 (0.00121)	29	0.000701 (0.00059)	-0.000693 (0.00056)
13	0.003860 (0.00139)	-0.003115 (0.00120)	30	-4.19E-05 (0.00050)	1.09E-05 (0.00049)
14	-0.000685 (0.00120)	0.000408 (0.00106)			
15	-0.001201 (0.00120)	0.002314 (0.00106)			
16	-0.000690 (0.00117)	-0.000188 (0.00102)			
17	0.002464 (0.00118)	-0.002161 (0.00101)			

(Standard Errors in Parentheses and Response of the variables in non-parentheses)

Annex-IX: Results from Impulse Response Function Based on VAR with dM_{2t}as Dependent Variable and Lagged $dLnCPI_t$ and dM_{2t} as Independent Variables
(Order of VAR: 1 to 4) $Response\ to\ Cholesky\ One\ S.D.Innovations\ \pm\ 2SE$

Response of $dLnCPI_t$			Response of $dLnCPI_t$		
period	$dLnCPI_t$	$dLnM_{2t}$	period	$dLnCPI_t$	$dLnM_{2t}$
1	-0.001442 (0.00237)	0.028066 (0.00167)	18	5.61E-05 (0.00079)	2.18E-05 (0.00079)
2	0.003407 (0.00204)	0.003871 (0.00239)	19	0.000827 (0.00078)	-0.001051 (0.00079)
3	0.003856 (0.00207)	-0.004830 (0.00241)	20	0.000276 (0.00073)	-7.32E-05 (0.00071)
4	0.001929 (0.00187)	5.60E-05 (0.00234)	21	-0.000772 (0.00072)	0.000869 (0.00070)
5	-0.001968 (0.00196)	0.008250 (0.00235)	22	-2.19E-05 (0.00062)	3.17E-05 (0.00063)
6	0.001909 (0.00165)	0.001236 (0.00163)	23	0.000555 (0.00061)	-0.000717 (0.00063)
7	0.003029 (0.00163)	-0.003481 (0.00153)	24	0.000182 (0.00056)	-6.02E-05 (0.00056)
8	0.001337 (0.00159)	-0.000165 (0.00153)	25	-0.000533 (0.00056)	0.000596 (0.00056)
9	-0.001857 (0.00160)	0.003489 (0.00151)	26	-4.52E-05 (0.00048)	3.76E-05 (0.00049)
10	0.000795 (0.00128)	0.000258 (0.00124)	27	0.000377 (0.00048)	-0.000490 (0.00049)
11	0.001969 (0.00125)	-0.002313 (0.00118)	28	0.000125 (0.00043)	-5.06E-05 (0.00044)
12	0.000771 (0.00122)	-0.000139 (0.00112)	29	-0.000363 (0.00043)	0.000409 (0.00043)
13	-0.001486 (0.00122)	0.001973 (0.00110)	30	-4.73E-05 (0.00036)	3.73E-05 (0.00038)
14	0.000270 (0.00100)	4.20E-05 (0.00098)			
15	0.001262 (0.00099)	-0.001552 (0.00097)			
16	0.000448 (0.00094)	-9.67E-05 (0.00089)			
17	-0.001094 (0.00093)	0.001281 (0.00088)			

(Standard Errors in Parentheses and Response of the variables in non-parentheses)

Annex-X: Variance Decomposition of $dLnCPI_t$

Period	S.E.	$dLnCPI_t$I	$dLnM_{1t}$	Period	S.E.	$dLnCPI_t$	$dLnM_{1t}$
1	0.018207	100.0000 (0.00000)	0.000000 (0.00000)	18	0.024155	78.00758 (7.93600)	21.99242 (7.93600)
2	0.018426	98.37206 (2.45118)	1.627936 (2.45118)	19	0.024296	77.12173 (8.31353)	22.87827 (8.31353)
3	0.018796	94.85925 (3.62773)	5.140748 (3.62773)	20	0.024300	77.10795 (8.41015)	22.89205 (8.41015)
4	0.018843	94.67706 (3.76265)	5.322937 (3.76265)	21	0.024593	76.09128 (8.72894)	23.90872 (8.72894)
5	0.020467	91.37876 (3.86736)	8.621239 (3.86736)	22	0.024658	76.07183 (8.83503)	23.92817 (8.83503)
6	0.020888	90.87107 (4.12449)	9.128926 (4.12449)	23	0.024768	75.42368 (9.14696)	24.57632 (9.14696)
7	0.021193	88.36090 (4.77012)	11.63910 (4.77012)	24	0.024771	75.41034 (9.24783)	24.58966 (9.24783)
8	0.021235	88.40634 (4.79641)	11.59366 (4.79641)	25	0.024978	74.69901 (9.50859)	25.30099 (9.50859)
9	0.022132	85.00658 (5.44776)	14.99342 (5.44776)	26	0.025019	74.68796 (9.60829)	25.31204 (9.60829)
10	0.022414	84.86138 (5.60881)	15.13862 (5.60881)	27	0.025106	74.20731 (9.86616)	25.79269 (9.86616)
11	0.022651	83.11325 (6.16066)	16.88675 (6.16066)	28	0.025108	74.19595 (9.96799)	25.80405 (9.96799)
12	0.022663	83.11882 (6.21551)	16.88118 (6.21551)	29	0.025256	73.68769 (10.1836)	26.31231 (10.1836)
13	0.023279	80.85881 (6.74419)	19.14119 (6.74419)	30	0.025283	73.68082 (10.2786)	26.31918 (10.2786)
14	0.023443	80.78207 (6.87713)	19.21793 (6.87713)				
15	0.023626	79.54800 (7.33574)	20.45200 (7.33574)				
16	0.023632	79.53805 (7.42009)	20.46195 (7.42009)				
17	0.024052	78.04533 (7.82066)	21.95467 (7.82066)				

Annex-XI: Variance Decomposition of $dLnM_{1t}$

Period	S.E.	$dLnCPI_t$I	$dLnM_{1t}$	Period	S.E.	$dLnCPI_t$	$dLnM_{1t}$
1	0.025703	0.054198 (0.90902)	99.94580 (0.90902)	18	0.039584	13.45822 (7.58438)	86.54178 (7.58438)
2	0.026257	4.189005 (3.96930)	95.81100 (3.96930)	19	0.040160	13.48641 (7.71558)	86.51359 (7.71558)
3	0.027471	4.859752 (4.27258)	95.14025 (4.27258)	20	0.040177	13.48472 (7.71972)	86.51528 (7.71972)
4	0.027526	5.238982 (4.22019)	94.76102 (4.22019)	21	0.040875	13.95686 (8.00183)	86.04314 (8.00183)
5	0.031621	7.885861 (4.35419)	92.11414 (4.35419)	22	0.040893	14.01229 (8.06679)	85.98771 (8.06679)
6	0.031732	8.470372 (4.63246)	91.52963 (4.63246)	23	0.041327	14.04016 (8.15626)	85.95984 (8.15626)
7	0.032967	8.474853 (4.91387)	91.52515 (4.91387)	24	0.041339	14.03617 (8.16272)	85.96383 (8.16272)
8	0.032998	8.561336 (4.90643)	91.43866 (4.90643)	25	0.041842	14.34047 (8.36030)	85.65953 (8.36030)
9	0.035217	10.77408 (5.75771)	89.22592 (5.75771)	26	0.041854	14.37232 (8.42104)	85.62768 (8.42104)
10	0.035281	11.06367 (5.89276)	88.93633 (5.89276)	27	0.042182	14.39979 (8.48425)	85.60021 (8.48425)
11	0.036283	11.09149 (6.19156)	88.90851 (6.19156)	28	0.042190	14.39564 (8.49310)	85.60436 (8.49310)
12	0.036314	11.12361 (6.19834)	88.87639 (6.19834)	29	0.042557	14.59736 (8.63505)	85.40264 (8.63505)
13	0.037742	12.39250 (6.80535)	87.60750 (6.80535)	30	0.042565	14.61569 (8.69268)	85.38431 (8.69268)
14	0.037785	12.56416 (6.89500)	87.43584 (6.89500)				
15	0.038550	12.59612 (7.09190)	87.40388 (7.09190)				
16	0.038573	12.60316 (7.09310)	87.39684 (7.09310)				
17	0.039557	13.36087 (7.51163)	86.63913 (7.51163)				

Annex-XII: Variance Decomposition of $dLnCPI_t$

Period	S.E.	$dLnCPI_t$I	$dLnM_{2t}$	Period	S.E.	$dLnCPI_t$	$dLnM_{2t}$
1	0.028103	0.263383 (0.95519)	99.73662 (0.95519)	17	0.026114	83.46320 (6.58097)	16.53680 (6.58097)
2	0.028573	1.676862 (1.80410)	98.32314 (1.80410)	18	0.026118	83.46161 (6.60666)	16.53839 (6.60666)
3	0.029233	3.342044 (2.95625)	96.65796 (2.95625)	19	0.026186	83.15711 (6.84473)	16.84289 (6.84473)
4	0.029297	3.761078 (3.11833)	96.23892 (3.11833)	20	0.026190	83.16207 (6.86182)	16.83793 (6.86182)
5	0.030500	3.886694 (3.33862)	96.11331 (3.33862)	21	0.026281	82.96063 (7.01501)	17.03937 (7.01501)
6	0.030585	4.254850 (3.59085)	95.74515 (3.59085)	22	0.026282	82.96049 (7.04467)	17.03951 (7.04467)
7	0.030931	5.119259 (4.29311)	94.88074 (4.29311)	23	0.026317	82.81663 (7.19342)	17.18337 (7.19342)
8	0.030960	5.296102 (4.37924)	94.70390 (4.37924)	24	0.026319	82.81922 (7.21512)	17.18078 (7.21512)
9	0.031211	5.565313 (4.70809)	94.43469 (4.70809)	25	0.026359	82.72449 (7.31526)	17.27551 (7.31526)
10	0.031223	5.626142 (4.77600)	94.37386 (4.77600)	26	0.026360	82.72453 (7.34697)	17.27547 (7.34697)
11	0.031370	5.967413 (5.13915)	94.03259 (5.13915)	27	0.026377	82.65663 (7.43901)	17.34337 (7.43901)
12	0.031380	6.024090 (5.19670)	93.97591 (5.19670)	28	0.026377	82.65785 (7.46444)	17.34215 (7.46444)
13	0.031477	6.209909 (5.43817)	93.79009 (5.43817)	29	0.026396	82.61310 (7.52848)	17.38690 (7.52848)
14	0.031478	6.216781 (5.47654)	93.78322 (5.47654)	30	0.026396	82.61313 (7.56011)	17.38687 (7.56011)
15	0.031542	6.351823 (5.68574)	93.64818 (5.68574)				
16	0.031545	6.370642 (5.73635)	93.62936 (5.73635)				
17	0.031590	6.472518 (5.89905)	93.52748 (5.89905)				

Annex-XIII: Variance Decomposition of $dLnM_{2t}$

Period	S.E.	$dLnCPI_t$I	$dLnM_{2t}$	Period	S.E.	$dLnCPI_t$	$dLnM_{2t}$
1	0.028103	0.263383 (0.95519)	99.73662 (0.95519)	18	0.031590	6.472809 (5.93130)	93.52719 (5.93130)
2	0.028573	1.676862 (1.80410)	98.32314 (1.80410)	19	0.031618	6.529674 (6.06062)	93.47033 (6.06062)
3	0.029233	3.342044 (2.95625)	96.65796 (2.95625)	20	0.031619	6.536784 (6.10567)	93.46322 (6.10567)
4	0.029297	3.761078 (3.11833)	96.23892 (3.11833)	21	0.031641	6.587465 (6.21478)	93.41253 (6.21478)
5	0.030500	3.886694 (3.33862)	96.11331 (3.33862)	22	0.031641	6.587504 (6.24342)	93.41250 (6.24342)
6	0.030585	4.254850 (3.59085)	95.74515 (3.59085)	23	0.031654	6.612826 (6.32689)	93.38717 (6.32689)
7	0.030931	5.119259 (4.29311)	94.88074 (4.29311)	24	0.031654	6.615878 (6.36606)	93.38412 (6.36606)
8	0.030960	5.296102 (4.37924)	94.70390 (4.37924)	25	0.031664	6.639949 (6.44045)	93.36005 (6.44045)
9	0.031211	5.565313 (4.70809)	94.43469 (4.70809)	26	0.031665	6.640129 (6.46545)	93.35987 (6.46545)
10	0.031223	5.626142 (4.77600)	94.37386 (4.77600)	27	0.031671	6.651800 (6.52094)	93.34820 (6.52094)
11	0.031370	5.967413 (5.13915)	94.03259 (5.13915)	28	0.031671	6.653234 (6.55461)	93.34677 (6.55461)
12	0.031380	6.024090 (5.19670)	93.97591 (5.19670)	29	0.031676	6.664413 (6.60637)	93.33559 (6.60637)
13	0.031477	6.209909 (5.43817)	93.79009 (5.43817)	30	0.031676	6.664612 (6.62778)	93.33539 (6.62778)
14	0.031478	6.216781 (5.47654)	93.78322 (5.47654)				
15	0.031542	6.351823 (5.68574)	93.64818 (5.68574)				
16	0.031545	6.370642 (5.73635)	93.62936 (5.73635)				
17	0.031590	6.472518 (5.89905)	93.52748 (5.89905)				