EVALUATING THE IMPACT OF MACRO ECONOMIC VARIABLES ON INFLATION AND FORECASTING INFLATION

by

Rachana Pandey

A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Master of Science in
Economics

Charlotte

2016

Approved by:

____
Dr Craig A. Depken II

____
Dr Azhar Iqbal

____
Dr Matthew R. Metzgar

ABSTRACT

RACHANA PANDEY. Evaluating the impact of macro economic variables on inflation and forecasting inflation. (Under the direction of DR. CRAIG A. DEPKEN II)

The objective of the current study is to empirically determine whether certain macroeconomic variables play a significant role in influencing inflation in the United States, the United Kingdom, and Canada, and also to forecast inflation. The study considers the unemployment rate, money supply, interest rate, gross domestic product, and stock prices on the basis of economic theory. In a vector auto regression (VAR) framework, the empirical estimation is carried out applying cointegration test and the vector error correction model (VECM). Furthermore, the impact of these macroeconomic variables on inflation is explained using impulse response functions (IRF). The empirical results show the long-term and short-term relationship among the variables. The results are consistent with the Phillips curve.

Keywords: Inflation, Vector Auto regression (VAR), Cointegration, Vector Error Correction Method, Impulse Response Function, Phillips curve

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

Inflation is considered as a key metric in macroeconomics and is defined as a broad increase in average prices across many goods and services in an economy over a sustained period of time. Inflation reduces the purchasing power and value of money. Inflation, an economic concept, has seen many modifications since neoclassical economists first defined it. The Phillips curve is considered one of the most important theories in macroeconomics. It claims an inverse relationship between the rate of inflation and the unemployment rate.

Ball and Mazumdar (2011) observed that during the Great Recession of 2007-08 the inverse relationship between unemployment rate and inflation rate digressed. Most of the OECD (The Organization for Economic Cooperation and Development) member countries experienced stagflation, a combination of high inflation, a high unemployment rate, and a stagnant GDP. The Phillips curve failed to explain the stagflation and thus leading to a new relation between high inflation and a high unemployment rate. This observed behavior raised many curious questions such as what factors were responsible for the change? How did it affect the relationship between inflation and unemployment rates and how did other macroeconomic variables affect this relation? This unusual behavior in the Phillips curve during the Great Recession served as a foundation for the modified Phillips curve, which implies that high unemployment does not cause low inflation, rather it causes a lower increase of inflation. The present interpretation of the Phillips curve is applicable and valid for many developed countries.

There are three types of inflation: (1) Cost-push inflation, which is caused by increased wages, supply shocks, higher taxes and devaluation of currency, which results in businesses raising prices to cover higher labor and input costs; (2) Demand-pull inflation, which is caused by increasing consumer demand because of easier availability of credit, increasing expectations of consumers, and an increase in government spending, which results in a rise in prices due to increased aggregate demand; and (3) Monetary inflation, caused by an expansion in the money supply because the government needs to cover its deficit by printing more money.

The most common measure of inflation is the Consumer Price Index (CPI). The CPI is defined as the measure of weighted average of consumer goods and services. For identifying the periods of inflation and deflation, the CPI is the most frequently used statistic. Inflation has a few other indicators like personal consumption expenditure (PCE), the wholesale price index (WPI), and the implicit price index (GDP Deflator). The CPI plays a major role for central banks in determining the interest rates. The interest rate has multilateral influence on many macroeconomic variables. Central banks try to regulate economic growth by indirectly increasing or decreasing the rates, thereby making borrowing and investing less desirable and saving more desirable when rates are high and vice versa when rates are low. Traders and currency speculators depend on the CPI as it serves as an early warning indicator of changes in determining central bank policy.

This research considers five macroeconomic exogenous variables in the model: unemployment rate (UR), gross domestic product (GDP), short-term interest rate (IR), broad money supply (M3), and stock prices (SP). In this study, vector autoregressive

(VAR) approach is used based on quarterly data for the period 1985 (Q1) to 2015 (Q4) for three economically developed countries: Canada, the United States, and Great Britain. The study also includes a forecast of inflation for 12 quarters (3 years). This paper is a complement to the existing literature. I have tried to explain the relationship between inflation and each exogenous variable in detail.

i. Relationship Between Inflation and GDP

Lupu (2007) observed that there exists positive relationship between inflation and the GDP growth rate in Romania for the short term. From this we can infer that as inflation increases, there is an increase in GDP and if inflation decreases so should GDP. Drukker et al (2005) argued that if inflation is below a threshold then it does not have a significant effect on GDP. It is only above this threshold that there is a positive relationship between inflation and GDP, in line with the assertion made by Lupu (2007).

ii. Relationship Between Inflation and Money Supply

Meltzer (1998) commented that money growth is not the right tool to predict inflation and so most economists, central bank staffs, and market practitioners rely on the Phillips curve. In the short run there is a weak correlation between inflation and money supply, however, for long term there is a significant relationship between them.

iii. Relationship Between Inflation and Short term Interest Rate

Mishkin and Simons (1995) examined the relationship between the expected inflation rate and the interest rate. They employed a model that estimated the state-space system and included observations on treasury bills with different maturities. It supported the idea that real interest rates and expected inflation show a negative correlation and real interest rates display greater volatility and weaker mean reversion as compared to the expected inflation. Crowder and Hoffman (1996) tested the long-run relationship between nominal interest rates and inflation. They used the quarterly data of the three-month T-bill rate and the implicit price deflator for total consumption expenditure and found that a unit percent increase in inflation yields a 1.34 percent increase in the nominal interest rate.

iv. Relationship Between Inflation and Stock Prices

Feldstein (1980) observed that stock prices increase when the inflation rate is very high. However, the stock prices fall when there is decrease in the inflation rate. He demonstrated that there is an effect of inflation on stock prices through various ways like corporate income taxation, cost depreciation and taxation of nominal capital gains.

v. Relationship Between Inflation and Unemployment Rate

Metin (1991) observed unemployment is an influential phenomenon, which is found in the economies, which are negatively influenced by inflation. The scale budget deficit seems to affect inflation significantly. The economic prospect regarding unemployment is measured as the product of the unemployment rate and amount to which people are protected.

The results of this empirical research help the reader to understand whether the change in the rate of inflation is subject to some macroeconomic variables. Researchers will find this study as a helpful tool for them to identify some basic economic variables that they should focus on while forecasting inflation and analyze the behavior of change in rate of inflation to provide valid suggestions that can be helpful in making policy changes and decision for economic development.

Besides, the Dickey Fuller Generalized Least Square (DF-GLS) unit root test to check the stationarity of data, a Johansen trace test for cointegration is also applied to predict the long relationship among the endogenous variable (CPI) and the exogenous variables. A vector error correction model helps in determining the extent of deviation from a long-run relationship in the short-run. Finally, I conduct an impulse response analysis on the estimated VAR model. An impulse response function (IRF) traces a one-unit shock in an exogenous variable and its impact on all other variables. The study aims to test the robustness of the results. For effective decision-making we must make sure that results are consistent between sub-samples, which is the essence of the Lucas critique. The out-of-sample forecast of CPI for all three countries was calculated as well as the root mean square forecasting error.

The remainder of this paper is as follows. The second section emphasizes the theoretical framework where the Phillips curve and related literature is discussed. The third section provides a review of the literature and some of the pertinent studies in this area. The fourth section explains the research methodology adopted in the research. The fifth section explains the data sources and explanations of each variable and related study. The sixth section analyzes the empirical results. The seventh section provides detail about the inflation forecast for the three countries. The last section concludes and makes certain recommendations based on the empirical results obtained from the research. It also provides suggestions for future research.

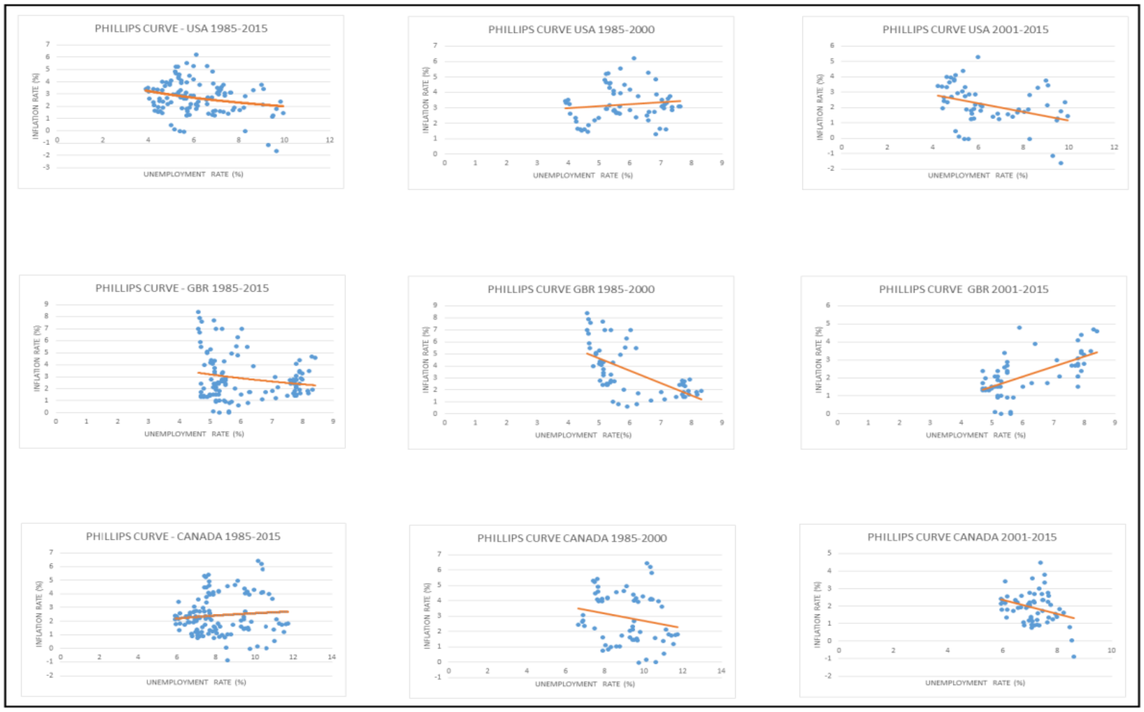
CHAPTER 2: THEORETICAL FRAMEWORK

2.1 The Phillips Curve

A.W Phillips (1958) analyzed the relationship between the unemployment rate and rate of change of money wages in the United Kingdom for the period 1861-1957. He hypothesized an inverse relationship between the unemployment rate and the inflation rate. The findings of this research helped economists understand the impact of intensive utilization of an economy's resources which lead to increased growth rates and decreasing unemployment rates while simultaneously also causing an increase in the inflation rates. Phillips surmised that the labor market gets tighter when unemployment rate is lower. As a result, firms should raise wages to attract scarce labor. The pressure is subsided at higher rates of unemployment. Friedman (1968) and Phelps (1967) distinguished between "short-run" and "long-run" Phillips curves. Inflation and unemployment remains inversely related as long as the average rate of inflation remains constant as happened in 1960. The policies that promote growth in the economy, increased employment, and sustained development are heavily dependent on the Phillips curve findings. Phillips curve's implications have been found true only in the short-term. It fails to explain when the inflation and unemployment are unexpectedly high.

Solow (1960) and Samuelson (1960) conducted similar trials for the unemployment rates and inflation rates for the USA and found similar outcomes as Phillips did. They concluded that in times of high inflation there existed low unemployment, and vice versa, and aptly named it the Phillips curve. These findings led governments across the world to believe they could control the unemployment rate as long as they were willing to tolerate a higher inflation rate. What followed was a general increase in worldwide inflation rates to try to boost employment rates. But in the 1970's most OECD countries began to experience not only high inflation levels but also high unemployment rates. Stagflation ensued and countries were trapped in an era of stagflation. Thus economists took another look at the Phillips curve and interpreted it to imply that high unemployment does not yield low inflation but rather slows the increase of inflation. This new information was the basis of the modified Phillips curve (Blanchard and Illing, 2009).

The plot of the Phillips curve for the three countries USA, UK, and Canada is shown below. The graph is plotted for complete sample period (1985-2015) and two sub samples (1985-2000 and 2001-2015) to analyze the effect of two different phases of business cycles (expansionary and contractionary) on the Phillips curve and how it affects the relation between rate of inflation and unemployment rate. From the graph (Graph1) it is clear that the Phillips curve seems to hold for majority of the sample and sub samples but the period of 1985-2015 in Canada, 2001-2015 in Great Britain, and 1985-2000 in the United States shows deviation from the Phillips curve.



Graph 1: Plot of Phillips curve for the USA, UK, and Canada for the period 1985-2015, 1985-2000, 2001-2015

CHAPTER 3: LITERATURE REVIEW

The quantity theory of money (QTM) explains the relation between the money supply and the price level in an economy and is directly proportional. In other words, for a given percentage change in the money supply levels, there is an equivalent change in the level of inflation or deflation, ceteris paribus. It is calculated and supported by Fisher's equation on quantity theory of money.

$MV=PY$,

where, M= Money Supply (amount of money available in an economy);

V= Velocity of money (within a given time period how many times on average, a unit of currency is exchanged for goods and services);

P= Price level in the economy;

Y= Level of real output in the economy (referred to as real GDP).

The right side of the equation represents nominal GDP (total dollar value of output in an economy). The QTM is considered as a useful instrument to control inflation in the long run.

Friedman (1970) noticed the influence of monetary policy on the price trend instead of inflation. Friedman suggested that the quantity theory also explained short-run money stock and prices. Sargent and Wallace (1981) cited the quantity theory to imply a unitary relationship between consumption and money growth. DeGrauwe and Polan (2005) disagreed with Friedman's (1970) opinion that "inflation is always and everywhere a monetary phenomenon." Nelson (2002) disagreed with De Grauwe and Polan's (DP) view that at low inflation rates monetary aggregates are not useful for monetary analysis. He also criticized their use of long-run average data in a cross-section, as it does not consider country-by-country differences in trends of velocity. After including Nelson's criticism into DP framework, the long-run relation between inflation and currency growth showed positive and statistically significant cross-sectional proof at all currency growth rates. This explains that even at low inflation rates the money supply is useful for monetary analysis. Also, when the long-run inflation rate is below 15%, the relationship between growths in the money supply in the long run and inflation is proportional (Thornton, 2011).

Several studies contributed towards understanding, modeling, and forecasting inflation. Several researchers and their studies also tried to determine the variables and factors affecting and influencing inflation. Fisher (1930) stressed the relationship between the rate of inflation and the nominal interest rate. He explained that in a perfectly functioning capital market, the sum of the inflation rate and the equilibrium real interest rate is the nominal interest rate. Pattanaik and Nadhanael (2011) argue that economic growth is slowed by high inflation. They proposed that an inflation threshold level of 6% should be maintained to achieve sustainable growth. Basu (2011) highlighted the importance of economic theories in determining the risk of high inflation.

Moreover, with so many divergent theories, forecasting of inflation is a complicated process and its measurement is difficult because of statistical errors (Cecchetti, 1996). John (2003) studied the causality between exchange rates and monetary aggregates where he used post-liberalization (1992 onwards for India) data and employed a VAR framework. The purpose of the study was to find which monetary aggregates influence and explains inflation. Since the model approach used a VAR, it is believed that M3 is a better measure compared to M1 and M2. Gospodinov, Maynard and Pesavento (2011) show that random small deviations from an exact unit root may produce impulse response estimators that are highly distorted and misleading. Quartey (2010) used the Johansen cointegration methodology to investigate the revenue-maximizing rate of inflation that is growth maximizing in Ghana. He concluded the negative impact of inflation on growth. Pattanaik (2010) used cointegrated VAR model to study the determinants of inflation in India and surmised the significance of a mix of demand and supply side factors. Virmani (2003) studied inflation in India where he used an error correction model (ECM) due to the inherent limitations in VAR. Khundrakpam and Pattanaik (2010) estimated a significant relationship between inflation and fiscal deficit that a 1% increase in fiscal deficit results in 0.6% increase in inflation.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Dickey Fuller-Generalized Least Square (DF-GLS) Unit Root Test

This test was developed by Elliot, Rothenberg, and Stock (1996). A stationary series is one in which the mean, variance, and auto-covariance are time invariant whereas a non-stationary series is one in which its mean, variance, or both change over time. This test is a two-step process. In the first step the trend and intercept is estimated by generalized least squares (GLS). In the second step we test for a unit autoregressive root in yt using a Dickey-Fuller test where Dickey-Fuller regression does not include a time trend or intercept. Stock and Watson (2007) provide an excellent discussion of the approach. The Augmented Dickey Fuller test involves fitting a regression approach of the following form:

$$\Delta y_t = \alpha + \beta y_{t-1} + \delta_t + \lambda_1 \Delta y_{t-1} + \ldots + \lambda_k \Delta y_{t-k} + \varepsilon_t,$$

where y_t is dependent variable, $_t$ is time variable, ε_t is the white noise error term. The null is H_0: the series has a random walk trend and is non-stationary and alternate hypothesis is H_1: the series is stationary around a linear time trend. The DF-GLS is applied analogously on GLS detrended data. The null hypothesis is that y_t is random walk, which may be with drift. The two possible alternatives hypothesis are y_t is stationary with linear time trend or y_t is stationary with a non-zero mean and no linear time trend. DF-GLS exhibits higher power and is more accurate compared to Augmented Dickey-Fuller (ADF) test. 4.2

Vector Auto Regression (VAR)

The vector auto regression (VAR) was introduced by Sims (1980) as a technique that could be used by macroeconomists to characterize the joint dynamic behavior of a collection of variables without requiring strong restrictions of the kind needed to identify underlying structural parameters. It has become a prevalent method of time-series modeling. A VAR consists of set of *n* endogenous variables.

A traditional VAR with n- variables consists of n-equations; one equation for each variable which includes a constant and lag(s), where the lag order is denoted by *P*. A VAR model with two variables which include one lag of each variable is denoted as *VAR (1)* as *P=1*.

For a *n*-variable system the VAR is defined as:

$$Y_t = \alpha_1 Y_{t-1} + \alpha_2 X_{1_{t-1}} + \dots + \alpha_n X_{n_{t-1}} + \varepsilon_{1t}$$

$$X_{1t} = \beta_1 Y_{t-1} + \beta_2 X_{1_{t-1}} + \dots + \beta_n X_{n_{t-1}} + \varepsilon_{2t}$$

. . . . .

. . . . .

$$X_{nt} = \Upsilon_1 Y_{t-1} + \Upsilon_2 X_{1_{t-1}} + \dots + \Upsilon_n X_{n_{t-1}} + \varepsilon_{nt}$$

A VAR is a simple statistical representation of an economic system, as it relies only on the variables that comprise the system and the lagged values of those variables. Let $Y_t = (y_{1t}, y_{2t}, \dots y_{nt})$ denote a (n x 1) vector of time series variables. The general form of p-lag vector regressive (VAR (p)) is of the form:

$Y_t = a_1 + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots + \Pi_p Y_{t-p} + \varepsilon_t,\ t=1,2\ldots,T,$ where Π_i are (n x n) coefficient matrices and ε_t is an (n x 1) unobservable zero mean white noise process (serially uncorrelated or independent) with time invariant covariance matrix $\sum$.

4.3 Cointegration

The Johansen test for cointegration, which is the test for linear combination of variables for unit roots, is basically a generalized form of the ADF test. The Johansen test is used to test all the co-integrating vectors when there are multiple variables. If two variables exist, each with unit roots, then at most there exists one co-integrating vector. Similarly, for n variables with unit roots, there is a maximum of $n-1$ co-integrating vectors. As is in the case of Dickey-Fuller test, the presence of unit roots in the Johansen test means that the standard asymptotic distributions do not apply.

For a system with two variables, let the eigenvalues be λ_1 and λ_2 with $\lambda_1 > \lambda_2$. If $\lambda_1 = 0$, then there are no cointegrating vectors. If $\lambda_1 = 0$ and $\lambda_2 \neq 0$, there is one cointegrating vector. If $\lambda_1 = 0$ and $\lambda_2 = 0$, the variables do not have unit roots.

The Johansen tests are likelihood tests and are called the maximum eigenvalue test and the trace test. Let r be the rank of Π, which is the same as the number of cointegrating vectors. The maximum eigenvalue test tests if the largest eigenvalue is zero with respect to the alternative that the next largest eigenvalue is zero. Initially we test if the rank of the matrix Π is zero. It is actually a log likelihood test ratio. Our null hypothesis is that $rank(\Pi) = 0$ and the alternative hypothesis is that $rank(\Pi) = 1$.

In the trace test, the null and alternate hypothesis is as follows:

H_0 : Rank=r (no cointegration)

H_1 : Rank>r (cointegration)

The column “H0: Rank=r” contains a value of “0,” which indicates that the maximum cointegration rank is zero means no cointegration. The “H1: Rank> r” is also “0” that is, the cointegration rank is greater than zero, which implies cointegration. In (Table 2, 4, and 6) the first row tests rank = 0 against rank > 0; the second row tests rank = 1 against *rank > 1* and so on. If we can reject the null than cointegration exists. We continue this until we find the order of co-integration by comparing the 5% critical values with the trace values. We determine the order of cointegration when we find that the critical value exceeds the trace value.

4.4 Vector Error Correction Model (VECM)

The VECM is used to determine short-run dynamics. This is a multivariate method where independent and dependent variables are estimated through a system of equations. A VECM is constructed from the first differences of cointegrated variables, their lags and error correction terms. It can be written as:

$$\Delta Y_t = \lambda + \alpha Y_{t-1} + \sum_{i=0}^{\infty} \beta_i \Delta X_{t-i} + \varepsilon_t,$$

where Y_t is a m x 1 vector of variables in the VAR, m is the number of variables, ΔY_t is a m x 1 vector of the first differences in Y_t, ΔX_{t-1} is a m x 1 vector of independent variables, λ is a m x 1 vector of intercept terms, α and β are m x m coefficients, and ε_t is an m x 1 error vector.

4.5 Impulse Response Function

Short–run dynamics can be analyzed using impulse response functions (IRF) upon the successful estimation of VECM. IRF display the sudden changes in exogenous variables due to sudden changes in endogenous variables. The IRF is calculated from moving average (MA) of VECM and is given by

$Y_t = \sum_{i=0}^{\infty} \alpha_i \varepsilon_t$,

where matrices α_i ($i=2,\ldots,n$) are recursively calculated.

Plotting the IRF's is a lucid way of seeing the response of the dependent variable due to shocks in the independent variables. The impact of a single impulse response may last for many periods due to the inherent auto regressive nature of the variables. The stochastic component of the solution gives us an idea of the short run adjustments due to shocks inputs of other variables. The IRF gradually decays thus reinforcing the fact that responses to such shocks are temporary in nature.

4.6 Root Mean Square Error (RMSE)

To estimate the average forecast error, the method applied in the research is RMSE. The out of sample root mean square error (RMSE) is the measure of average forecast error. To calculate RMSE the following formula is employed:

$$\text{RMSE} = \sqrt{\frac{1}{t}\Sigma(Y_{t+1} - \hat{Y}_{t+1})^2}$$

where,

Y_{t+1} = one period ahead forecast;

$\hat{Y}_{t+1}$ = actual value of the target variable.

A model with a lower value of RMSE is considered to be a better model. The out-of-sample RMSE is a better measure of forecast evaluation.

CHAPTER 5: DATA

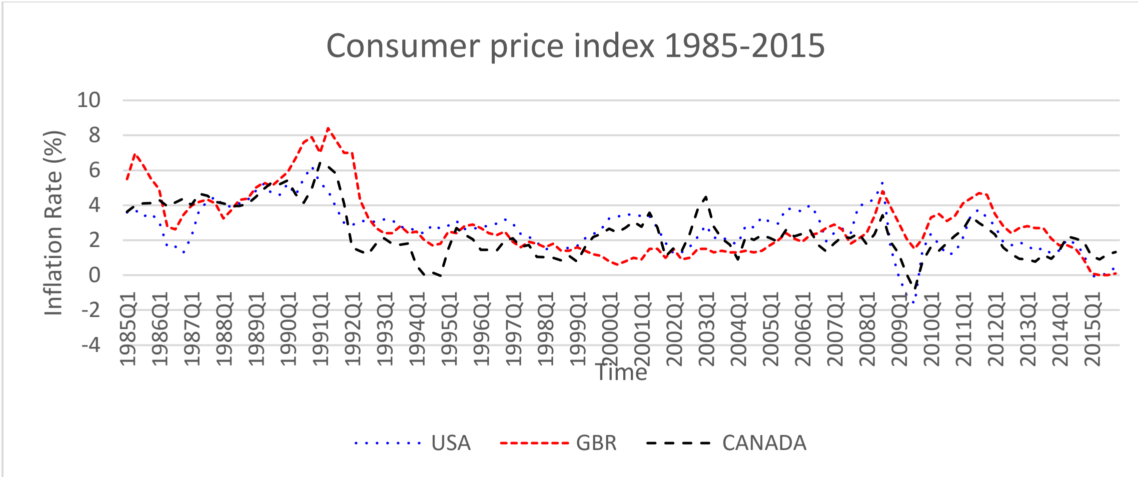
5.1 Data Sources

For my model, I consider six time series: the inflation rate, the unemployment rate, the short-term interest rate, money supply (M3), the gross domestic product (GDP) and stock prices. All of the six series were downloaded from the OECD (The Organization for Economic Cooperation and Development) and the FRED (Federal Reserve Economic Development) database. SAS has been used for the analysis of such data.

5.2 Data Description

i. Consumer Price Index

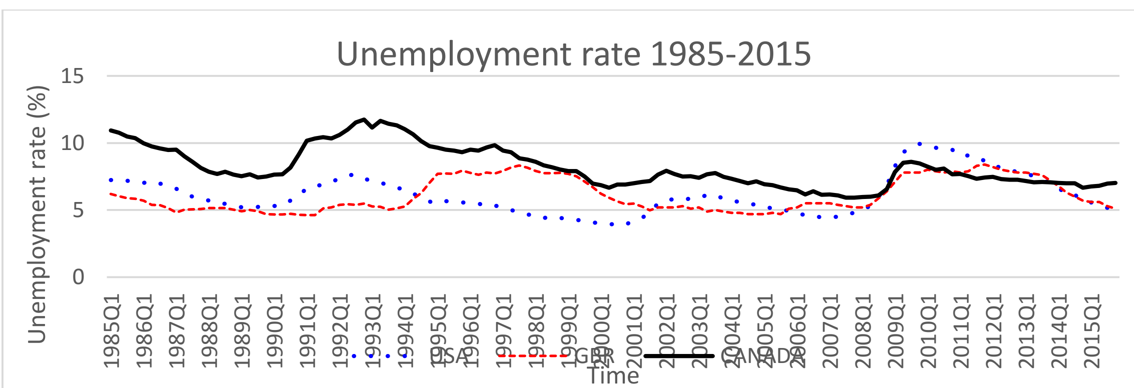
Consumer Price Index (CPI) is defined as the weighted average of consumer goods and services with respect to time. For identifying the periods of inflation and deflation, the CPI is the most frequently used statistic. Inflation has a few other indicators like Personal Consumption Expenditure (PCE), Wholesale Price Index (WPI), and Implicit Price Index (GDP Deflator). The rate of inflation is calculated by using CPI quarterly data and converted to percentage change. The plot of CPI for all the three countries is shown in the graph below.



Graph 2: Plot of CPI for USA, UK, and Canada for the period of 1985-2015

ii. Rate of Unemployment

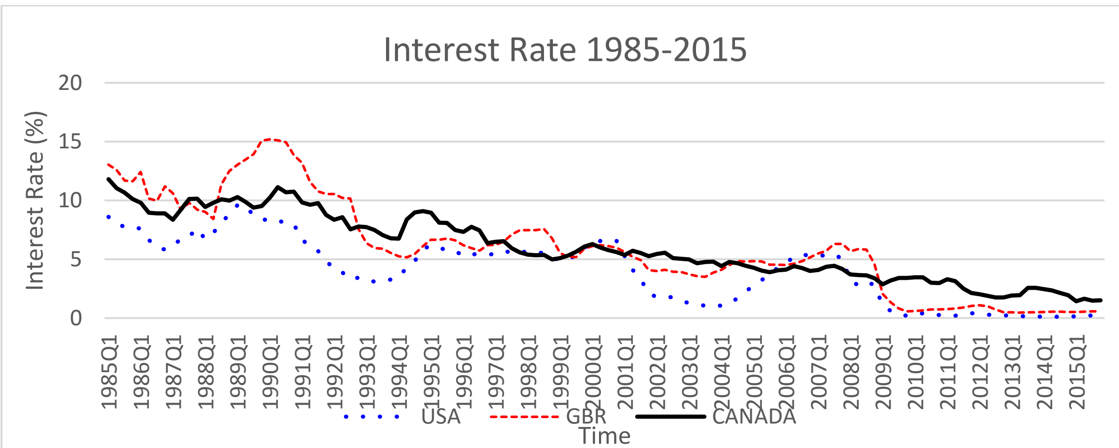
The unemployment rate is defined as the measure of prevalence of unemployment and is expressed as a percentage, calculated by dividing the number of unemployed individuals by all individuals in labor force. Quarterly data are downloaded for this study. The unemployment rate data of UK for the period of 1985(Q1) to 1999 (Q1) is collected from FRED and for the remaining period from OECD. The plot of unemployment rate for the US, UK, and Canada is shown in the graph below.



Graph 3: Plot of Unemployment Rate for USA, UK, and Canada for the period of 1985-2015

iii. Interest Rate

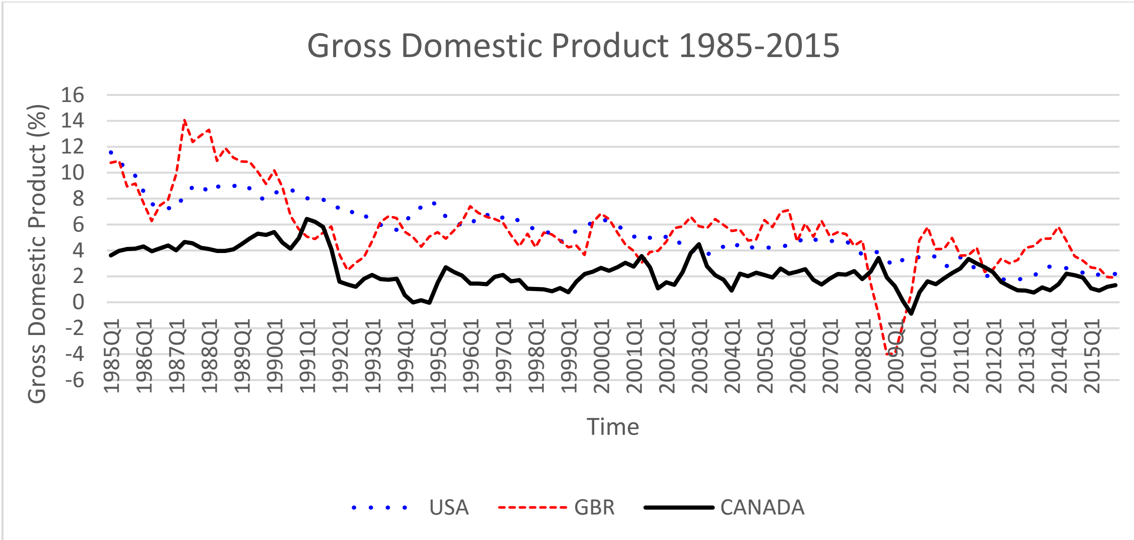
Interest rates (IR) are expressed either as rates charged while borrowing money or the rates paid on savings investments. For the purposes of this study we have considered Interest Rates (IR) that are charged while borrowing money i.e. the cost of funds. Quarterly data on the percentage change in short-term interest rate is used in this study. Short-term interest rates are the rates at which short term borrowings are affected between financial institutions or the rate which short-term government paper is issued or traded in the market. Below is a plot of interest rates for the US, UK, and Canada.



Graph 4: Plot Interest Rate for USA, UK, and Canada for the period of 1985-2015

iv. Gross Domestic Product

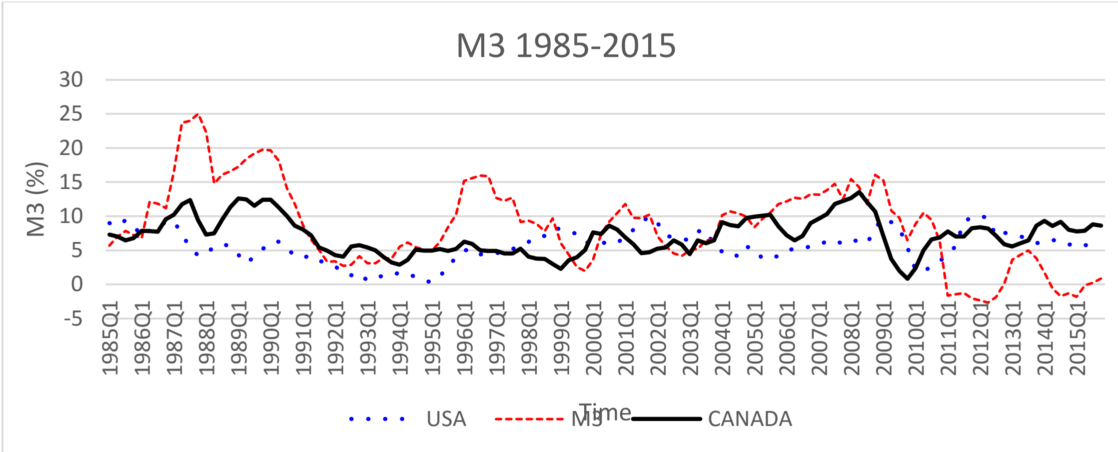
Gross domestic product (GDP) is defined as the monetary measure of goods and services produced within the boundaries of the country in specific time period. The data are quarterly data, seasonally adjusted and measured in percentage change from the previous quarter. The plot for GDP is shown in the graph below for the three countries.



Graph 5: Plot of GDP for USA, UK, and Canada for the period of 1985-2015

v. Money Supply (M3)

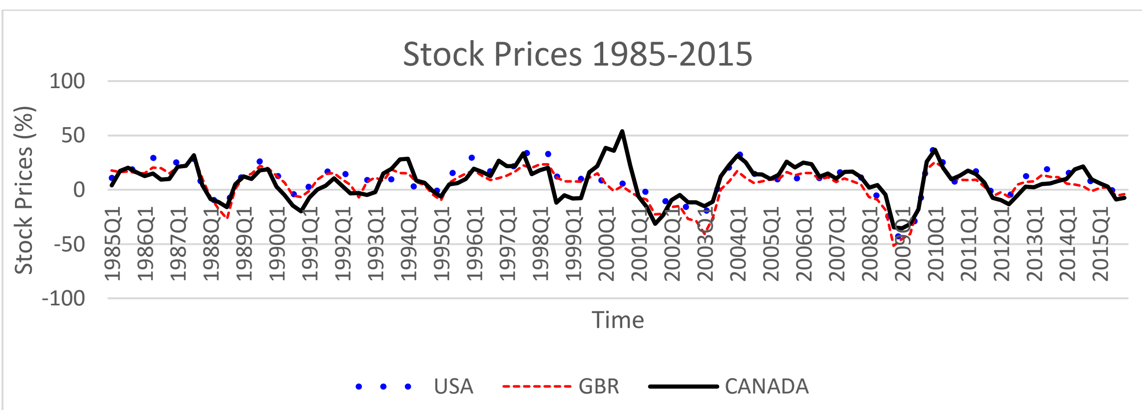
The money supply comprises safe assets that any household and businesses can hold. These are basically short term investments, which are being used to pay-off any immediate debts. Several widely used standard measures of money supply are M1, M2, and M3, and their exact classification varies from country to country. The money supply reflects the liquidity or spending ability that different types of money can have. M1 is considered to be most liquid form and it is also called narrow money. Examples of narrow money or M1 are traveler's cheques, cash or currency in the hands of the public, demand deposits, and various other deposits against which cheques can be written. It includes coins and notes in circulation and other equivalents that are easily convertible in to cash. M2 is comprised of short-time deposits in banks, money-market funds with maturity less than 24 hours, and M1. M3 consists of M2 plus money market funds with maturity more than 24 hours and long-term time deposits. I have plotted the graph for the US, UK, and Canada of broad money (M3), which is shown in the graph below.



Graph 6: Plot of M3 for USA, UK, and Canada for the period of 1985-2015

vi. Stock Price

The data for stock prices are calculated from the prices of common shares of the companies traded on national or foreign stock exchanges. They are determined by the closing daily values of the stock exchange for the monthly data. They are expressed as simple arithmetic averages of the daily data. The stock prices graph for the US, UK, and Canada are plotted below.



Graph 7: Plot of Stock Price for USA, UK, and Canada for the period of 1985-2015

One important reason to use the United States, the United Kingdom, and Canada is their standard measure of money supply. All the three countries follow the exact classification of M1, M2, and M3. M1 is the narrow money, M2 is the funds with the maturity period less than 24 hours, and M3 includes M1 and M2 along with the funds with maturity period more than 24 hours, therefore called broad money. Economic theory suggests that that money supply has a major impact on inflation and each country has its own classification for measure of money supply. A second reason is the large amount of trade between these three countries. The commercial and economic relations between these three countries are historically strong and mutually advantageous.

5.3 Data Statistics

Table 7, 8, and 9 (Appendix B) report the summary of descriptive statistics. It includes the exogenous and endogenous variables selected for study. A total of 124 quarterly observations have been examined and for each variable and then the following statistics is estimated. The maximum measures the upper bound and the minimum measures the lower bound of the variables for the chosen time span considered for the study. The average value of the series is represented by mean and standard deviation measures the dispersion of the series. CPI for the USA, UK, and Canada reports the mean of 2.705, 2.876, and 2.415 respectively and standard deviation value as 1.324, 1.829, and 1.430 respectively.

CHAPTER 6: RESULTS

6.1 United States of America

Table 1 reports the DF-GLS values for the USA. From the respective DF-GLS values of each variable we confirm that GDP, M3, and UR are each non-stationary. Since the DF-GLS values exceed the critical values (at the 5% significant level), we fail to reject the null hypothesis. The fit diagnostic graph 11 (Appendix A) confirms that these series show a trend of increase and then decrease. These series were converted to be stationary by taking first difference yielding dGDP, dM3, and dUR. DF-GLS values do not exceed the critical values (at 5% significant level) for CPI, IR, and SP, and each are stationary.

Table 1: Unit root test DF-GLS for USA

Variable	Type	Pr < DFGLS	Variance	Lags	Standard error	t Value	Root MSE
CPI	Single Mean	<.0001	0.5328	4	0.119	22.74	1.32494
	Trend	0.0055					
GDP	Single Mean	<.0001	0.1566	4	0.2043	26.85	2.27527
	Trend	0.1948					
IR	Single Mean	<.0001	0.9387	3	0.2492	16.17	2.77445
	Trend	0.0099					
SP	Single Mean	<.0001	455.2449	5	1.3498	6.81	15.03055
	Trend	0.0006					
UR	Single Mean	<.0001	0.9592	3	0.1313	46.57	1.46255
	Trend	0.0717					
M3	Single Mean	<.0001	1.6991	5	0.211	26.66	2.34948
	Trend	0.3448					

next I applied the Johansen test for cointegration, based on maximum likelihood estimation procedure and the maximum lag value tested was 4. The appropriate lag order (P) is recommended on the basis of SBC (Schwarz Bayesian Criterion) value is P= 1. Cointegration test uses rank test using trace value and critical value (5% significant level). Table 2 reports the results of the Johansen test. This confirms the rank of cointegration order as 5, which suggests a strong relation among the variables and they move together in long run. Result confirms that UR and CPI move together in long run and support the economic theory of the Phillips curve.

Table 2: Cointegration rank test using trace test - USA						
H0:Rank=r	H1:Rank>r	Eigenvalue	Trace	5% Critical value	Drift in ECM	Drift in process
0	0	0.688	305.8221	82.61	NOINT	Constant
1	1	0.469	163.7247	59.24		
2	2	0.335	86.5004	39.71		
3	3	0.1681	36.7286	24.08		
4	4	0.0908	14.2697	12.21		
5	5	0.0215	2.6573	4.14		

The application of the vector error correction model (VECM) helps to examine the long and short- run relationship between the variables. The VECM equation of CPI is:

$$CPI_t = - 0.1469CPI_{t-1} + 0.2223dGDP_{t-1} + 0.0698IR_{t-1} - 0.04093dM3_{t-1}$$

$$- 0.5019dUR_{t-1} + 0.0028SP_{t-1} + \varepsilon_t,$$

where

ε_t = error term;

d = the first difference of series;

t-1 = a lag of one period is used.

The value of VECM gives the extent of correction in the next time period. The negative values of the coefficients of M3 and UR of the USA indicate that M3 and UR have negative impact on inflation rate of USA in long run. A positive unit change in money supply (M3) and unemployment rate (UR) causes a negative change in the rate of inflation of 0.041% and 0.502%, respectively. This means the rate of inflation decreases with the increase in M3, this contradicts the quantity theory of money but when rate of inflation decreases then unemployment rate increase, this is in accordance with the Phillips curve. The positive values of the coefficients of GDP, IR, and SP indicate that these variables have a direct relationship with rate of inflation as shown the VECM equation. A positive unit change in GDP, IR, and SP cause the CPI to increase by 0.222%, 0.069% and 0.003%, respectively.

Finally, I conducted IRF analysis on the estimated VAR model. The data set spanning 1985-2015 was divided into sub samples comprising data from 1985-2000 and 2001-2015 respectively. The IRF of these periods are displayed in graph 14 (Appendix A). We can see that for a 1% increase in unemployment rate, the CPI reduces by 0.6% points in 1985-2015 in the first quarter and also in 2001-2015 for the first quarter thus following the Phillips curve. In the period 1985-2000 for the first quarter CPI reduces marginally for a 1% increase in unemployment rate. For a unit increase in stock prices, the CPI increases marginally in 1985-2015 and 2001-2015 for the first quarter. During 1985-2000, CPI reduces marginally. For a 1% increase in GDP, the CPI increases by 0.25% in 1985-2015 period for the first quarter and by 0.4% in 1985-2000 for the first quarter. CPI reduces by 0.1% for a unit increase in GDP in 2001-2015 for the first quarter. For a unit impulse response in IR, CPI increases in all the periods by 0.08%, 0.1% and 0.125% in the first quarters for the periods 1985-2015, 1985-2000 and 2001-2015 respectively. We can also observe that for a unit shock response in M3, CPI decreases by 0.4% and by 0.35% for the first quarter in the periods 1985-2015 and 2001-2015 respectively. CPI increases by 0.07% during the first quarter for the period 1985-2000. All the impulse response function graphs eventually decay to zero by the 12^{th} quarter. IRF graph confirms the relation between UR and CPI is negative and consistent with samples and sub sample. Therefore, result is consistent with the Phillips curve and Lucas critique. IRF graph also shows consistent result for GDP and IR thereby, confirming that they follow Lucas critique and consistent along country. However, SP and M3 results vary for sub samples and confirm to be inconsistent with Lucas critique and inconsistent along country. Moreover, IRF graph shows the negative relation with CPI for the sample (1985-2015) and sub sample (2001-2015) period.

6.2 Great Britain

Table 3 reports the DF-GLS values for Great Britain. From the table we conclude that CPI, GDP, M3, and UR are each non-stationary. Since the DF-GLS values for the following non-stationary variables exceed the critical value (5% significant level), we fail to reject the null hypothesis. Fit diagnostic graph 12 (Appendix A) confirms the same. These series were converted in to stationary by taking first difference yielding (*dCPI, dGDP, dM3, dUR, and dSP*). Series of IR and SP in table report the critical value (at 5 % significant level) is greater than DF-GLS value; we reject the null hypothesis and conclude each stationary.

Table 3: Unit root test DF-GLS for GBR							
Variables	Type	Pr < DFGLS	Variance	Lags	Standard error	t Value	Root MSE
CPI	Single Mean	<0.0001	0.8546	6	0.1643	17.51	1.82956
	Trend	0.0771					
GDP	Single Mean	<.0001	1.225	4	0.2655	20.95	2.956
	Trend	0.0647					
IR	Single Mean	<.0001	0.8042	5	0.3627	16.56	4.03908
	Trend	0.0178					
SP	Single Mean	<.0001	184.696	5	1.35	3.4	15.03249
	Trend	0.0071					
UR	Single Mean	<.0001	0.4528	3	0.1118	54.66	1.24491
	Trend	0.1584					
M3	Single Mean	<0.0001	11.5468	5	0.5512	15.64	6.13744
		0.1476					

Once all the variables became stationary, I conducted the Johansen cointegration trace test. The maximum lag value tested in this case is 4. On the basis of the SBC value I selected the appropriate lag order *(P = 1)*. Table 4 shows the cointegration results, which gives a clear picture of the cointegration rank, which is 5. The trace value is less than the 5% critical value; therefore reject the null hypothesis. This confirms that variables are cointegrated and move with each other in long run. Result confirms that UR and CPI move together in long run and support the economic theory of the Phillips curve.

Table 4: Cointegration rank test using trace test - GBR						
H0:Rank=r	H1:Rank>r	Eigen value	Trace	5% Critical value	Drift in ECM	Drift in Process
0	0	0.5462	295.4483	82.61	NOINT	Constant
1	1	0.5033	199.0682	59.24		
2	2	0.3949	113.7	39.71		
3	3	0.2282	52.4083	24.08		
4	4	0.1307	20.8126	12.21		
5	5	0.0301	3.7269	4.14		

The next step was the application of VECM to examine the long and short run relationships between the endogenous and exogenous variables. The VECM equation of CPI for Great Britain is as follows:

$$dCPI_t = - 0.7815dCPI_{t-1} + 0.0879dGDP_{t-1} - 0.00274IR_{t-1} - 0.0191dM3_{t-1}$$

$- 0.0752dUR_{t-1} + 0.0005SP_{t-1} + \varepsilon_t,$

where

ε_t = error term;

d = the first difference of series;

t-1 = a lag of one period is used.

The negative values of the coefficients of interest rate, money supply and unemployment rate for Great Britain indicate that they have a negative impact on the consumer price index implying that short-term interest rate, money supply and unemployment rate have an inverse relationship with rate of inflation in the long run. Thus CPI reduces by 0.003 % 0.019% and 0.075% for a unit increase in interest rate, money supply and unemployment rate respectively. The relationship between inflation and unemployment rate is an inverse and is consistent with the Phillips curve. The positive values of the coefficients of gross domestic product and stock price indicate that they have a positive impact on consumer price index thus confirming their direct relationship with rate of inflation in the long run. The CPI increases by 0.088%, and 0.001% for a unit increase in the GDP and stock prices respectively. The coefficients are statistically significant.

Finally, I conducted an IRF analysis on the estimated VAR model. The data set spanning 1985-2015 was divided into sub samples comprising data from 1985-2000 and 2001-2015 respectively. The IRF of these periods are displayed in graph 15 (Appendix A). We can see that for a 1% increase in unemployment rate, the CPI decreases by 0.1% across all periods. For a unit impulse in stock prices, minimal changes are observed in CPI. For a 1% increase in GDP, the CPI increases by 0.9% for the period 1985-2015 for the first quarter. CPI increases by 0.14% for the period 1985-2000 for the first quarter and by 0.1% for the period 2001-2015 for the first quarter. An impulse in interest rate for the period 1985-2015 causes minor changes in CPI for the first quarter. For the first quarter in the 1985-2000 period CPI decreases by 0.02% while it increases by 0.045% for the first quarter during the 2001-2015 period. For a unit impulse response in M3, minor changes are seen in CPI across all time periods. All IRF's eventually decay to zero by the 12th quarter. IRF graphs for impulse in IR, M3, and SP shows inconsistency in result with samples and sub samples therefore inconsistent with Lucas critique. UR and GDP graphs confirm the result is consistent across country (1985-2015) and consistent with Lucas critique. Money supply shows negative relation with CPI and IRF graph confirms that it is inconsistent with quantity theory of money.

6.3 Canada

Table 5 reports the DF-GLS values for Canada. We can confirm that CPI, UR, and M3 are each non-stationary. Since the DF-GLS values exceed the critical values (at the 5% significant level), we fail to reject the null hypothesis. The fit diagnostic graph 13 (Appendix A) also helps us concur the same. GDP, IR, and SP are each stationary. I converted the non-stationary variables into stationary ones by taking their first differences yielding dCPI, dUR, and dM3.

Table 5: Unit root test DF-GLS for Canada							
Variables	Type	Pr < DFGLS	Variance	Lags	Standard error	t Value	Root MSE
	Single Mean	<0.0001					
CPI	Trend	0.2517	0.1974	4	0.1284	18.81	1.43022
	Single Mean	<.0001					
GDP	Trend	0.0057	0.3945	3	0.0609	9.75	0.67847
	Single Mean	<.0001					
IR	Trend	0.0144	0.1918	3	0.2523	23.62	2.80941
	Single Mean	<.0001					
SP	Trend	0.0124	778.11	8	1.4302	5.07	15.9265
	Single Mean	<.0001					
UR	Trend	0.1568	0.323	3	0.1349	60.67	1.50209
	Single Mean	<.0001					
M3	Trend	0.179	1.5591	4	0.2426	29.52	2.70192

Next I conducted the Johansen cointegration trace test to check the long run relations between the variables. Table 6 reports the results for the test. The trace test was conducted for various lag lengths with a maximum lag length of four. I selected the appropriate lag order on the basis of minimum SBC (Schwarz-Bayesian Information Criterion) values. Using these values we select the rank of cointegration and is 5 with lag order of 1. Thus we can conclude from the rank order that the variables are cointegrated and move together in long run. In other words although the variables are not stationary at levels, they closely move with each other in the long run.

Table 6: Cointegration rank test using trace test - Canada						
H0:Rank=r	H1:Rank>r	Eigen value	Trace	5% Critical value	Drift in ECM	Drift in process
0	0	0.5453	293.031	82.61	NOINT	Constant
1	1	0.491	196.87	59.24		
2	2	0.3913	114.483	39.71		
3	3	0.2401	53.915	24.08		
4	4	0.1195	20.4176	12.21		
5	5	0.0393	4.0173	4.14		

The next step was the application of VECM to examine the long and short-run relationships between the endogenous (CPI) and exogenous variables (GDP, IR, UR, M3, and SP). The VECM equation of CPI is as follows:

$$dCPI_t = -0.8214dCPI_{t-1} + 0.2241GDP_{t-1} - 0.0137IR_{t-1} + 0.1759dM3_{t-1}$$
$$+ 0.3717dUR_{t-1} - 0.0059SP_{t-1} + \varepsilon_t,$$

where

ε_t = error term;

d = the first difference of series;

t-1 = a lag of one period is used.

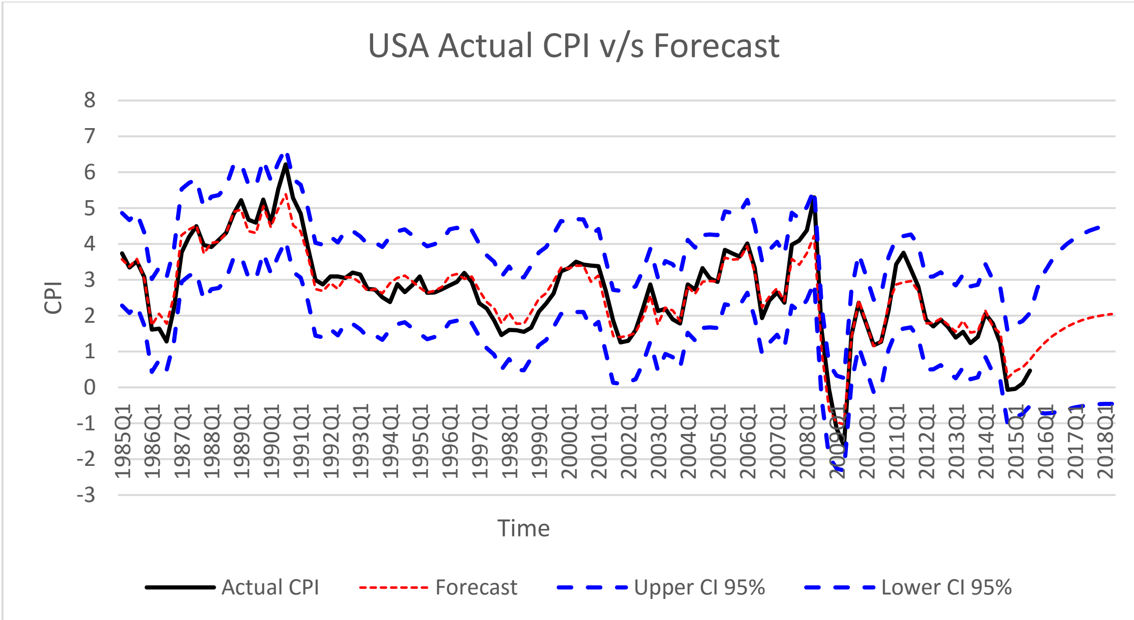
The negative values of the coefficients on the interest rate and the stock prices for Canada indicate that they have an inverse relationship with rate of inflation in the long run. Thus CPI reduces by 0.014% and 0.006% for a unit increases in the interest rates and the stock prices respectively. The positive values of the coefficients of GDP, money supply and unemployment rate indicate that they have a direct relationship with the rate of inflation in the long run. The CPI increases by 0.224%, 0.176%, and 0.372% for a unit increase in the gross domestic product, money supply and the unemployment rate respectively. Coefficient for M3 is consistent with the quantity theory of money as the result confirms positive relation between M3 and CPI. VECM equation reports positive relation between CPI and UR and this is inconsistent with the Phillips curve.

The next step was the analysis of IRF for Canada. Graph 16 (Appendix A) reports IRF graphs. The data set spanning 1985-2015 was divided into sub samples comprising data from 1985 to 2000, and 2001 to 2015 respectively. It can be seen that an increase in unemployment rate by 1% leads to increase in CPI for all the periods, which is inconsistent with the Phillips curve. For a 1% increase in stock prices, CPI decreases in all the periods. For a 1% increase in gross domestic product, CPI increases in all periods with the highest increase of 0.36% in the first sub-sample for the first quarter. An increase in interest rates by 1% points leads to a very minor increase in CPI in all the periods. The maximum increase of 0.07% is observed in the period 2000-2015 for the first quarter. An increase in money supply by 1 % shows an increase in CPI by 0.002% for the period 2000-2015 for the first quarter. This is consistent with quantity theory of money. For the period 1985-2000, CPI increases by 0.3% for the first quarter before eventually decaying to zero. For the period 2001-2015, CPI increases by 0.01% for the first quarter and then reduces by 0.08% for the second quarter, before becoming zero. All the IRF graphs eventually decay to zero by the 12th quarter. IRF graphs reports inconsistent results between sample and sub sample for impulse in IR, M3, and UR hence inconsistent with Lucas critique. Result for IR, M3, and UR is inconsistent across country as per impulse response graph

CHAPTER 7: FORECAST

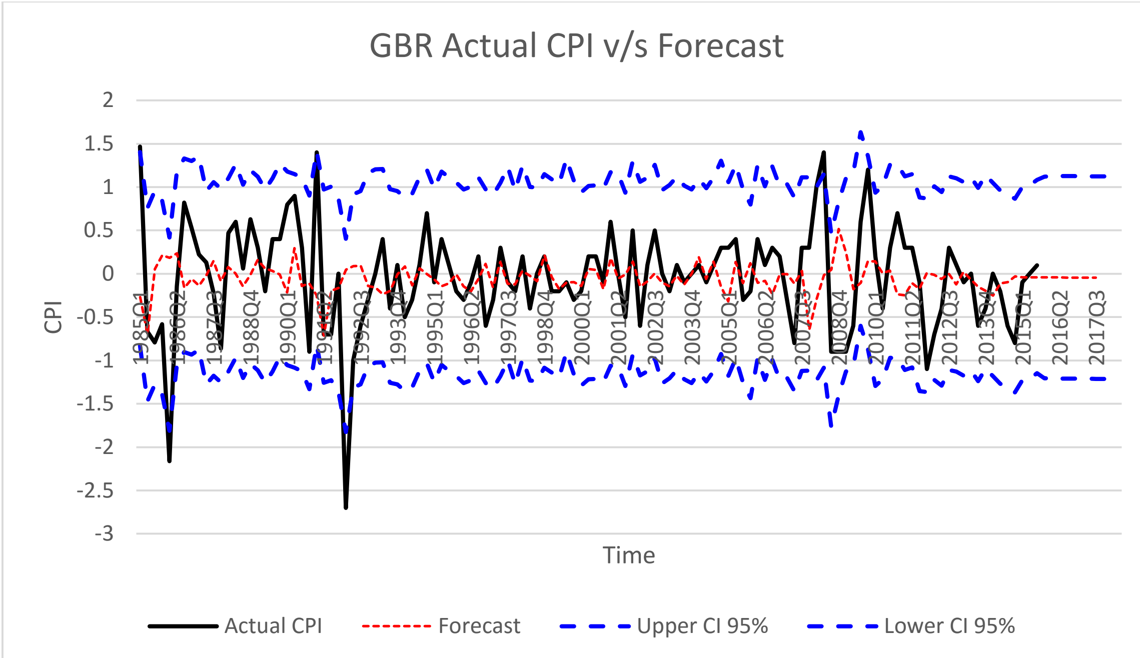
Graph 8, 9 and 10 shows forecast graph for the US, UK, and Canada respectively. The graph is plotted between the actual and forecasted values. Table 10, 11, and 12 (Appendix B) shows the forecast value for the US, UK, and Canada. The dashed line (upper CI and lower CI) in the graph shows 95% confidence interval with its upper and lower limits. The straight line (Actual CPI) indicates the actual values whereas dotted line (Forecast) shows the forecast values. The trend for the complete data set between the confidence limit is similar.

Below is the CPI forecast graph plotted for the USA. The actual values and the predicted values are close. USA forecasted values show an increasing trend. From 2016 (Q2) the forecast value keeps on increasing further. The inflation will increase in the third quarter of 2016 as this can be concluded from the graph. The RMSE for the USA is 0.071. The forecast values fall within the upper and lower bounds, which shows the accuracy of forecast. Table 8 (Appendix B) shows the quarterly forecasted value with the respective standard deviation.



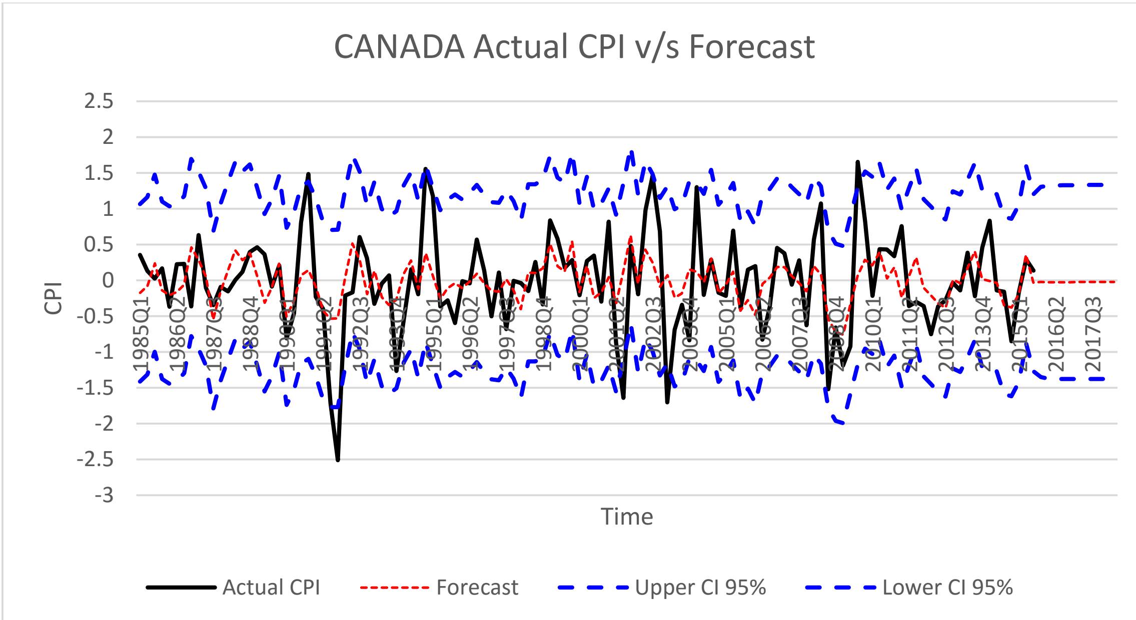
Graph 8: USA Actual CPI v/s Forecasted CPI

The plot of CPI forecast for the United Kingdom is given in the below graph. The forecast values fall within the upper and lower confidence interval. The forecast values are more or less stable. The forecast line shows a smooth line, which implies that there is less chance of increase in inflation as per the forecast. Table 9 (Appendix B) shows the values of forecasted CPI is decreasing but the change is minor. The RMSE for the UK is calculated to be 0.093.



Graph 9: Great Britain Actual CPI v/s Forecasted CPI

Forecast of CPI for Canada is plotted and shown in the graph below. After looking at the graph, analyzed the trend for CPI (forecast) is constant. Out of 12 forecast values (quarterly), the lowest forecast value reported is in 2016 (Q1) and the highest is in 2018 (Q4). The values with standard deviation are reported in Table 10 (Appendix B). The forecast values fall within the confidence limit. The calculated RMSE for Canada is 0. 106.



Graph 10: Canada Actual CPI v/s Forecasted CPI

From the calculated RMSE values of the US, UK, and Canada as 0.0710, 0.093, 0.106, respectively, we summarize that the forecast for USA shows the smallest RMSE value; hence the forecast is good compared to Canada forecast with highest RMSE value.

Comparing the forecast results for the US, UK, and Canada, we see that the forecast for the US is more tight than those of the other two countries. The reason is that the three economies diverge in size, per capita income, productivity, and net savings. The United States is very large compared to Canada and Great Britain and therefore the United States inflation rate is likely less influenced by variables omitted from the analysis such as the exchange rate and the price of oil.

The effect of macroeconomic variables on inflation is estimated separately for all the three countries. This research excludes any inter-country relationships among the macroeconomic variables. For example, a change in the GDP of the United States is not included in the model of inflation for Canada. The inflation forecasts might have shown different results if the study included other variables such as the exchange rate or the price of oil.

CHAPTER 8: CONCLUSION

The objective of this study is to analyze the effect of selected macroeconomic variables, unemployment rate, interest rate, GDP, money supply and stock prices, on inflation in three countries viz. the United States of America, the United Kingdom, and Canada. I also forecasted the percentage change in CPI for these countries. This empirical study performs the necessary analysis to answer whether the changes in the identified macroeconomic variables affect inflation rate. The research employs various tests like the unit root (DF-GLS) to test for stationarity of variables at the 5% significance level, taking the first differences to convert non-stationary data into stationary, checking for rank of cointegration using the Johansen test, application of VECM to determine the long and short run dynamics between the variables and CPI and finally an IRF analysis to check the effect of change in exogenous variables and its impact on CPI. Lucas critique implies that conclusion or result should not change with a change in sub sample. To test the robustness of result I have tested the sub samples in IRF. I also forecasted the percentage change in CPI for 12 quarters using a VAR model.

The empirical results obtained for the United States from Johansen cointegration test reports that there is long run relationship between exogenous and endogenous variables. This clearly implies that CPI is influenced by unemployment rate, GDP, interest rate, money supply, and stock prices in long run. The empirical results support economic theory for the sample period 1985-2015. The coefficient equation for CPI obtained from VECM is highly significant. VECM equation confirms that GDP, interest rate, and stock prices are directly related to CPI while money supply and unemployment rates are inversely related with CPI. The USA follows the Phillips curve and coefficients are consistent with economic theory. Impulse response results confirm that sub sample and sample results are same for the unemployment rate, interest rate and GDP. These variables show results are robust. Exogenous variables like M3 and SP shows different results for the sample and sub sample so can be confirmed that these variables are inconsistent with Lucas critique and quantity theory of money. From the IRF graph analyzed that response to shock is felt around twelve quarters, which suggests that CPI responds to shock after one lag. Inflation is forecasted which shows an increase over time and will be positive.

The empirical results obtained from the cointegration test for the United Kingdom reports the strong relationship between the exogenous and endogenous variables. The important conclusion can be drawn that CPI is influenced by unemployment rate, interest rate, GDP, money supply, and stock prices in long run. The empirical results support economic theory for the sample period 1985-2015. The VECM equation reports that GDP and stock prices are positively related to CPI whereas interest rate, unemployment rate and money supply are negatively related with CPI. The United Kingdom follows the Phillips curve. The IRF graph shows the consistent result for UR and GDP for sub samples and consistent with Lucas critique. These variables show results are robust. IR, M3, and SP show minor change hence inconsistent with Lucas critique. Impulse in M3 result confirms the inconsistent behavior with quantity theory of money. Inflation is forecasted and shows slight decrease over time and remain negative.

The results obtained from cointegration test for Canada shows strong relationship between the exogenous variables and CPI, consistent with economic theory. The VECM equation for CPI reports GDP, money supply and unemployment rate are positively related with CPI whereas interest rate and stock prices are negatively related with CPI. Results for Canada follows the Phillips curve and is consistent with economic theory. The IRF graph shows consistent result between sub samples for GDP and SP hence consistent with Lucas critique. These variables show results are robust. UR, IR, and M3 are inconsistent with Lucas critique. Impulse in GDP and M3 results confirm that they are in accordance with economic theory and consistent with quantity theory. Inflation is forecasted to increase and decrease slightly with time although it will still be negative.

On the basis of analysis of empirical results obtained from various research methodologies and forecast values, following policy recommendations can be drawn. The United States of America, the United Kingdom, and Canada results are consistent with the Phillips curve therefore, decision makers in those countries can utilize the Phillips curve to influence inflation. The US inflation forecast seems to be in the desired range and hence minor tweaking is all that is required. Governments should try to improve GDP growth by implementing favorable fiscal policies. In order to increase CPI in the United Kingdom, money supply and interest rates can be reduced as they are negatively related with CPI. To increase CPI in Canada, money supply can be increased as it is positively related with CPI while interest rates can be reduced. Governments should also try to reduce the unemployment rate by undertaking reforms. The government should try to reduce the unemployment level to the natural level of unemployment. Change in money supply and interest rate can done by the central bank of a country. Money supply can be increased or decreased if the central bank purchases or sell bonds. The central bank can also alter the reserve requirements and change the discount rate for the purpose. Interest rates can be varied directly by the central bank.

8.1 Further Research

Exchange rates and oil prices are often considered to be important variables in determining inflation. These variables are excluded from this study because of their highly volatile nature and due to lack of consistent data, but might be considered for further study. The study can be expanded and modified by considering developing countries such as India, China, Brazil, or countries like Venezuela that have triple-digit inflation rate, or to study countries in Africa. Results might show large variations and this will help in analyzing the real problems and test the impact of macro variables, micro variables, economic theories, and many more basis for comparison. Thus, there is scope of further study for the countries, which exhibit very high inflation, very low inflation, or moderate inflation. This study is based on the data sample from 1985-2015. The data can be sub-divided to study the effect of post and pre great recession effects in detail. This can help in analyzing any structural break, relationship between the variables over time and economies, which evolve over time. This will improve the effectiveness of decision-making.

REFERENCES

Atkeson, Andrew and Lee E. Ohanian. 2001. "Are Phillips Curve Useful for Forecasting Inflation?," *Federal Reserve Bank of Minneapolis Quarterly Review*, Vol.25, pages 2-11.

Silvia, John E., Azhar Iqbal, Sarah W. House and Erik Nelson. 2014. "The Great Inflation: Once in a Lifetime?," Wells Fargo Securities Economics Group Special Commentary, pages 12-32.

Ball, Laurence and Sandeep Mazumder. 2011. "Inflation Dynamics and the Great Recession," pages 32-40.

Batura, N. 2008. "Understanding Recent Trends in Inflation," *Economic & Political Weekly, Vol. XLIII, No. 24,* pages 108-111.

Baum, Christopher F. 2013. "VAR, SVAR And VECM Models," pages 5-16.

Dwyer, Gerald P. and R. W. Hafer. 1999. "Are Money Growth and Inflation Still Related?," *Federal Reserve Bank of Atlanta, issue Q2,* pages 2-10.

Eichenbaum, M. 1992. "Interpreting the Macroeconomic Time Series Facts the Elects of Monetary Policy by Christopher Sims European Economic Review," pages 1001-1011.

Enders, Walter. 1995. "Applied Econometric Time Series," 2nd edition.

Engle, Robert F. and C. W. J., Granger. 1987. "Co-integration and Error Correction: Representation, Estimation, and Testing," pages 251-276.

Erbaykal, E. and Okuyan H. 2008. "Does Inflation Depress Economic Growth? Evidence from Turkey," *International Research Journal of Finance and Economics, Vol. 13, No. 17,* pages 2-8.

Ghosh, A. and S. Phillips. 1998. "Warning: Inflation may be Harmful to your Growth," *IMF working Papers Vol. 45, No.4*, pages 3-23.

Gujarati, Damodar N. and Porter, Dawn C. 2008. "Basic Econometrics," 5th edition, McGraw Hill.

Hillinger, Claude, Bernd Süssmuth and Marco Sunder. 2012. "The Quantity Theory of Money and Friedmanian Monetary Policy: An Empirical Investigation," pages 1-19.

Kasidi, Faraji and Kenani Mwakanemela. 2013. "Impact Of Inflation On Economic Growth: A Case Study Of Tanzania," pages 2-20.

Kunst, Robert. 2010. “Applied Times Series Analysis, Estimating the US Phillips Curve,” pages 2-9.

Mahmood, Yasar, Rabia Bokhari and Aslam Muhammad. 2013. “Trade-Off Between Inflation, Interest and Unemployment Rate of Pakistan: a Cointegration Analysis,” pages 2-9.

Mamo, Fikirte Tsegaye. 2012. “Economic Growth and Inflation,” pages 630-631.

Mankiw, Gregory N. 2001. “U.S. Monetary Policy During the 1990s,” *NBER Working Paper 8471,* pages 4-25.

Meltzer, Allan H. 2005. “Origins of the Great Inflation,” *Federal Reserve Bank of St. Louis Review, March/April 2005, 87(2, Part2),* pages 145-175.

Murphy, Robert G. 2013. “Explaining Inflation in the Aftermath of the Great Recession,” pages 1-25.

Òscar, Jordà. 2004. “Estimation and Inference of Impulse Responses by Local Projections,” pages 5-17.

Patnaik, Anuradha. 2010. “Study of Inflation in India: A Cointegrated Vector Autoregression Approach,” pages 3-12.

Potscher, B. M. 1991. “Effects of Model Selection on Inference Econometric Theory,” pages 63-185.

Russell, Bill and Anindya Banerjee. 2007. “The Long-run Phillips Curve and Nonstationary Inflation,” *Journal of Macroeconomics, Vol.30,* pages 1792-1815.

Sidrauski, M. 1967. “Rational Choice and Patterns of Growth in a Monetary Economy,” *American Economic Review 57(2),* pages 534-544.

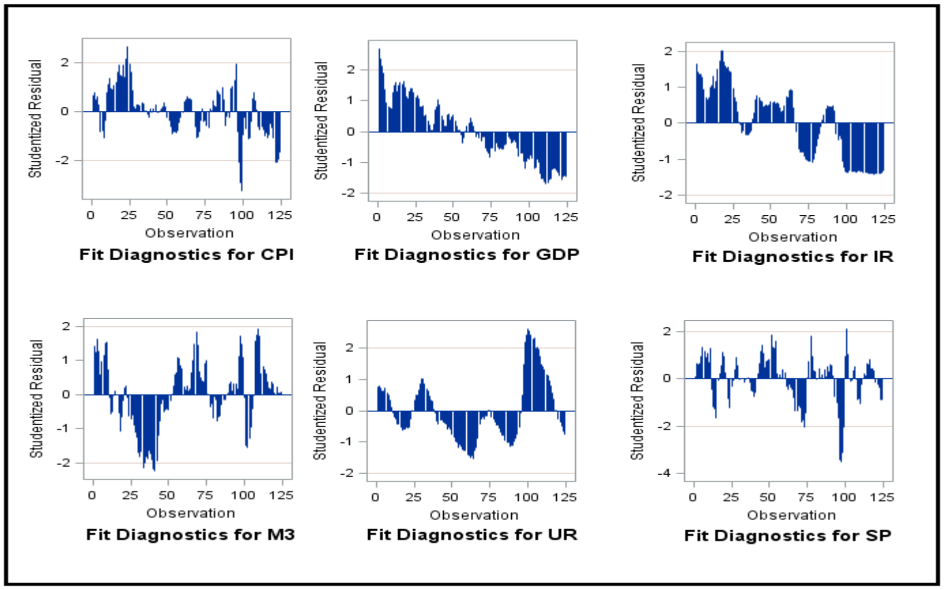
Silvia, John E., Azhar Iqbal, Sam Bullard, Sarah Watt and Kaylyn Swankoski. 2014. “Economic and Business Forecasting”.

Stock, James and Mark Watson. 1999. “Forecasting Inflation”, *Journal of Monetary Economics, Vol.44 (2),* pages 293-335.

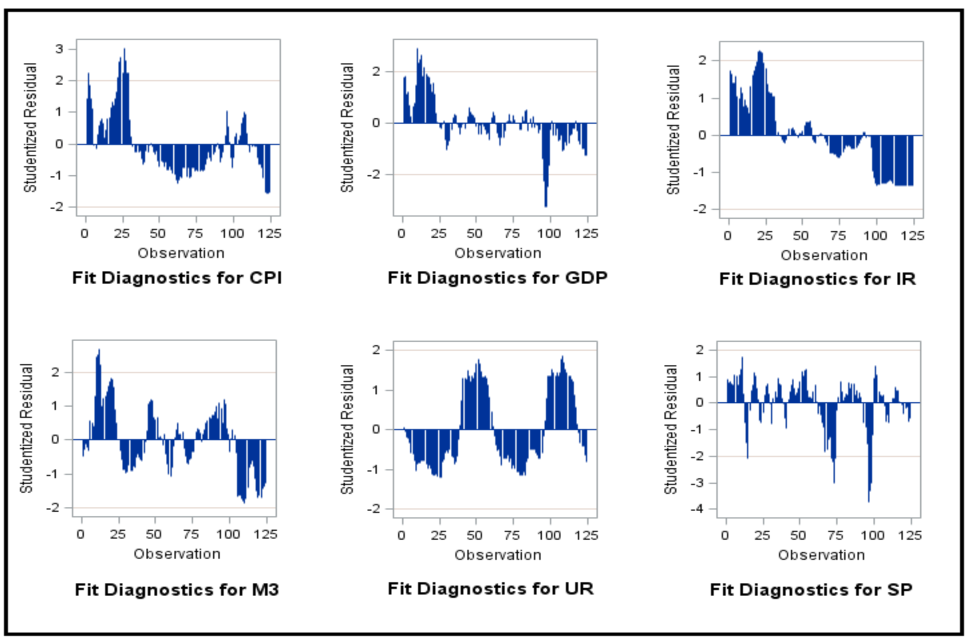
Stock, James and Mark Watson. 2001. “Vector Autoregressions,” *Journal of Economic Perspectives, Vol.15, No.4, fall 2001*, pages 101-115.

Stock, James and Watson, Mark. 2006. “Introduction to Econometrics,” 2nd edition, Pearson Education.

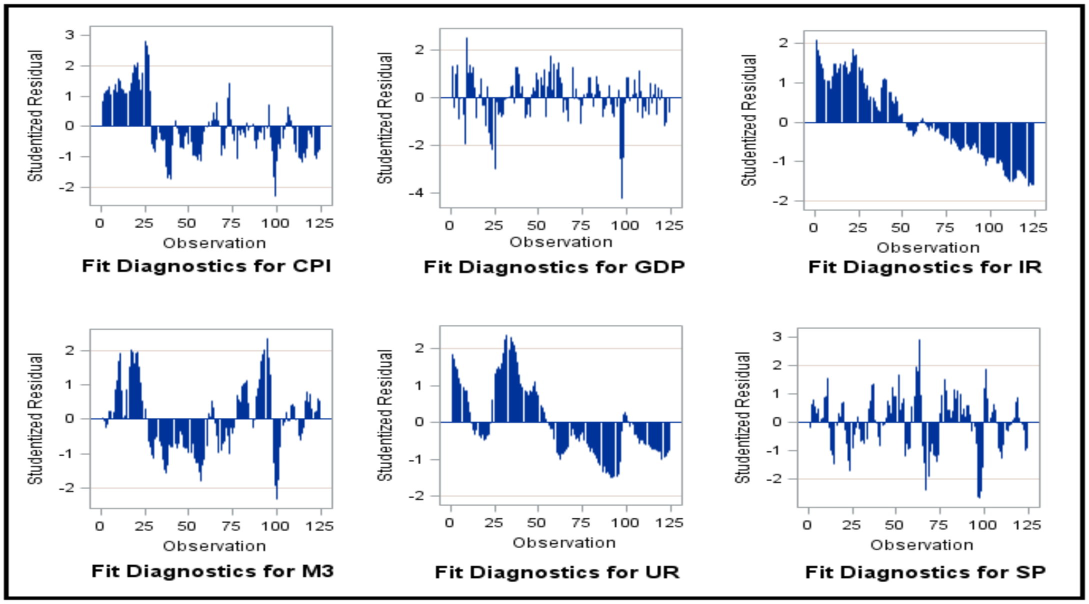
APPENDIX A: LIST OF GRAPHS



Graph 11: Fit diagnostic graph for USA



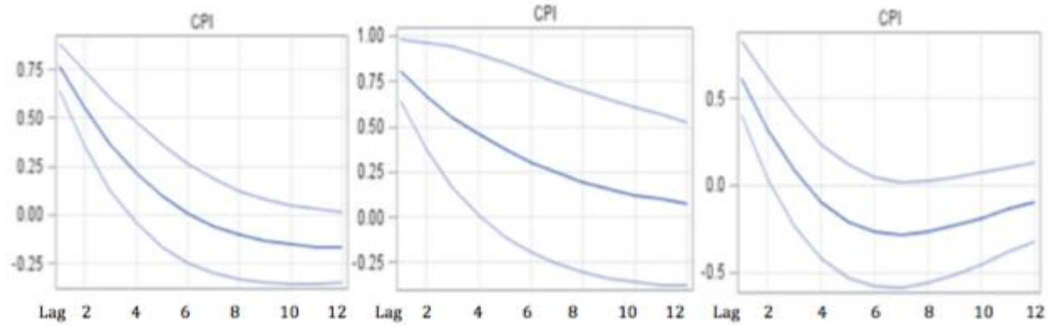
Graph 12: Fit diagnostic graph for UK



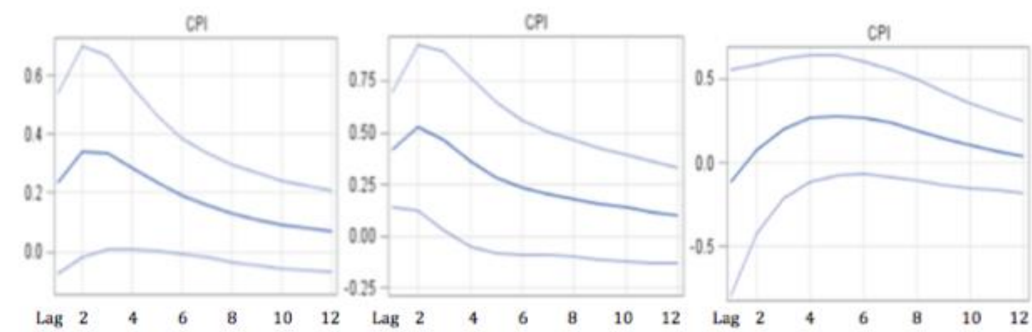
Graph 13: Fit diagnostic graph for Canada

USA

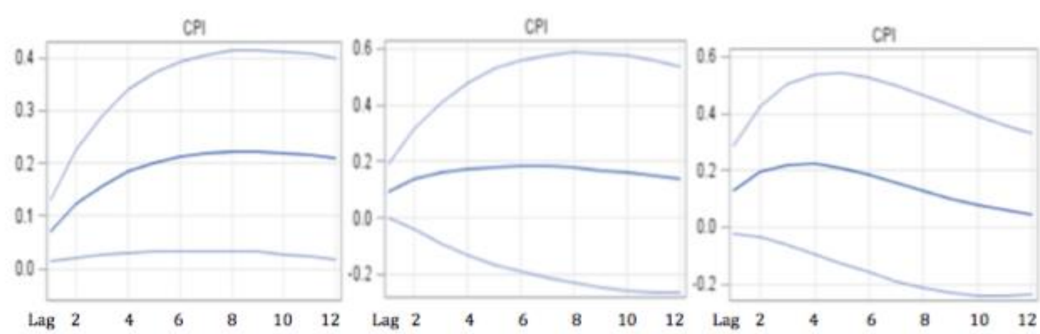
(1985-2015) (1985-2000) (2001-2015)



Response to impulse in dCPI

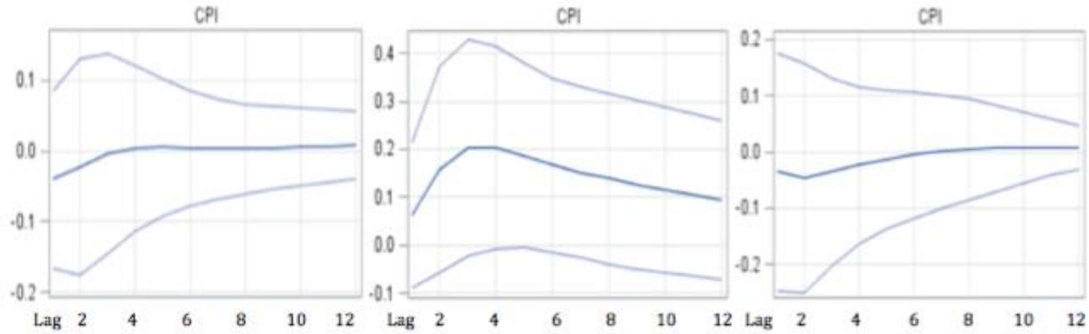


Response to impulse in dGDP

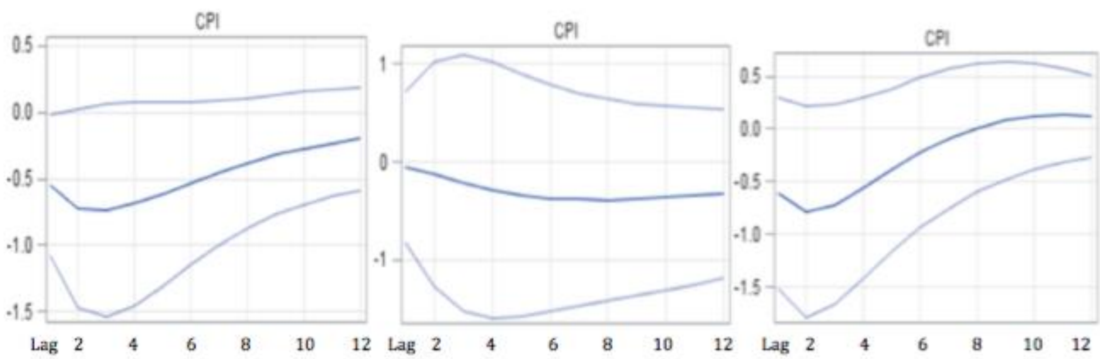


Response to impulse in IR

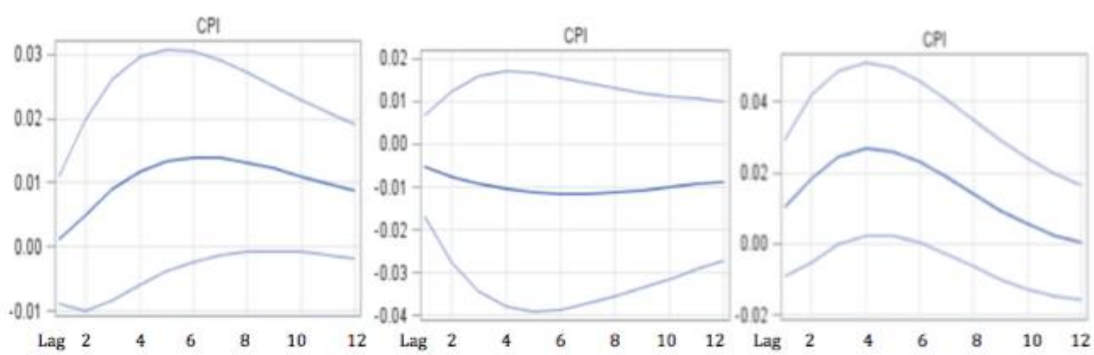
(1985-2015) (1985-2000) (2001-2015)



Response to impulse in dM3



Response to impulse in dUR

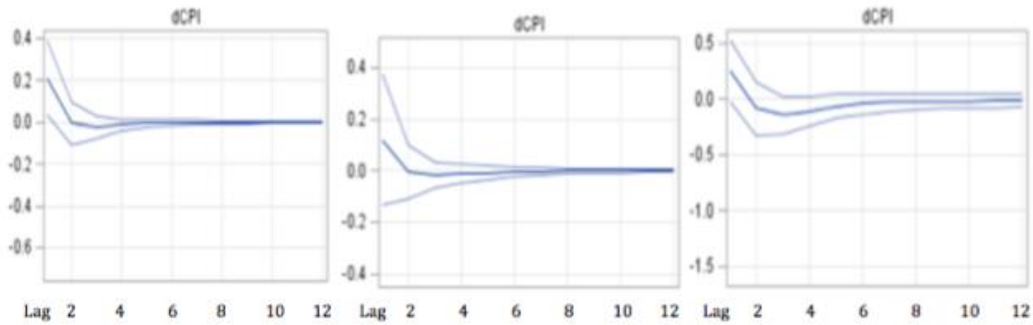


Response to impulse in SP

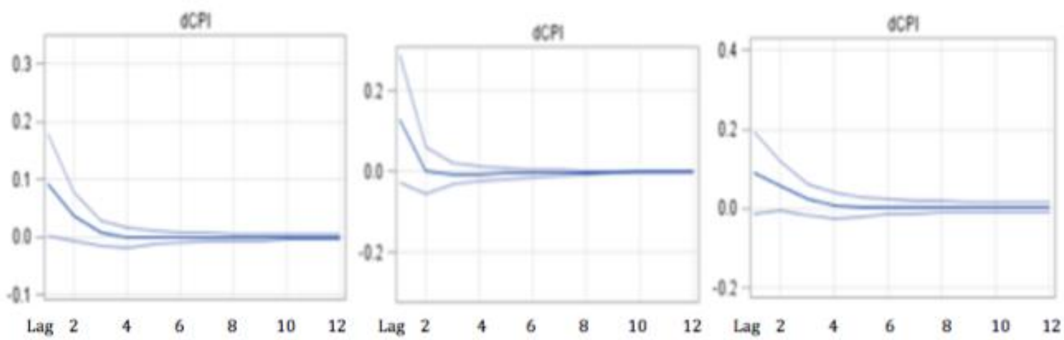
Graph 14: Impulse response graph for USA

UK

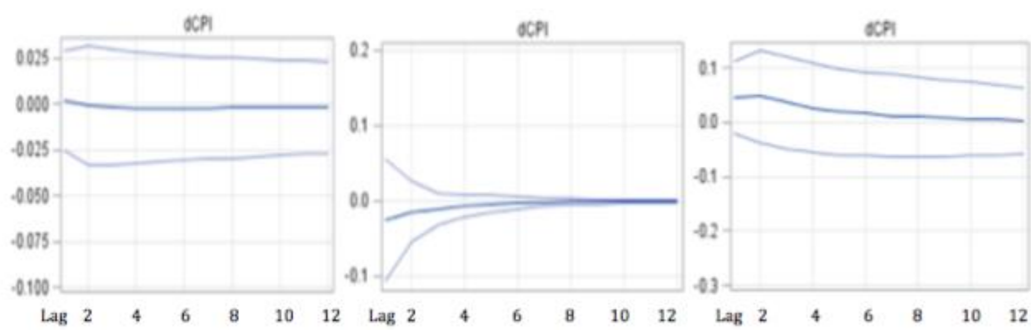
(1985-2015) (1985-2000) (2001-2015)



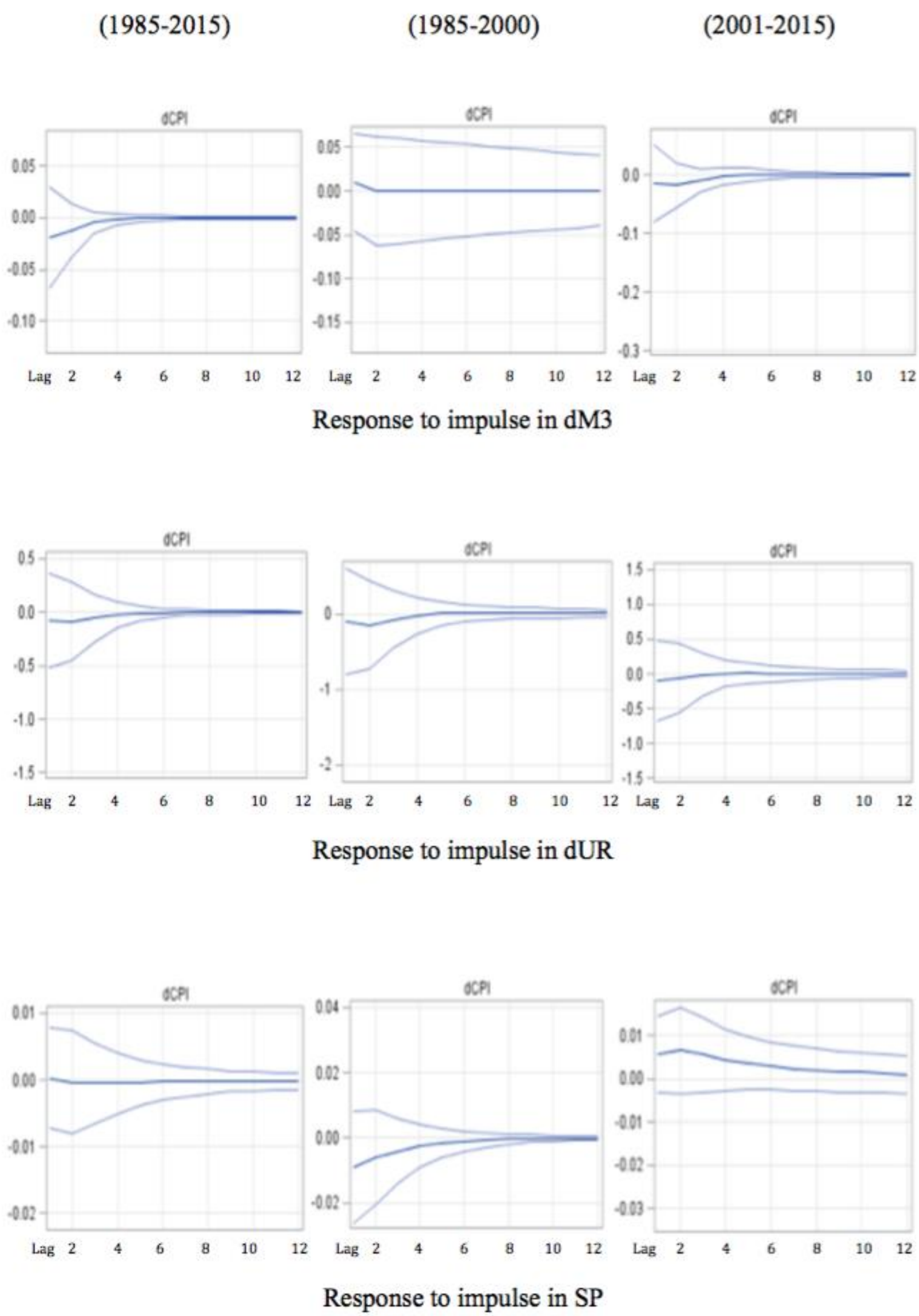
Response to impulse in dCPI



Response to impulse in dGDP



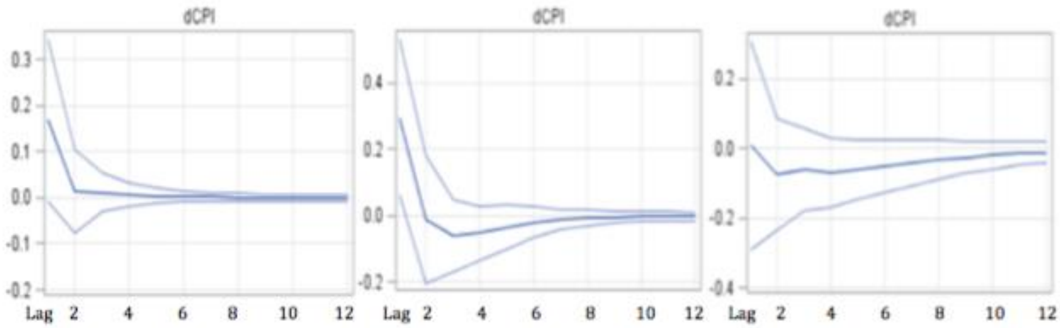
Response to impulse in IR



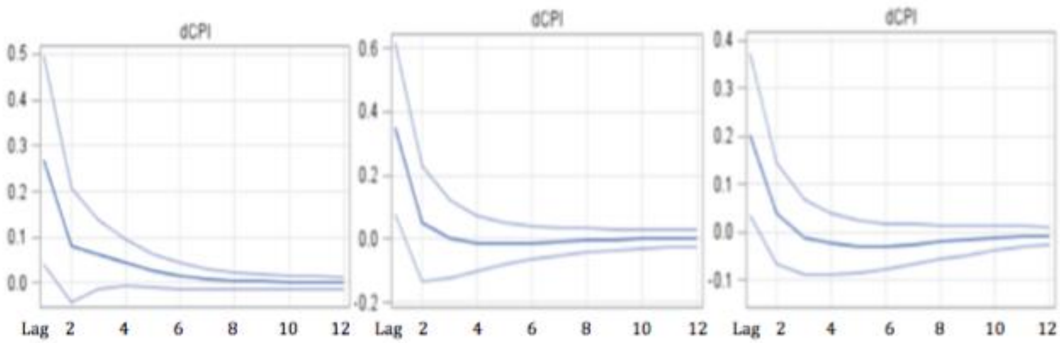
Graph 15: Impulse response graph for UK

Canada

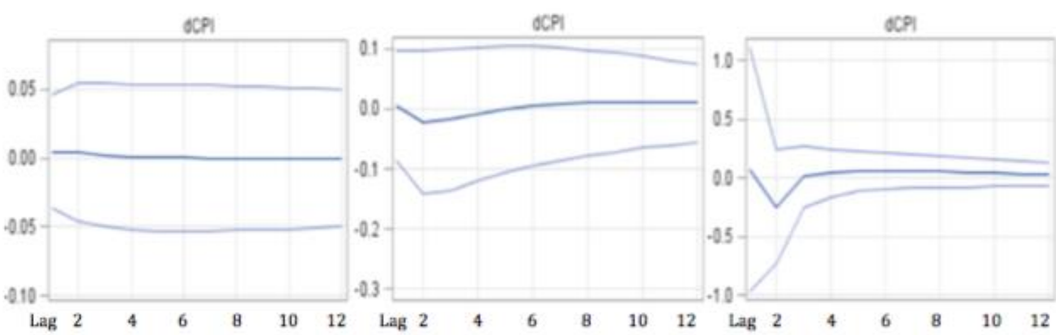
(1985-2015) (1985-2000) (2001-2015)



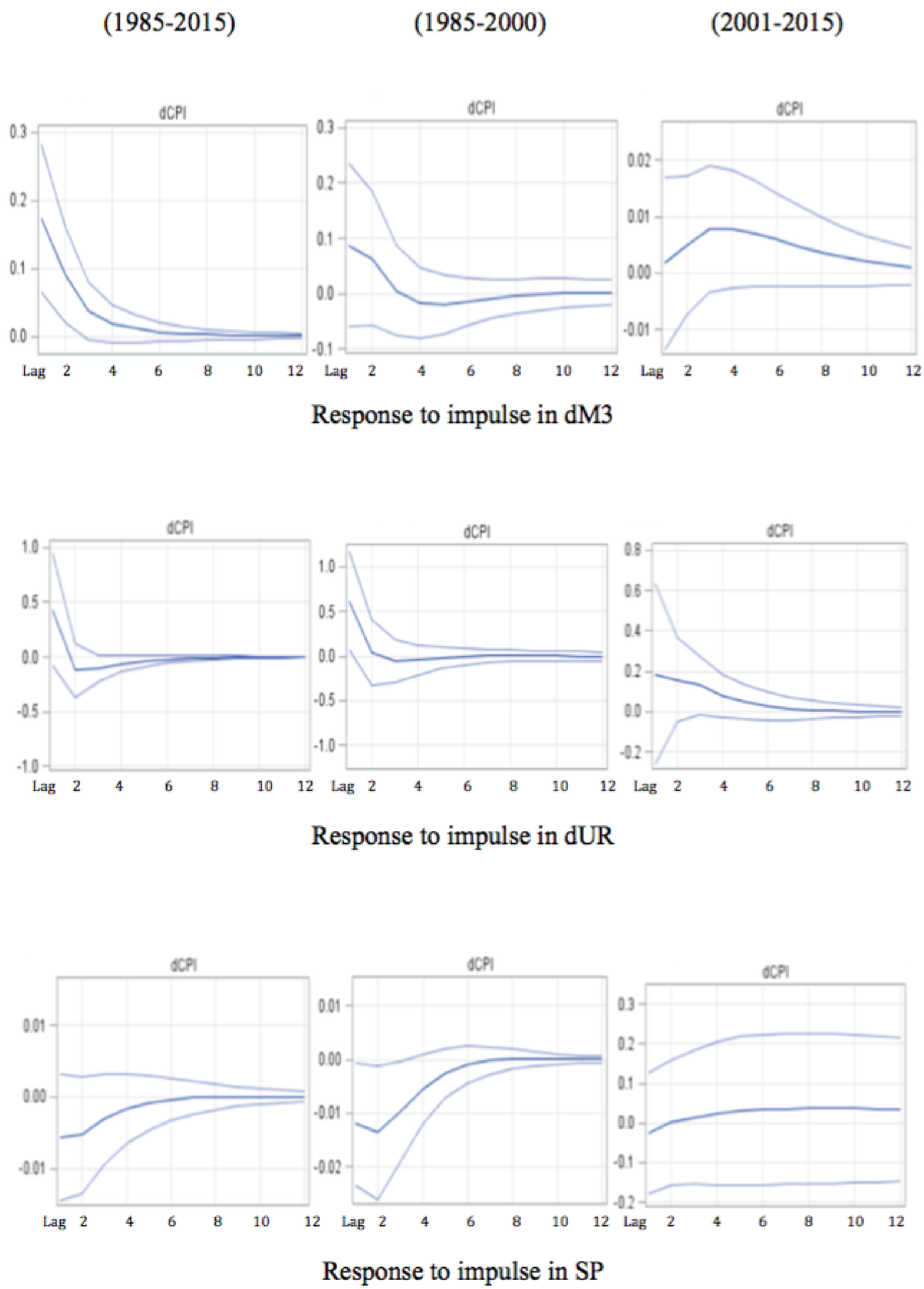
Response to Impulse in dCPI



Response to impulse in dGDP



Response to impulse in IR



Graph 16: Impulse response graph for Canada

APPENDIX B: LIST OF TABLES

Table 7: Data statistics for USA

Variable	No. of observations	Mean	Standard deviation	Minimum	Maximum
CPI	124	2.705	1.325	-1.623	6.224
GDP	124	5.487	2.275	1.643	11.583
IR	124	4.028	2.774	0.113	9.600
SP	124	9.191	15.031	-43.360	41.074
UR	124	6.116	1.463	3.900	9.933
M3	124	5.626	2.349	0.356	10.139

Table 8: Data statistics for UK

Variable	No. of observations	Mean	Standard deviation	Minimum	Maximum
CPI	124	2.876	1.830	0.001	8.400
GDP	124	5.562	2.956	-3.994	14.090
IR	124	6.007	4.039	0.485	15.186
SP	124	4.588	15.032	-51.582	30.577
UR	124	6.111	1.245	4.618	8.400
M3	124	8.621	6.137	-2.653	25.024

Table 9: Data statistics for Canada

Variable	No. of Observations	Mean	Standard deviation	Minimum	Maximum
CPI	124	2.415	1.430	-0.864	6.439
GDP	124	0.594	0.678	-2.285	2.316
IR	124	5.959	2.809	1.442	11.807
SP	124	7.249	15.927	-35.555	53.787
UR	124	8.184	1.502	5.933	11.733
M3	124	7.163	2.702	0.848	13.531

Table 10: Forecast table for USA

Time period	Forecast	Standard deviation	Lower CI	Upper CI
2016 Q1	0.778	0.660	-0.516	2.072
2016 Q2	1.037	0.880	-0.688	2.762
2016 Q3	1.252	1.011	-0.731	3.234
2016 Q4	1.429	1.092	-0.711	3.569
2017 Q1	1.575	1.143	-0.665	3.816
2017 Q2	1.697	1.178	-0.611	4.005
2017 Q3	1.796	1.203	-0.562	4.154
2017 Q4	1.875	1.223	-0.521	4.272
2018 Q1	1.938	1.239	-0.491	4.367
2018 Q2	1.986	1.254	-0.471	4.443
2018 Q3	2.021	1.266	-0.460	4.503
2018 Q4	2.047	1.277	-0.456	4.550

Table 11: Forecast table for UK

Time period	Forecast	Standard deviation	Lower CI	Upper CI
2016 Q1	-0.032	0.569	-1.148	1.084
2016 Q2	-0.043	0.594	-1.207	1.121
2016 Q3	-0.040	0.595	-1.208	1.127
2016 Q4	-0.040	0.596	-1.208	1.128
2017 Q1	-0.041	0.596	-1.209	1.127
2017 Q2	-0.042	0.596	-1.210	1.126
2017 Q3	-0.043	0.596	-1.211	1.125
2017 Q4	-0.043	0.596	-1.211	1.125
2018 Q1	-0.043	0.596	-1.211	1.125
2018 Q2	-0.044	0.596	-1.212	1.125
2018 Q3	-0.044	0.596	-1.212	1.124
2018 Q4	-0.044	0.596	-1.212	1.124

Table 12: Forecast table for Canada

Time period	Forecast	Standard deviation	Lower CI	Upper CI
2016 Q1	-0.033	0.631	-1.271	1.205
2016 Q2	-0.022	0.678	-1.351	1.308
2016 Q3	-0.024	0.687	-1.371	1.322
2016 Q4	-0.026	0.690	-1.378	1.325
2017 Q1	-0.026	0.690	-1.379	1.327
2017 Q2	-0.025	0.691	-1.379	1.329
2017 Q3	-0.024	0.691	-1.378	1.330
2017 Q4	-0.023	0.691	-1.378	1.331
2018 Q1	-0.022	0.691	-1.377	1.332
2018 Q2	-0.022	0.691	-1.376	1.333
2018 Q3	-0.021	0.691	-1.376	1.333
2018 Q4	-0.021	0.691	-1.375	1.334