MACROECONOMIC DYNAMICS AND MONETARY POLICY IN A GLOBAL WORLD

Researcher

Shahzada Muhammad Naeem Nawaz.

Reg. No. 102-SE/PhD/S07

Supervisors

Prof. Dr. Asad Zaman

Prof. Dr. Ather Maqsood Ahmed

SCHOOL OF ECONOMICS
INTERNATIONAL INSTITUTE OF ISLAMIC ECONOMICS
INTERNATIONAL ISLAMIC UNIVERSITY, ISLAMABAD.

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Shahzada Muhammad Naeem Nawaz
Reg. No. 102-SE/PhD/S07

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Supervisor
Prof. Dr. Asad Zaman

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Co-supervisor
Prof. Dr. Ather Maqsood Ahmed

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Shahzada Muhammad Naeem Nawaz
Reg. No: 102-SE/PhD Eco/S07

Accepted by the International Institute of Islamic Economics, International Islamic University, Islamabad, as partial fulfillment of the requirements for the award of degree of PhD in Economics.

Supervisor:

Prof. Dr Asad Zaman
Vice Chancellor
PIDE, Islamabad

Co-Supervisor:

Prof. Dr. Ather Maqsood Ahmed
NBS, NUST, Islamabad

Internal Examiner:

Dr. Arshad Ali Bhatti
Assistant Professor, IIIE,
International Islamic University, Islamabad

External Examiner:

Prof. Dr. Eatzaz Ahmad
School of Economics
Quaid e Azam University, Islamabad

External Examiner:

Prof. Dr. Atiya Yasmin Javid
PIDE, Islamabad

Head
International Institute of Islamic Economics
International Islamic University, Islamabad

Director General
International Institute of Islamic Economics
International Islamic University, Islamabad

Date of Viva Voce: 2-3-2015

بسم الله الرحمن الرحيم

Dedicated to My Baba Jan

ABSTRACT

The New Keynesian (NK) models have advantage over the Real Business Cycle (RBC) models as they allow rigidities in the structure of the model, hence provide built-in mechanism to incorporate the structural shocks. There is hardly any study on Pakistan's economy which developed and estimated the model under the NK framework. The researcher intended to formulate and estimate closed and open economy NK models using robust econometric method (that provide consistent and efficient estimates like FIML). Purchasing Power Parity and Uncovered Interest Parity conditions are relaxed. On the empirical side, we investigate the macroeconomic dynamics in response to unanticipated monetary shock. The reaction of the monetary authority (the State Bank of Pakistan) in response to structural shocks has been assessed by exploring the role of forward looking expectations.

We estimate the structural parameters, the impulse response functions and the forecast error variance decomposition. Expectations of the economic agents are found to play prominent role in the prevailing market structure of the country. The State Bank of Pakistan (SBP) has been found to respond to shocks after a lag of one or more periods indicating time inconsistency problem which is due to discretionary monetary policy stance being adopted by the monetary authority. Interest rate channel is found to be important to control the dynamics of the economy in comparison to exchange rate channel. There is no indication of price puzzle but the exchange rate puzzle is evident. The exchange rate has significant positive impact on inflation. SBP has never exercised the interest rate rule during the period of investigation and left the policy at discretion. The results have shown the importance of expectations on the part of economic agents in determining macroeconomic dynamics of the economy. The expectations are mainly forward looking for closed and open economy models. Risk premium shock has permanent positive effect on macroeconomic aggregates in the long run. Variance decomposition identified cost push shock as the most important source of error variance in forecasting all the macroeconomic aggregates followed by fiscal and monetary shocks respectively.

The distorted beliefs of economic agents about the stance of monetary policy have pointed towards weak effectiveness of the monetary policy. The results suggest that the SBP would have to adopt an independent and transparent monetary policy by following some sort of Taylor-type rule.

Keywords: *New Keynesian Models, Real Business Cycle Models, Forward Looking Expectations, SVAR Model, Purchasing Power Parity, Uncovered Interest Parity, Interest Rate channel, Exchange Rate channel, Exchange Rate Puzzle, Price Puzzle, Unanticipated Monetary Shock*

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CHAPTER 1

INTRODUCTION

The macroeconomic models of the 1970s were heavily criticized due to lack of theoretical foundations.[1] This criticism ultimately resulted in emergence of more sophisticated models with structural basis of optimization behavior on the part of economic agents in New Classical framework and named as Real Business Cycle (RBC) models. However, these models were deficient of more realistic assumptions like prevalence of monopolistic structure in goods and labor markets, price rigidities etc. On the other hand, models formulated under Keynesian framework were deficient of microeconomic foundations. However, followers of Keynesian perspective overcame this deficiency and provided the microeconomic foundations and the emergent models were named as Dynamic Stochastic General Equilibrium (DSGE) models under New Keynesian (NK) framework. Instead of focusing solely on technology shocks, these models relied on money non-neutrality in the short run along with other truly driving forces of the economy. Thus, the NK models of today have vastly improved the earlier versions as they include the role of expectations on the part of economic agents and require policy makers to incorporate the role of expectations to attain macroeconomic stability.

[1] See the extensive work of 1970s of such luminaries as Lucas, Barro, Sargant, and Wallace.

As a matter of fact, very little work has been done for Pakistan considering the NK models under rational expectations specifically addressing the econometric considerations appropriately that could be meaningful for the policy makers. This thesis tries to fill this gap in the literature. Thus the researcher aims to formulate and estimate closed and open economy NK models using robust econometric models.

This thesis focuses on the construction and estimation of close and open economy NK macroeconomic models to evaluate the conduct of monetary policy. The theoretical models developed here emphasizes the importance of intertemporal optimization behavior on the part of economic agents, the role of forward looking expectations and nominal price rigidities under monopolistically competitive market structure.

This thesis takes the lead over others as the rational expectations NK model has been estimated through maximum likelihood estimation procedure – a pioneering attempt in Pakistan. It is one of the only two applications of a New Keynesian Model-restricted SVAR estimating procedure. First attempt has recently been made by Leu (2011) for the Australian Economy. The identification scheme applied is unique in the sense that it has not been adopted earlier for modeling the Pakistan's economy. We have also attempted to implement the expectations type Taylor rule which provides an insight to the policy makers to target inflation and output gap to stabilize the economy.

NK models have a knack to relax counterfactual assumptions like holding of uncovered interest parity (UIP) and purchasing power parity (PPP) conditions. These models also provide the opportunity to include the forward looking behavior on the part of economic agents thus addressing the Lucas critique efficiently. Due to the advantages of NK models over the real business cycle models, these models become more popular.

Kocherlakota (2010) argued that DSGE models need to incorporate both price stickiness and financial market imperfections. There has now been growing consensus among the macroeconomists that due to non-incorporations of financial market imperfections, DSGE models failed to predict the financial crisis of 2007-10.

This dissertation is distinctive, to the earlier work done for the economy of Pakistan, on at least one point, that is, we allow financial friction in the model. Thus UIP, law of one price and PPP no longer hold. However, managing the unavailability of parameters is another common feature of the earlier work done for Pakistan. Ahmed et al. (2012) did their work on annual data.

Further, it is important to note that some of the common features of emerging economies, which differentiate them from developed economies, need to be embedded in the economic models for meaningful policy implications. These include; small open economies vulnerable to external shocks, weak financial sector and weak economic and political institutions. We tried to capture at least first two features.

Two equations system whose structure consists of expectations type IS equation and a NK Phillips curve has been developed. These two equations are complemented with the equation describing how monetary policy is conducted and the equation for relaxed UIP condition for open economy model.

Abstracting from rational expectations or assuming that the time-varying risk premium is negatively correlated with an expected depreciation in exchange rate may better explain the empirical facts (Froot and Thaler, 1990). McCallum (1994) explains the apparent empirical failure of UIP condition with the hypothesis that central banks systematically manage interest rate differentials to avoid frequent changes in the exchange rate. So, it seems preferable to use commoner approach to describe the relationship between interest rate and exchange rate. A rise in real interest rate will lead to appreciation in real exchange rate making domestic assets more attractive for the foreign as well as domestic investors. UIP condition is frequently rejected in empirical studies; an overview is provided by Froot and Thaler (1990) and McCallum (1994). In this context the exchange rate disconnect puzzle describes the more general, weak relation between the exchange rate and virtually any macroeconomic variable. The related forward premium puzzle states that the forward premium incorrectly predicts the direction of future changes in the exchange rate. It suggests rejection of uncovered interest rate parity (it holds only if individuals are risk neutral), as explained by Obstfeld and Rogoff (2000) and McCallum (1994).

Many emerging and developing economies have been switched from fixed exchange rate to a more independent monetary policy which has made open economy aspects to be more important in analyzing monetary policy. Considering the fact that PPP condition may not hold for the countries like Pakistan where the countries have never adopted the flexible exchange rate system in its true letter and spirit. It results in significant impact of exchange rate movements on the aggregate demand and the price level. Therefore, the role of exchange rate has been incorporated in the model. It further allows the researcher to investigate the significance of exchange rate on the macroeconomic dynamics.

We follow the expectations type Taylor rule which provides an insight to the policy makers to target inflation and output gap to stabilize the economy for the closed economy model. However, for the open economy model, the expectations type Taylor rule has been augmented by incorporating the expected changes in exchange rate in the reaction function.

This thesis has three main objectives to accomplish. First is to investigate the macroeconomic dynamics in response to unanticipated monetary shock in the presence of rigidities in the goods and labor markets. Second is to assess the reaction of monetary authorities in response to internal and external structural shocks. Third is to highlight the importance of forward looking expectations on the part of economic agents in policy making along with estimating the structural parameters to assess the magnitude and direction of relationship among macroeconomic aggregates. Additionally, two secondary objectives are also covered. First is the assessment of the significance of risk premium shock in destabilizing the economy. Second is the identification of the sources of variations in the macroeconomic aggregates.

The framework developed here is mostly based on the canonical models discussed in Goodfriend and King (1997), Clarida, Gali and Gertler (1999), Gali and Monacelli (2005) and Gali (2007), among others.

Bernanke and Mihov (1998) argue that tracing the dynamic replication of the economy to a monetary policy innovation delivers an expedient of observing the effects of policy changes under minimal identifying posits and also rationalizes the prominence of the VAR-predicated approach on monetary policy shocks. This study incorporates the Structural Vector Autoregressive (SVAR) model to meet the objective of empirical estimation of the models. Main feature of the SVAR model is the use of economic theory to impose restrictions which end up with reliable results.

Deep structural parameters are estimated by following the two-steps procedure proposed by Keating (1990). First, estimation of the reduced form VAR model is required to retrieve residuals and reduced form parameters which will be used in identified restriction. Second, use the identified restrictions to estimate the structural model through maximum likelihood estimation procedure. Keating (1990) named this approach as the SVAR model. Employing SVAR model enable us to obtain structural parameter estimates. Impulse response analysis has been conducted which provided a valuable insight on the significance of internal and external structural shocks to the macroeconomic dynamics of the economy. Forecast error variance decomposition has also been computed which has the advantage to identify the sources of variation in the macroeconomic aggregates.

The results seem to confirm that the SBP has been pursuing discretionary policy rather than adopting any rule. This has been observed by examining the structural parameter estimates of the interest rate rule and the response of interest rate to the structural shocks. These findings highlight the role of expectations and the need for incorporating the direct and indirect impacts of factors which affect the macroeconomic dynamics. It, therefore, provides an insight to the policy makers to achieve the short term and medium term targeted levels of inflation and economic growth in a more effective manner.

Chapter two reviews the literature which does not incorporate the DSGE framework. Chapter three develops the closed and open economy rational expectations models. Chapter four discusses the methodology in detail and also presents the detailed procedure of the identifying restrictions. After finalizing the restrictions based on derived structural models, Chapter five presents the estimated results following two-steps procedure prescribed by Keating (1990). The estimated structural parameters along with impulse responses and variance decomposition are discussed in detail. Finally, Chapter 6 concludes the thesis, suggests policy implications and scope for future research in the area of macroeconomic modeling.

CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

Literature in the field of macroeconomics, specifically on monetary policy, combines a wide range of methods with diverse and sometimes conflicting results. Most of the studies in this field consider developed economies with few exceptions that worked on emerging market economies. Research by Pain, Koske and Sollie (2006) and Borio and Filardo (2006) along with others point out the increased role of open economy factors in determining macroeconomic performance of a country making it more difficult for the monetary authorities to stabilize the economy by focusing on domestic factors only. Ihrig *et al.* (2006) find little support for the hypothesis of increased role of open economy factors in determining inflation. Ball (2006) pointed out smaller effect of globalization on inflation. Rogoff (2003) contradicts most of the empirical studies by concluding that Phillips curve will become steeper with more globalization.

Globalization also affects the channels of monetary transmission by making exchange rate channel more important than interest rate as compared to the era of less integrated economies.

Remaining part of this chapter will cover the literature on macroeconomic dynamics and monetary policy in a global environment in two parts. First part will discuss the literature with special emphasis on macroeconomic determinants of aggregate demand (output gap) and aggregate supply (inflation). Second part will discuss the transmission channels that help monetary authorities to stabilize the economy.

2.2 OPEN ECONOMY FRAMEWORK AND MONETARY POLICY

Friedman (1963) considers inflation as a monetary phenomenon. In the presence of independent monetary policy, inflation rate is solely controlled or managed by monetary authorities in the long time horizon. In the short and medium runs some other factors like domestic output gap and exchange rate may also play a role in helping monetary authorities to keep inflation and economic growth within or around the targeted range. The dynamics of output and inflation are influenced by domestic as well as open economy factors as the domestic markets are increasingly integrated with foreign markets. Thus, the price level of both the goods and inputs are not exclusively determined by demand and supply situation prevailing in the domestic economy.

The idea presented in Barro and Gordon's (1983) model is that the monetary authority and the public are involved in a game. The authority makes decisions that influence the inflation rate and then public forms expectations accordingly. The model is useful in understanding the monetary policy and the various hypotheses about global inflation in recent years. Romer (1993) uses the framework presented by Barro and Gordon (1983) to explain the effect of open economy variables on inflation and conclude that Phillips curve will become steeper as the economies get more open. As monetary expansion will raise the cost for households and businesses for real depreciation in currency and if increased share of foreign goods is evident then there will be greater increase in inflation. He documents a negative correlation between openness and long-run inflation which is consistent with the theory and finds the correlation between openness and inflation to be robust after conditioning on other variables. He also points that inflation is low in the world's richest countries regardless of how open they are and suggests that these countries have solved the problem of time-consistency.

Lane (1997) and Campillo and Miron (1997) find that greater openness is associated with low inflation after conditioning the other variables. Lane (1997) emphasizes the importance of rigidities in the domestically traded goods in strong relation between openness of economy and rise in prices. Campillo and Miron (1997) conclude that differences in inflation across countries are due to structural factors such as openness, political stability and tax policy not due to institutional arrangements. Loungani, Razin, and Yuen (2002) find that countries with more capital controls have steeper Phillips curves. The authors base their empirical work on thirty five countries and use the measure created by Ball, Mankiw, and Romer (1988). They find that the Phillips curve becomes flatter as countries become more open to international capital flows which contradict the finding by Romer.

Temple (2002) examines the relationship between openness and the sacrifice ratios that Ball (1994) and Ball, Mankiw, and Romer (1988) compute for various disinflations.

Temple (2002) finds that the time-inconsistency explanation may not account for the robust openness–inflation result.

Consumer spending is one of the major parts of aggregate demand and is one of the important determinants of economic growth. Energy price hikes affect consumer expenditures in various ways, directly and indirectly. Direct effects include discretionary income effect, uncertainty effect, the operating cost effect and an increase in precautionary savings. Discretionary income effect stems from the fact that household devote major part of their income to energy bills. An unexpected increase in energy prices will erode their income as they will need to pay more for consuming the same amount of energy. Consequently they left with less money after paying energy bills, to finance other expenditures (Eldestien & Kilian 2008). Secondly, empirical findings confirm that energy prices are the most volatile in nature than other commodities (Regnier 2007). The volatile nature of energy prices creates a great deal of uncertainty about the direction of energy prices in the future. The optimizing household will be expected to delay their spending on the irreversible purchases of consumer durables (Brown & Yucci 2002, Pindyck 1991 & Barnanke 1983) until the uncertainty vanish or low enough. Moreover, the demand for goods complementary in use with energy products decline even more likes motor vehicles (Hamilton 2009, 1988) due to operating cost effect. Increase in precautionary savings in response to an oil price shock is another source of decline in demand. To smooth consumption in case of unemployment or decrease in real wage due to real wage rigidities worker adjust their consumption expenditures accordingly. Kilian (2007) argue that workers perceive oil price shock as shock to employment, more volatility on part of oil prices implies greater uncertainty about successfully employed in the future. However these effects are bounded to energy, and energy consuming products. Indirect effects are much more important in explaining the observed impact of real oil price shocks on consumption expenditures. Indirect effects involve shift in expenditure patterns mainly invoked by relative price changes, uncertainty effect and user cost (Hamilton, 2009). In case of positive oil price shock automobile industry is generally affected the most. As a result the resource reallocation process is triggered. On one hand the value of such products like car is much more than the value of energy consumed by the car as fuel. Secondly owing to imperfections in factor markets will delay the adjustment process. Like industry specific skills seniority etc make it difficult for workers to adjust in other industries and remains unemployed for longer spans, waiting for favorable conditions. Another study by Mehra and Preston (2006) studied the impact of exogenous oil price shocks caused by military conflects on aggregate consumption for the US economy using quarterly data over the period 1962:Q1-2004:Q2. Using Hamilton's (1996) NOPI they found negative relationship between oil price increase and aggregate consumption expenditures for the US. They reinforce the Hooker (1996) findings in case of consumption spending that oil price increase in a stable environment dose matter rather a correction to previous declines. Consumer spending is found to be insensitive to oil price decrease implies asymmetric relationship between oil price and consumption spending.

It has been widely recognized that monetary policy conduct plays vital role in curbing destabilizing repercussions of demand and supply shock (Romer & Romer, 1989). In literature, the 1970s recession is commonly attributed to oil price shocks. But recent experience and relatively small share of oil in production process makes it difficult for standard macroeconomic models to explain the deep recession of the 70s. Hence many indirect channels are advocated in this respect that seems helpful in resolving this issue, including endogenous monetary policy response to actual and expected inflationary consequences of a positive oil price shock. Bernanke Gertler and Watson (1997, 2004) show that Fed is mostly concerned with price stability instead of output growth. Since a positive oil price shock is suspected to create inflation. Fed Mostly respond by rising interest rate to curb expected future inflation. But Fed's contractionary policy amplifies the decline in real output and employment. Through VAR technique Bernanke Gertler and Watson (1997, 2004) conduct a counterfactual experiment to illustrate the impact of an accommodative monetary policy on real output and employment. The optimal lag length they decided using Akaike Information Criteria (AIC) is 7 months. They show that 150 bps increase in Federal funds rate is associated with 10% increase in oil price increase with 0.7% decline in real output. Their major finding was that Fed reaction is the major source of the 1970's deep recession. Moreover, these recessions could have been avoided by not responding to these shocks, at the cost of welfare loss due to price instability. The major contribution of the paper was that the endogenous response of the monetary policy tightening is the important cause of adverse impact of oil price shock on the economic activity. Hamilton and Herrera (2004) challenged the Bernanke Gertler and Watson (1997) findings on methodological grounds. They show that Bernanke Gertler and Watson's (1997, 2004) estimates depend on lag length included in the model. Most of the studies proved that oil price shocks affect output and prices after t quarters. Hence the lag-length considered by Bernanke Gertler and Watson (1997, 2004) is incapable of capturing the exact effect of an oil price shock. In response Hamilton and Herrera (2004) extended the same model with the same data but with 4 quarters (12 months) show that by including further lags monetary policy seems to be incapable to avoid the contractionary consequences of an oil price shock. Secondly the implausibility of the Fed's ability to reduce the federal funds rate by 900 bps and the money supply increase would be large enough against suggested by Bernanke Gertler and Watson (1997, 2004). In contrast, Bersky and Kilian (2002) show that instead of supply shocks the monetary arrangements (regime shift) which occurs simultaneously with oil price shock, is the major cause of 1970s deep stagflation. And there is no reason to expect stagflation due to supply shocks (Oil price shock) in the future.

Bernanke Gertler and Watson's (1997, 2004) empirical findings motivate researchers to assess the relative importance of oil price shocks to monetary policy response as the possible cause of the 70's recession. On theoretical grounds Leduc and Sill (2004) developed a DSGE model in New-Keynesian framework to assess the contribution of endogenous central bank's response to an oil price shock. With a closed economy model with nominal rigidities, they found that monetary policy tightening can be counted as secondary source to the recessionary consequences. They show that oil price increase contribute 60% while monetary policy caused a 40% drop in real output. Moreover, inflation targeting policy outperforms than other rules in wake of oil price shock. In response to Leduc and Sill, Carlstrom and Fuerst (2006) with a more inflexible markets extended Bernanke Gertler and Watson's (1997, 2004) contribution with a standard NK

DSGE model assess the relevancy of the Lucas critique. Secondly they consider different neutral policy versions including wicksellian interest rate policy and money growth peg, in addition to Leduc and Sill (2004) interest rate peg only. They found quite different impact of oil price shock on output and inflation under different monetary policy versions, in which wicksellian policy outperforms in imitating the real behavior of the economy. Finally they found that monetary policy is incapable to explain the 70s recession and all of the recessionary process is attributed to Oil price increase. To assess the impact of oil price shock on macro variables with respect to time Herrera and Pesavento (2007) studied the US economy through VAR, impulse response and variance decomposition found that the macroeconomic variables including GDP, CPI inflation, inventories and sales respond differently across the sub-samples (1959-1979 and 1985-2006). Moreover, the role of monetary policy in dampening volatility is assessed; they found an almost negligible role of monetary policy in mitigating volatility except in 2006.

Natal (2012) revisited the role of monetary policy response to a positive oil price shock using New-Keynesian DSGE model. Important features of the model are, incorporating oil in production and directly in consumption, imperfect substitution of oil with other factors at least in the short-run and non-availability of fiscal transfers to mitigate welfare loss due to oil price shock. Natal (2012) argue that central banks are mostly conscious about long-term price stability, however in case of positive oil price shocks they always reluctant to react aggressively considering the output-inflation tradeoff. Natal (2012) found that optimal response to a positive oil price shock is just like inflation targeting, while long-run price stability depends on the central bank credibility and not on short-run deviation from the optimal rule. Gregorio et al. (2007) assessing the causes of fall in oil price pass-through into different measures of inflation found the same results for 34 countries with the help of New Keynesian Phillips curve augmented with oil prices. They argue that credibility bonus is one of the many other variables contributed to the moderation process. Blanchard and Gali (2010) documented the impact of the credibility of monetary policy on inflation expectations; they show that monetary authority is successful to anchor inflation expectations in wake of positive oil price shocks. They attribute the increased credibility to improved communications, transparency and the adoption of rule based policies (inflation targeting). Kilian and Lewis (2009) re-examined the relative contribution of direct and indirect channels through which oil prices affect real economic activity. Contractionary monetary policy in response to a positive oil price shock was although widely studied and proved to be an important source of amplifying the recessionary consequences. In contrast to theoretical models, Kilian (2008a, 2008b, 2010, 2011) states that there is no empirical evidence to suggest that the monetary policy reaction is an important source of output drop and that the overall combined effect of oil price increase through direct and indirect channels is negligible. Kilian (2008a, 2008b, 2010, 2011) emphasis the underlying source of oil price shock rather than the oil price shock emphasizing the endogenity of oil prices.

2.3 Monetary Transmission

Open economy factors may have significant impact on the ability of monetary policy makers by influencing the conducts through which they stabilize the economy. Taylor (1995) named these transmission channels of decisions made by monetary authorities to inflation and GDP as monetary transmission channels. Empirical studies identify two aspects of monetary transmission mechanism First, the dynamics of unanticipated monetary contraction and second, the identification of channels of monetary transmission to the macroeconomic aggregates. With the emergence of trade among countries, an increased role of exchange rate as monetary transmission mechanism, is expected which needs to be assessed. Accordingly, literature is reviewed by focusing on the increased role of globalization through exchange rate on monetary transmission mechanism which actually did not operate through Phillips curve mechanism.

Interest rate channel emphasizes the role of money market equilibrium in changing the interest rates. Any change in the stance by the central bank affects money supply in the country which results in changes in the short-term interest rates, thus changing aggregate demand and output. According to Ramey, (1993), the working of the interest rate channel is based on two assumptions. First, there are two classes of assets, money and all other assets lumped together. Following Walras' Law, the analysis focuses on money market only so interest rate channel is also named as "money view." Second, there are no close substitutes for money. Most people are of the view that money view depicts an incomplete story of working of monetary policy. This reflects that some channels, other than exchange rate and interest rate channel, may also be important with the integration of economies during the past few decades.

According to Kamin and Rogers (2000), in open economies and also in developing countries, the exchange rate channel plays an important role with only undeveloped markets for real estate, equities and bonds. Interest rate increases in response to monetary contraction which also results in raising the demand of domestic assets. Thus, due to inflow of foreign exchange, real and nominal exchange rates will appreciate when flexible exchange rate is in practice.

The standard version of the PPP theory implies that a country with an appreciating (depreciating) currency should experience a proportional decrease (increase) in prices in the long run (Rogoff, 1996) and the pass-through effect is equal to unity. However, empirical studies rarely confirm the standard version of the PPP theory. On the other hand, the relative version of the PPP theory assumes that the relation between price levels of baskets of similar goods across countries should be constant and not necessarily equal to one.

Taylor (1995) attempts that under fixed or heavily managed exchange rate environment; the scope of monetary policy is ruthlessly limited when high rate capital mobility is witnessed. He also distinguishes the importance of financial prices, such as interest rate and exchange rate, as compared to the quantities. He further discusses that spending decisions of the domestic households are influenced by changes in interest rate and the quantities of imports and exports are influenced by changes in the real exchange rate.

King (1986), being the first one to address the relative importance of the money view and credit view, employs an unrestricted five-variable VAR model that includes GNP, demand deposits, commercial and industrial bank loans, other bank loans, rates on short-term commercial and industrial loans, and the three-month Treasury bill rate. He finds bank deposits to be superior. Bernanke (1986) employs structural VAR model by using seasonally adjusted quarterly data for the US economy (1953:1-1984:4). He observes that money and credit are of equal importance in the monetary policy transmission mechanisms.

Bernanke and Blinder (1992) argue that banks are unlikely to reduce lending immediately after money is tightened because that may result to bring many borrowers to bankruptcy. One of the conclusions of their model is that if money demand shocks are larger than the credit demand shocks, then monetary policy targeting credit is a better choice.

Siregar and Ward (2002) aim at measuring the impact of monetary shocks by using SVAR model for the Indonesian economy. However, they do not include the price level variable which is one of the key variables in any SVAR model of monetary transmission mechanisms. Similarly, the exclusion of the bank credit market in the model makes it impossible to examine the role possibly played by bank loans in the monetary transmission.

Siswanto *et al.* (2002), by employing VAR model for the Indonesian economy, attempt to investigate the influence of monetary shock on exchange rate in comparison to risk factor shock on the exchange rate. They further work on how the monetary induced exchange rate change is transmitted into inflation via direct and indirect pass-through effects. Their results show that the exchange rate channel is weak during the pre-crisis period due to pegging exchange rate regime. During the post-crisis period under floating exchange rate regime, exchange rate channel seems to work better and both direct and indirect exchange-rate pass-through effect.

Disyatat and Vongsinsirikul (2003) investigate the exchange rate and asset price channels for Thailand by estimating two four-variable VAR models and impose a recursive structure on the VAR model. They find that the exchange rate channel works stronger after the crisis period because Thailand adopted free floating exchange rate to account for the 1998 financial crisis. They find the asset price channel to be very weak for the reason that the capital market is still in its early developmental stage and that equity holding accounts for a tiny fraction of the people's asset portfolio. Nagayasu (2007) analyzes the increasing role of exchange rate as monetary transmission mechanism for the Japanese economy. Among many exchange rate theories this paper focuses on the standard theory which is based on the monetary approach to exchange rate determination. For the purpose Nagayasu (2007) uses quarterly data for the period 1970Q1-2003Q1 and includes exchange rate, money and output. He employs the co-integration analysis along with VEC and VAR models to empirically estimate the impact of monetary expansion on exchange rate and then of exchange rate on GDP. His results find no evidence to support the view that depreciation in local currency enhances economic growth. Thus the study concludes that the focus on exchange rate channel to boost the economy is premature.

2.4 EMPIRICAL STUDIES IN PAKISTAN

Hyder and Khan (2002) constructs monetary conditions index by taking into account only two monetary transmission channels, that is, exchange rate channel and interest rate. They employ Johenson's method and used the first cointegrating vector to estimate the relative importance of exchange rate and interest rate. The estimated monetary condition ratio is 1:2.79.

Agha *et al.* (2005) investigate the monetary transmission channels in Pakistan by using VAR and conclude exchange rate to be the least important channel. Although VAR method has the property to treat all the variables simultaneously but unfortunately it does not stand on economic foundations. Thus there is need to investigate the channels of monetary transmission by employing more preferred econometric models which may use economic theory like Structural VAR model. Alam and Waheed (2006) while investigating the monetary transmission mechanism at sectoral level in Pakistan finds that sector specific real effects of monetary policy are evident.

2.5 CONCLUDING REMARKS

The literature cited above reveals that there is no consensus about the impact of globalization on macroeconomic performance. The results are more or so mixed. Some studies like Romer (1993), Lane (1997), and Rogoff (2003) suggest that globalization make the Phillips curve steeper and some other studies like Kuttner and Robinson (2010) suggest that with the increase in the role of global factors in domestic performance of an economy, Phillips curve will become flatter. Some studies like Ihrig *et al.* (2007) find little support for the increased role of globalization in determining domestic inflation. Most of the studies points to conclude negative relationship between globalization and inflation, and more economic growth for more open economies. There is diversity in methods used for the empirical estimation like Error Correction model, Panel data model, time series regression analysis, GMM, Probit model or correlation analysis supplemented by Graphical analysis. There is very little work done for emerging market economies and comprehensive review on the effect of globalization on key macroeconomic variables is needed so as to remove confusion about the effect of globalization on inflation and economic growth. There may be different role of the monetary authorities to stabilize the economy in the presence of more open economies because there will be international factors which may influence the targeted levels of inflation and economic growth. So globalization may have serious repercussions for the monetary policy of a country. Some other factors may also influence inflation behavior like independent monetary policy, luck, prudent fiscal policies, higher productivity growth and deregulation that can lower the inflation hence need assessment in line with globalization. A review and possible explanations for the possible flattening of the Phillips curve do not seem to be presented in the literature for the emerging market economies. Reliable and more preferred econometric techniques will play vital role in this regard. Masson (2001) while discussing various impacts of globalization says that globalization produces both winners and losers. According to Masson (2001), it is important to provide social safety nets to compensate the losers from adverse effects of globalization and also policies devised to equalize opportunities including improved public education, health and security.

Exchange rate may become one of the important channels of monetary transmission mechanism as the economies are more open than before. This link of globalization is actually missing in the literature especially for the emerging market economies which needs to be studied in the present situation where the world is fast becoming a global village.

One important aspect missing in the literature cited above is the lack of microeconomic foundations and nominal rigidities. Lucas critique has also not been incorporated. It is reflected in the contradictions found in the literature. In essence, the requirements to develop a structural model which may be free from this kind of criticism thus help the policy makers to follow the right direction to stabilize the economy. Haider and Khan (2008) and Ahmed *et. al* (2012) however, claim to work on DSGE model for Pakistan by managing the unavailability of microeconomic parameter values but it do not represent the macroeconomic model for Pakistan's economy.

CHAPTER 3

THEORETICAL MODEL

3.1 INTRODUCTION

Since the last four decades various fundamental changes in macroeconomic modeling have been observed. During 1970s, the models based on Keynesian framework were criticized on theoretical and empirical grounds hence authenticity challenged by various economists like Lucas (1976), Sims (1980) along with others. These models showed poor forecasting performance because of non-inclusion of stagflation in the models (Gali and Gertler, 2007). Lucas (1976) emphasized the absence of ability of macroeconomic models to forecast the consequences of unannounced policy changes. In response, seminal paper by Kydland and Prescott (1982) come about and was treated as first generation of DSGE models to study Real business cycles (RBC). Rebelo (2005) indicates that RBC models explain response of rational economic agents to technology shocks. Then there came the NK models wherein frictions in economy are allowed.

NK macroeconomic models possess various features including the most important base line feature in the modeling approach. NK models are based on the idea of DSGE models, meaning thereby that all the economic agents are well aware that their decision determines the future economic environment. However, uncertainty is the built-in feature due to exogenous shocks that affect the macroeconomic dynamics. All the markets are considered in these models; therefore, these are General Equilibrium models.

Gali (2008) provided three features of the NK models which differentiate these from the Real Business Cycle models. First, NK models assume monopolistic competition in the markets, that is, firms set their prices over and above the marginal cost using market power which is a source of price stickiness in the economy. Second, firms do not adjust prices frequently due to allied cost like menu cost, etc. Hence the economy is not frictionless due to prevalence of nominal rigidities. This, in turn, generates forward looking behavior on the part of firms. Third, as the nominal rigidities are prevailing in the economy, therefore in the short run money is non-neutral. In practice, as a result of changes in the nominal interest rate by the monetary authorities, prices do not change proportionately (real interest rate vary accordingly) which results in changes in employment and output levels. The existence of nominal rigidities (subsequently the non-neutrality of money) provides a channel to the monetary authorities to intervene and stabilize the economy (Gali, 2008).

The economy is described mainly by the four structural equations, aggregate demand, aggregate supply, UIP (relaxed through incorporating risk premium shock) and the monetary policy equation. Each equation in the system is originated from the optimizing behavior of economic agents keeping in consideration the constraints prevailing in the economy. Aggregate demand equation depends positively on the expected future real activity and negatively on the real interest rate along with its dependence on exchange rate or foreign output gap (if modeling an open economy). Aggregate demand along with expected inflation helps in determining the inflation and open economy factors are also important in explaining fluctuations in inflation. UIP equation[2] is also a part of the model. These equations then come together into the monetary policy equation. Thus simultaneous system of equations is formulated to explain the dynamics of economy where monetary policy makers try to stabilize economy through semblance of the Taylor type rule. It closes the model and describes relationship among output, inflation, exchange rate and interest rate. Expectations regarding key macroeconomic variables by the economic agents play prominent role in determining the dynamics of macroeconomic aggregates which is treated as expectations channel in the literature of monetary economics. Every equation in the system possesses a structural shock (fiscal shock, cost push shock, risk premium shock and interest rate shock) which provides fluctuations of the macroeconomic variables around the steady state path.

The underlying assumptions in both the closed economy and open economy models are as under:-

1. Government Expenditures are exogenous.
2. Capital is assumed fixed as DSGE models discuss the short run dynamics of the economy.
3. Household carry risk free investment made in the firms on which they receive fixed return each period. Thus no allocation of funds is needed in the budget constraint. (ownership of firm by the household).

[2] Uncovered interest parity condition is relaxed by applying simple approach that just shows the proportionate relation between real interest rate and exchange rate, and a random shock.

[3] Real money balances are assumed to be endogenous based on the fact that short term nominal interest

4. All the economic agents are assumed to form rational expectations.
5. Real money balances are assumed to be endogenous based on the fact that short term nominal interest rates are used as an instrument of monetary policy in DSGE models thus LM equation have no role to play in the final model.

The framework we are going to develop here is based mostly on the canonical models discussed in Clarida, Gali and Gertler (1999), Gali and Monacelli (2005) and Gali (2007), among others. The next section will present closed economy macroeconomic model. Then in section 3.3, we fully describe the open economy macroeconomic model.

3.2 Closed Economy Forward Looking Macroeconomic Model

This section presents closed economy model which consist of three main economic agents. First, the households who put demand for goods and services hence provide Euler equation of consumption. Second, the profit maximizing firms who provide forward looking Phillips curve equation (aggregate supply equation) and the third is the central bank that follows the Taylor type interest rate rule. Model is also solved to provide log linearized steady state solution which affords the researcher estimate the model and the subsequent analysis.

3.2.1 Households' Decision

A representative household is assumed to be one among infinitely lived identical individuals of a closed macro economy who seeks to maximize utility considering money in utility function. The preferences for such a household are described by an intertemporal Constant Relative Risk Aversion (ICRRA) utility function as

$$U = E_t \sum_{k=0}^{\infty} \beta^k \left[\frac{C_{t+k}{}^{1-\sigma}}{1-\sigma} + \frac{\gamma}{1-b}\left(\frac{M_{t+k}}{P_{t+k}}\right)^{1-b} - \frac{N_{t+k}{}^{1+\varphi}}{1+\varphi}\right] \quad (3.1)$$

Where C_t is consumption which can be taken as a composite index of consumption, $\frac{M_{t+k}}{P_{t+k}}$ are real money balances[3] and N_t is the time devoted to employment [thus time devoted to leisure is $(1 - N_t)$]. β^k represents intertemporal discount factor describing the time preferences rate, σ denotes the inverse of elasticity of intertemporal substitution in consumption (also gives the degree of relative risk aversion), b is the inverted interest rate elasticity of money demand and φ represents the inverse of wage elasticity of labor supply. γ is the weight of nominal balance in household's utility function. E_t is the operator for expectations which are formed at time t. $\sigma > 0, \varphi > 1, b > 0$ *but* $b \neq 1$ and $\beta_i \in (0,1)$.

C_t is consumption index of domestic goods defined through CES function as:

$$C_t = \left(\int_0^1 C_{j,t}{}^{\frac{\varepsilon-1}{\epsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (3.2)$$

Where, $j \in (0,1)$ denotes the variety of goods, $\varepsilon > 1$, gives the elasticity of inter-temporal substitution between varieties produced within any country.

[3] Real money balances are assumed to be endogenous based on the fact that short term nominal interest rates are used as an instrument of monetary policy in DSGE models (see, Woordford, 2003). It also holds for Pakistan as studied by Omer and Saqib (2008).

Households try to minimize the cost of achieving the level of the composite consumption by achieving the least expensive combinations of domestically produced goods which can be derived as follows:

$$L = \int_0^1 P_{j,t} C_{j,t} dj - \psi_t \left[\left(\int_0^1 C_{j,t}^{\frac{\varepsilon-1}{\epsilon}} dj \right)^{\frac{\varepsilon}{\epsilon-1}} - C_t \right] \tag{3.3}$$

Employing first order condition gives the following two equations

$$C_{j,t} = \left(\frac{P_{j,t}}{\psi_t} \right)^{-\varepsilon} C_t \tag{3.4}$$

$$\psi_t = \left[\int_0^1 P_{j,t}^{\,1-\varepsilon} dj \right]^{\frac{1}{1-\epsilon}} = P_t \tag{3.5}$$

Equation (3.5) represents domestic price index.

Putting value of ψ_t from equation (3.5) in equation (3.4) gives the demand function as:

$$C_{j,t} = \left(\frac{P_{j,t}}{P_t} \right)^{-\varepsilon} C_t \tag{3.6}$$

Thus utility is a nested function of $C_{j,t}$.

Households maximize their utility based on budget constraint of the following form

$$\int_0^1 (P_{H,t} C_{H,t})\, di + M_t + E_t(\vartheta_{t,t+1} D_{t+1}) \leq D_t + M_{t-1} + W_t N_t + \Gamma_t$$

$$P_t C_t + M_t + E_t(\vartheta_{t,t+1} D_{t+1}) \leq D_t + M_{t-1} + W_t N_t + \Gamma_t$$

The left hand side of the above budget constraint represents the expenditures made on consumption of goods, money holdings and the expenditures to buy risk free bonds for holding during the current period which will mature in the next period, i.e. after one period. $D_{t+1} = (1 + i_t)B_t$, i.e. the value of bonds in the next period which are purchased in the current period which are further discounted with the stochastic discount factor $\vartheta_{t,t+1} = \frac{1}{1+i_t}$ thus $E_t(\vartheta_{t,t+1}D_{t+1})$ is ultimately equal to B_t and it appears in this fashion just to show the significance of these bonds for the next period.

The right hand side shows income received through labour supply (W_tN_t), income on risk free bond held in the last period $[D_t = (1 + i_{t-1})B_{t-1}]$, the income (profit) received from the one time risk free investment made in the firms, lump-sum transfers/taxes by the household (Γ_t) and the money held during the last period is represented as M_{t-1}.

The above budget constraint in real terms can be transformed as

$$C_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} = (1 + i_{t-1})\left(\frac{B_{t-1}}{P_t}\right) + \frac{M_{t-1}}{P_t} + \left(\frac{W_t}{P_t}\right)N_t + \Gamma_t \quad (3.7)$$

Maximizing equation (3.1) subject to equation (3.7):

$$L = E_t \sum_{k=0}^{\infty} \beta^k \left[\frac{C_{t+k}{}^{1-\sigma}}{1-\sigma} + \frac{\gamma}{1-b}\left(\frac{M_{t+k}}{P_{t+k}}\right)^{1-b} - \frac{N_{t+k}{}^{1+\varphi}}{1+\varphi}\right]$$

$$-\sum_{k=0}^{\infty} \lambda_{t+k}\left[C_{t+k} + \frac{M_{t+k}}{P_{t+k}} + \frac{B_{t+k}}{P_{t+k}} - (1 + i_{t-1+k})\left(\frac{B_{t-1+k}}{P_{t+k}}\right) - \frac{M_{t-1+k}}{P_{t+k}} - \left(\frac{W_{t+k}}{P_{t+k}}\right)N_{t+k} - \Gamma_{t+k}\right]$$

The Utility function prescribed here represents the life time utility function and the expenditures are also based on the life time income (wealth). However, we are specifying the case for two periods only so the above Lagrangian function is to be expanded up to one period, i.e. for k=0 & 1. The first order condition is applied for C_t, C_{t+1}, B_t, N_t and M_t.

Applying First Order Condition

$$C_t: \qquad C_t^{-\sigma} - \lambda_t = 0 \qquad \Rightarrow \; C_t^{-\sigma} = \lambda_t \tag{3.8}$$

$$C_{t+1}: \qquad E_t\beta[\,C_{t+1}^{-\sigma}] - \lambda_{t+1} = 0 \qquad \Rightarrow \; E_t\beta[\,C_{t+1}^{-\sigma}] = \lambda_{t+1} \tag{3.9}$$

$$B_t: \qquad -\frac{\lambda_t}{P_t} + E_t\left[\lambda_{t+1}\frac{(1+i_t)}{P_{t+1}}\right] = 0 \tag{3.10}$$

$$N_t: \qquad -N_t{}^{\varphi} + \left(\frac{W_t}{P_t}\right)\lambda_t = 0 \tag{3.11}$$

$$M_t: \quad \gamma\left(\frac{M_t}{P_t}\right)^{-b}\left(\frac{1}{P_t}\right) - \frac{\lambda_t}{P_t} + E_t\left[\lambda_{t+1}\frac{1}{P_{t+1}}\right] = 0 \tag{3.12}$$

Substituting equation (3.8) and (3.9) in equation (3.10)

$$-\frac{C_t^{-\sigma}}{P_t} + E_t\left[\beta C_{t+1}^{-\sigma}\frac{(1+i_t)}{P_{t+1}}\right] = 0 \tag{3.13}$$

Rearranging equation (3.13) gives

$$C_t^{-\sigma} = \beta(1+i_t)P_tE_t\left[\frac{C_{t+1}{}^{-\sigma}}{P_{t+1}}\right] \tag{3.14}$$

This equation represents the Euler equation of consumption, that is, the intertemporal consumption allocation.

Log-linearizing equation (3.14)

$$-\sigma \ln c_t = \ln\beta + \ln i_t - E_t(P_{t+1} - P_t) - \sigma E_t \ln c_{t+1}$$

$$lnc_t = -\frac{1}{\sigma}ln\beta - \frac{1}{\sigma}lni_t + \frac{1}{\sigma}E_t\pi_{t+1} + E_tlnc_{t+1}$$

$$\hat{c}_t = E_t\hat{c}_{t+1} - \frac{1}{\sigma}\left(\hat{\imath}_t - E_t\pi_{t+1} - \rho\right) \tag{3.14-A}$$

In equation (3.14-A), $\rho = -ln\beta$, the time discount rate, $\hat{\imath}_t$ is the short term nominal interest rate and π_{t+1} is the inflation rate based on CPI at time $t+1$ expected at time t . $\frac{1}{\sigma}$ is the inverse of degree of relative risk aversion.

DERIVING LM EQUATION OR THE MARGINAL RATE OF SUBSTITUTION BETWEEN MONEY AND CONSUMPTION

Solving equation (3.12) to get LM equation gives the following.

$$\gamma\left(\frac{M_t}{P_t}\right)^{-b}\left(\frac{1}{P_t}\right)-\frac{\lambda_t}{P_t}+E_t\left[\lambda_{t+1}\frac{1}{P_{t+1}}\right]=0$$

$$\gamma\left(\frac{M_t}{P_t}\right)^{-b}\left(\frac{1}{P_t}\right)=\frac{\lambda_t}{P_t}-E_t\left[\lambda_{t+1}\frac{1}{P_{t+1}}\right]$$

From equation (3.9), we know that $E_t\beta[\,C_{t+1}^{-\sigma}] = \lambda_{t+1}$ and from equation (3.8), we know that $C_t^{-\sigma} = \lambda_t$

$$\gamma\left(\frac{M_t}{P_t}\right)^{-b}\left(\frac{1}{P_t}\right)=\frac{C_t^{-\sigma}}{P_t}-E_t\left[\frac{E_t\beta[\,C_{t+1}^{-\sigma}]}{P_{t+1}}\right] \qquad (3.13)''$$

Rewrite equation (3.14)

$$C_t^{-\sigma} = \beta(1+i_t)P_tE_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\right] \qquad (3.14)$$

$$\frac{C_t^{-\sigma}}{(1+i_t)P_t} = E_t\beta\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\right] \qquad (3.14)''$$

Using equation (3.14)'', equation (3.13)'' will take the form as follows:-

$$\gamma\left(\frac{M_t}{P_t}\right)^{-b}\left(\frac{1}{P_t}\right)=\frac{C_t^{-\sigma}}{P_t}-\left[\frac{C_t^{-\sigma}}{(1+i_t)P_t}\right]$$

$$\gamma\left(\frac{M_t}{P_t}\right)^{-b}\left(\frac{1}{P_t}\right)=C_t^{-\sigma}\left[\frac{i_t}{(1+i_t)}\right]\frac{1}{P_t}$$

$$\frac{\gamma\left(\frac{M_t}{P_t}\right)^{-b}}{C_t^{-\sigma}}=\left[\frac{i_t}{(1+i_t)}\right] \tag{3.14-B}$$

The above equation [3.14-B] represents the marginal rate of substitution between money and consumption and is equal to the opportunity cost of holding money. Real money balances are assumed to be endogenous based on the fact that short term nominal interest rates are used as an instrument of monetary policy in DSGE models (see, Woordford, 2003). It also holds for Pakistan as studied by Omer and Saqib (2008).

Now substitute value of λ_t from equation (3.8) in equation (3.11) which gives equality of marginal rate of substitution between labour and consumption ($MRS_{L,C}$) and real wages (labour-leisure choice equation).

$$\frac{N_t^{\varphi}}{C_t^{-\sigma}}=\left(\frac{W_t}{P_t}\right) \tag{3.15}$$

Log-linearizing equation (3.15) gives

$$\varphi n_t+\sigma c_t=w_t-p_t \tag{3.16}$$

It represents that marginal rate of substitution between leisure and consumption is equal to real wage.

Deriving IS Curve

$$\hat{c}_t = E_t\hat{c}_{t+1} - \frac{1}{\sigma}\left(\hat{\imath}_t - E_t\pi_{t+1} - \rho\right) \tag{3.17}$$

$$y_t = \hat{c}_t + g_t$$

Thus $y_t - g_t = \hat{c}_t$ and $\hat{c}_{t+1} = y_{t+1} - g_{t+1}$

$$y_t - g_t = E_t(y_{t+1} - g_{t+1}) - \left(\frac{1}{\sigma}\right)\left(\hat{\imath}_t - E_t\pi_{t+1} - \rho\right)$$

$$y_t = E_t(y_{t+1} - g_{t+1}) + g_t - \left(\frac{1}{\sigma}\right)\left(\hat{\imath}_t - E_t\pi_{t+1} - \rho\right)$$

$$y_t = E_t(y_{t+1}) - E_t(g_{t+1} - g_t) - \left(\frac{1}{\sigma}\right)\left(\hat{\imath}_t - E_t\pi_{t+1} - \rho\right)$$

Using $x_t \boxminus y_t - y_t^p$, where x_t is output gap, then the above equation can be written as

$$y_t - y_t^p = E_t\left(y_{t+1} - y_{t+1}^p\right) + E_t\left(y_{t+1}^p - \Delta g_{t+1}\right) - \left(\frac{1}{\sigma}\right)\left(\hat{\imath}_t - E_t\pi_{t+1} - \rho\right)$$

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \epsilon_t^f \tag{3.18}$$

This equation is named as the forward looking IS equation which shows that domestic output gap depends inversely on the real interest rate $[i_t - E_t\pi_{t+1}]$, that is, it reveals that with the rise in real interest rate consumers will save more which results in reduction in aggregate spending. Thus central bank can influence the consumption pattern of households through changes in the nominal interest rate (which results in changes in the real interest rate due to sluggish changes in the prices). Domestic output gap is directly determined by the future output gap expected in the current period $(E_t x_{t+1})$. ϵ_t^f is the disturbance term which obeys: $\epsilon_t^f = \mu\epsilon_{t-1}^f + \hat{e}_t$; $0 \leq \mu \leq 1$ and $\hat{e}_t$is i.i.d. random variable with zero expected value zero and variance as constant.

3.2.2 Firms' Decision

Profit maximization is the major objective to which any representative firm converges three constraints. The first is the demand function, given in equation (3.6), the second is the production function and the third constraint is based on the fact that in any period a specific percentage of firms do not change their prices.

Consider that this is labor which varies in the short run:

Thus $Y_{j,t} = Z_t N_{j,t}$

Z_t is the country specific aggregate productivity disturbance which is assumed to be stochastic with constant returns to scale, that is, $E(Z_t) = 1$.

Aggregate output can be defined as

$$Y_t = \left[\int_0^1 Y_t\,(j)^{-(1-\rho)}dj\right]^{\frac{1}{-(1-\rho)}} \tag{3.19}$$

$$lnY_t = \left[\int_0^1 lnY_t\,(j)^{-(1-\rho)}dj\right]^{\frac{1}{-(1-\rho)}} = \ln(Z_t) + \ln(N_t)$$

$$y_t = z_t + n_t$$

Firm j minimize cost subject to producing the firm specific good $Y_{j,t}$

$$L = \left(\frac{W_t}{P_t}\right) N_t + \varphi_t(Y_{j,t} - Z_t N_{j,t})$$

First order condition gives

$$MC_t = \varphi_t = \frac{\left(\frac{W_t}{P_t}\right)}{Z_t}$$

$$mc_t = \widetilde{w}_t - \widetilde{p}_t - \widetilde{z}_t \tag{3.20}$$

The Lagrange Multiplier is interpreted as the real marginal cost of the firm. According to Ireland (2003), the convex nature of the adjustment cost makes the optimum behavior of firms dynamic. Real wages positively influence the real marginal cost and factor productivity of labor has negative impact on real marginal cost.

Firms that have the objective to maximize their profits change the price level $P_{j,t}$ in time period t as:

$$\max \sum_{k=0}^{\infty} E_t \left[(\theta_t)^k \left\{ \Delta_{k,t+k} \left(C_{j,t+k} \left[\frac{P_{j,t}}{P_{t+k}} - \varphi_{t+k} \right] \right) \right\} \right] \tag{3.21}$$

The demand function which is constraint to this profit maximization is reproduced as

$$C_{j,t} = \left(\frac{P_{j,t}}{P_t} \right)^{-\varepsilon} C_t \tag{3.6}$$

It may also be noted that the Calvo price assumption also prevails.

Re-writing equation (3.14)

$$C_t^{-\sigma} = \beta(1 + i_t) P_t E_t \left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \right]$$

Rearranging it to get the discount factor

$$\Delta_{K,t+1} = \frac{1}{(1+i_t)} = \beta E_t \left[\frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \right] \left[\frac{P_t}{P_{t+1}} \right] \tag{3.22}$$

Setting $\left(\frac{P_t}{P_{t+1}} \right) = 1$

$$\Delta_{k,t+k} = \frac{1}{(1+i_t)} = \beta E_t \left[\frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \right] \tag{3.23}$$

While setting prices, firms take into consideration the demand elasticity which may prevail in future. Now substitute demand function, presented in equation (3.6), in profit function at equation (3.21)

$$\max \sum_{k=0}^{\infty} E_t \left[(\theta_t)^k \left\{ \Delta_{k,t+k} \left(C_{t+k} \left[\frac{P_{j,t}}{P_{t+k}} \left(\frac{P_t}{P_{t+k}} \right)^{-\eta} - \varphi_{t+k} \left(\frac{P_t}{P_{t+k}} \right)^{-\eta} \right] \right) \right\} \right]$$

$$\sum_{k=0}^{\infty} E_t \left[(\theta_t)^k \left\{ \Delta_{k,t+k} \left(C_{t+k} \left[P_{j,t}^{(1-\eta)} \left(\frac{1}{P_{t+k}} \right)^{1-\eta} - \varphi_{t+k} P_{j,t}^{-\eta} \left(\frac{1}{P_{t+k}} \right)^{-\eta} \right] \right) \right\} \right] = 0$$

First order condition, with respect to $P_{j,t}$, gives

$$\Sigma_{k=0}^{\infty} E_t \left[(\theta_t)^k \left\{ \Delta_{k,t+k} \left(C_{t+k} \left[(1-\varepsilon) P_{j,t}^{-\varepsilon} \left(\frac{1}{P_{t+k}} \right)^{1-\varepsilon} - \varphi_{t+k} (-\varepsilon) P_{j,t}^{-\varepsilon-1} \left(\frac{1}{P_{t+k}} \right)^{-\varepsilon} \right] \right) \right\} \right] = 0$$

$$\Sigma_{k=0}^{\infty} E_t \left[(\theta_t)^k \left\{ \Delta_{k,t+k} \left(C_{t+k} \left[(1-\varepsilon) \left(\frac{1}{P_{t+k}} \right)^{1-\varepsilon} P_{j,t} + \varepsilon \varphi_{t+k} \left(\frac{1}{P_{t+k}} \right)^{-\varepsilon} \right] \left(\frac{1}{P_{j,t}} \right) P_{j,t}^{-\varepsilon} \right) \right\} \right] = 0$$

$$\Sigma_{k=0}^{\infty} E_t \left[(\theta_t)^k \Delta_{k,t+k} \left(C_{t+k} \left[(1-\varepsilon) \left(\frac{P_{j,t}}{P_{t+k}} \right) + \eta \varphi_{t+k} \right] \left(\frac{1}{P_{j,t}} \right) \left(\frac{P_{j,t}}{P_{t+k}} \right)^{-\varepsilon} \right) \right] = 0 \qquad (3.24)$$

Put value of $\Delta_{k,t+k}$ from equation (3.23) gives the following equation[4].

$$\left(\frac{P^{*}_{j,t}}{P_t} \right) = \left(\frac{\varepsilon}{1-\varepsilon} \right) \frac{E_t \Sigma_{k=0}^{\infty} (\beta\theta_t)^k (C_{t+k})^{1-\sigma} \varphi_{t+k} \left(\frac{P_{t+k}}{P_t} \right)^{\varepsilon}}{E_t \Sigma_{k=0}^{\infty} (\beta\theta_t)^k (C_{t+k})^{1-\sigma} \left(\frac{P_{t+k}}{P_t} \right)^{\varepsilon-1}} \qquad (3.25)$$

The above equation reveals that firms, which follow sticky prices, set their prices optimally with a mark-up of $\left(\frac{\varepsilon}{1-\varepsilon}\right)$. The remaining fraction represents the discounted value of costs and revenues of the firm.

[4] Detailed mathematical procedure is described in Appendix A-3.2.

However, in a situation where all firms set their prices, that is, the prices are flexible then the above equation will be transformed as

$$\frac{P^*_{j,t}}{P_t} = \left(\frac{\varepsilon}{1-\varepsilon}\right)\varphi_t \tag{3.26}$$

As all the firms charge equal prices when there are no frictions in the economy. So the above equation can be written as

$$1 = \left(\frac{\varepsilon}{1-\varepsilon}\right)\varphi_t$$

$$\left(\frac{1-\varepsilon}{\varepsilon}\right) = \varphi_t = \frac{\left(\frac{W_t}{P_t}\right)}{Z_t}$$

Using equation (3.15)

$$\left(\frac{1-\varepsilon}{\varepsilon}\right)Z_t = \frac{N_t^{\varphi}}{C_t^{-\sigma}} \xrightarrow{yields} \varphi n_t + \sigma(y_t - g_t) = z_t$$

$$y_t - z_t = n_t$$

$$\varphi(y_t - z_t) + \sigma(y_t - g_t) = z_t \xrightarrow{yields} (\varphi + \sigma)y_t - \sigma g_t = (1 + \varphi)z_t$$

$$y^f{}_t = \left(\frac{1+\varphi}{\varphi+\sigma}\right)z_t + \left(\frac{\sigma}{\varphi+\sigma}\right)g_t$$

$y^f{}_t$ denotes the equilibrium level of output when prices are flexible. From the definition of P_t and the assumption of Calvo pricing, the price index is now based on the average of newly adjusted price$P^*{}_t$ and the price level of the previous period as

$$P_t^{1-\rho} = (1-\theta_t)P^*{}_{j,t}{}^{1-\rho} + \theta_t P_{t-1}{}^{1-\rho}$$

The existence of the assumption of price rigidity in the economy reveals the fact that firms can set the prices freely but they are unaware of the point in time to change the price in future. $(1-\theta_t)$ denotes fraction of firms who adjust prices while θ_t firms keep their prices unchanged.

Taking log of the above equation

$$p_t = (1-\theta_t)p^*_{j,t} + \theta_t p_{t-1} \tag{3.27}$$

The above equation shows the general price level in steady state which is weighted average of the firms which adjust their prices each period, $(1-\theta_t)$ and θ_t firms do not adjust their price. Out of $(1-\theta_t)$ firms that do adjust their price, $(1-\omega)$ firms set price in forward looking manner and the remaining ω firms behave in a backward looking way toward price adjustment. So

$$p^*_t = (1-\omega)p^f_t + \omega(p^*_{t-1})$$

$$1 = (1-\theta_t)\left(\frac{P^*_{j,t}}{P_t}\right)^{1-\rho} + \theta_t\left(\frac{P_{t-1}}{P_t}\right)^{1-\rho} \tag{3.28}$$

Log-linearizing gives

$$log\left(\frac{P^*_{j,t}}{P_t}\right) = \left(\frac{\theta_t}{1-\theta_t}\right)\pi_t \tag{3.29}$$

Firms' optimal price setting rule (equation 3.25) can now be rewritten as

$$\left[E_t \sum_{k=0}^{\infty}(\beta\theta_t)^k (C_{t+k})^{1-\sigma}\left(\frac{P_{t+k}}{P_t}\right)^{\varepsilon-1}\right]F_t = \mu\left[E_t \sum_{k=0}^{\infty}(\beta\theta_t)^k (C_{t+k})^{1-\sigma}\varphi_{t+k}\left(\frac{P_{t+k}}{P_t}\right)^{\varepsilon}\right] \tag{3.30}$$

Where $F_t = \left(\frac{P^*_{j,t}}{P_t}\right)$ and $\mu = \left(\frac{\varepsilon}{1-\varepsilon}\right)$

Both sides of equation (3.30) can be approximated by using Taylor series rule[5]

$$\hat{f}_t\hat{p}_{t+k}\hat{p}_t\hat{c}_{t+k} = \bar{f}\bar{p}\bar{c} + \overline{pc}(f_t - \bar{f}) + \bar{f}\bar{c}(p_{t+i} - \bar{p}) + \bar{f}\bar{c}(p_t - \bar{p}) + \bar{f}\bar{p}(c_{t+k} - \bar{c})$$

Variables with hat denote log-linear deviations from the steady state and variables with bar denote the steady state variables. Finally, it gives following equation in a two period framework.

$$\hat{f}_t = (1 - \theta_t\beta)\hat{\varphi}_t + \theta_t\beta(E_t\hat{\varphi}_{t+1} + E_t\pi_{t+1}) \tag{3.31}$$

From equation (3.26), the situation where all firms adjust their prices and equation (3.29)

$$log\left(\frac{P^*_{j,t}}{P_t}\right) = \left(\frac{\varepsilon}{1-\varepsilon}\right)\hat{\varphi}_t = \left(\frac{\theta_t}{1-\theta_t}\right)\pi_t \tag{3.32}$$

$$\left(\frac{\theta_t}{1-\theta_t}\right)\pi_t = (1 - \theta_t\beta)\hat{\varphi}_t + \theta_t\beta\left(\left(\frac{\theta_t}{1-\theta_t}\right)E_t\pi_{t+1} + E_t\pi_{t+1}\right) \tag{3.33}$$

$$\left(\frac{\theta_t}{1-\theta_t}\right)\pi_t = (1 - \theta_t\beta)\hat{\varphi}_t + \theta_t\beta\left(\left(\frac{1}{1-\theta_t}\right)E_t\pi_{t+1}\right) \tag{3.34}$$

$$\boldsymbol{\pi_t = \lambda\hat{\varphi}_t + \beta E_t\pi_{t+1}} \tag{3.35}$$

$$mc_t = (\tilde{w}_t - \tilde{p}_t) - \tilde{z}_t$$

Using log linear form of equation (3.15) gives

$$mc_t = \varphi n_t + \sigma c_t - z_t$$

$$mc_t = \varphi y_t + \sigma c_t - (1 + \varphi)z_t \tag{3.36}$$

[5] Detailed procedure can be seen at appendix B-3.2

Following Clarida *et al.* (2001), cost push shock can be added which represents the imperfections in the labour market

$$\hat{\varphi}_t = \left(\frac{1-\varepsilon}{\varepsilon}\right) Z_t \ = \frac{N_t{}^{\varphi}}{C_t^{-\sigma}} e^{\epsilon_t^c}$$

$$\widehat{mc}_t = \varphi n_t + \sigma(y_t \ - g_t) + \epsilon_t^c - \ z_t$$

$$y_t - z_t = n_t$$

$$\widehat{mc}_t = \varphi(y_t - z_t) + \sigma(y_t \ - g_t) + \epsilon_t^c - \ z_t$$

$$\widehat{mc}_t = (\varphi + \sigma) y_t - (1 + \varphi) z_t + \epsilon_t^c - \sigma g_t$$

$$\widehat{mc}_t = (\varphi + \sigma) \left[y_t - \left(\frac{1+\varphi}{\varphi+\sigma}\right) z_t + \epsilon_t^c - \left(\frac{\sigma}{\varphi+\sigma}\right) g_t \right]$$

$$\widehat{mc}_t = (\varphi + \sigma)\left[y_t - y^f{}_t\right] + \epsilon_t^c$$

$$\widehat{mc}_t = (\varphi + \sigma) x_t + \epsilon_t^c$$

It will finally give us the NK Phillips curve of the form

$$\boldsymbol{\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda_0 x_t + \epsilon_t^c} \tag{3.37}$$

According to Walsh (2003, p.253), adding cost push shock in the NK Phillips curve equation also affects the equilibrium level of output at flexible prices.

3.2.3 Monetary policy objective

Monetary policy in the closed economy, in the short run, has the objective to achieve stability in price level and reduction in real economic fluctuations which can be captured through output gap. However, in the long run, monetary policy attains only price stability at sustainable growth in real economic activity and the employment level.

Thus central bank targets inflation and output gap to stabilize the economy by adjusting the interest rate which results in changes in real interest rate due to price rigidity. According to Clarida *et al.* (2001), it would be true for the open economies as well due the fact that terms of trade are proportional to the output gap. It seems to be unjustified if central bank targets output gap to be zero because of the presence of distortions in the market.

Following Svensson (2007), the standard intertemporal objective function over the two variables, that is, inflation (π_t) and the output gap (x_t) can be written as:

$$E_t\{\sum_{k=0}^{\infty} \beta^k \ [(\pi_{t+k} - \pi^t)^2 + \alpha x_{t+k}^2]\} \qquad (3.38)$$

Where α is the relative weight on output stabilization objective, β is the discount factor, π_t is inflation rate, π^t is the targeted inflation rate and x_t is the output gap. Both the target variables in the loss function are denoted as deviation from their deterministic trend. E_t denotes the expectations operator which is based on the information set at time t. If the central bank also likes to target exchange rate changes, an additional term may be added to the loss function.

Optimality Condition for Monetary policy

There is no agreed upon definition of inflation targeting as such by using which we may specify the way monetary policy is being implemented.

The Central bank has the objective to minimize the loss subject to the given Phillips curve derived in equation (3.37) for given expectations.

$$(\pi_t - \pi^t)^2 + \alpha x_t^2 + F_t$$

Subject to

$$\pi_t = \lambda_0 x_t + H_t$$

Where $F_t = E_t\{\sum_{k=1}^{\infty} \beta^k \ [(\pi_{t+k} - \pi^t)^2 + \alpha x_{t+k}^2]\}$ and

$H_t = \varphi\beta\pi_{t-1} + (1-\varphi)\beta E_t\{\pi_{t+1}\} + u_t$ are taken as given. It reflects that expectations are formed by the firms and households therefore central bank cannot control the expectations.

$$L = [(\pi_t - \pi^t)^2 + \alpha x_t^2 + F_t] + \psi[\pi_t - \lambda_0 x_t - H_t]$$

First order condition yields

$$\pi_t: \qquad 2(\pi_t - \pi^t) + \psi = 0 \quad \xrightarrow{yields} -(\pi_t - \pi^t) = \left(\frac{\psi}{2}\right) \qquad (3.39)$$

$$x_t \qquad 2\alpha x_t - \lambda_0 \psi = 0 \quad \xrightarrow{yields} x_t = -\frac{\lambda_0}{\alpha}(\pi_t - \pi^t) \quad (3.40)$$

The **interest rate reaction function** is derived by inserting the reduced form of output gap in the aggregate demand equation and solving it for the nominal interest rate.

Using aggregate demand equation to get equation for nominal interest rate,

$$x_t = -\varphi(i_t) + \varphi E_t\pi_{t+1} + \varphi\rho - \frac{\lambda_0}{\alpha}\left(E_t\pi_{t+1} - \pi^t\right) + \epsilon_t^f$$

$$x_t = -\varphi(i_t) + \varphi E_t\pi_{t+1} + \varphi\rho - \frac{\lambda_0}{\alpha} E_t\pi_{t+1} + \frac{\lambda_0}{\alpha}\pi^t + \epsilon_t^f$$

Solve for interest rate*

$$\varphi(i_t) = -x_t + \varphi E_t\pi_{t+1} + \varphi\rho + \frac{\lambda_0}{\alpha}\pi^t - \frac{\lambda_0}{\alpha} E_t\pi_{t+1} + \epsilon_t^f$$

$$i_t = \gamma_3 + \gamma_1(E_t\pi_{t+1}) + \gamma_2 x_t + \epsilon_t^i \quad (3.41)$$

The above equation is the interest rate rule which is based on the desired or the targeted levels of inflation and output gap.

3.3 OPEN ECONOMY MODEL RELAXING PPP AND UIP CONDITIONS

3.3.1. Households' Decision

A representative household, who is living in a small open economy, pursues to maximize his utility from a basket of consumption (C_t), real money balances $\left(\frac{M_{t+i}}{P_{t+i}}\right)$ and time devoted to employment (N_t).

However, C_t represents the index of composite consumption for domestically and foreign produced goods and is is defined as

$$C_t = \left[(1-\alpha)^{\frac{1}{\varepsilon}}\left(C_{H,t}\right)^{\frac{\varepsilon-1}{\varepsilon}} + \alpha^{\frac{1}{\varepsilon}}\left(C_{F,t}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}} \quad (3.42)$$

Where ε is the price elasticity of substitution between home and foreign goods. $\alpha \in (0,1)$ is the share of trade and the degree of openness can also be measure with α.

Index of consumption for domestically produced goods $(C_{H,t})$ as defined in equation (2) is reproduced:

$$C_{H,t} = \left(\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\epsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{3.43}$$

Where, $j \in (0,1)$ denotes the goods variety.

Consumption index for imported goods is written by

$$C_{F,t} = \left(\int_0^1 C_{i,t}^{\frac{\gamma-1}{\gamma}} di\right)^{\frac{\gamma}{\gamma-1}} \tag{3.44}$$

Where $C_{i,t}$ is defined as

$$C_{i,t} = \left(\int_0^1 C_{i,t}(j)^{\frac{\varepsilon-1}{\epsilon}} dj\right)^{\frac{\varepsilon}{\epsilon-1}} \tag{3.45}$$

γ the measures for substitution between goods which are produced by different foreign countries.

Households try to minimize the cost of achieving the level of the composite consumption good by achieving the least expensive combinations of both domestic and foreign goods.

$$L = \int_0^1 P_{H,t}(j) C_{H,t} dj - \psi_t \left[\left(\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\epsilon}} dj\right)^{\frac{\varepsilon}{\epsilon-1}} - C_{H,t}\right] \tag{3.46}$$

First order condition gives the following demand functions for domestically produced goods and foreign goods demanded by the domestic consumers

$$C_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon} C_{H,t} \tag{3.47}$$

$$C_{i,t}(i) = \left(\frac{P_{i,t}(i)}{P_{i,t}}\right)^{-\varepsilon} C_{i,t} \tag{3.48}$$

The expenditures allocated optimally and to be made on goods imported from different countries implies

$$C_{i,t} = \left(\frac{P_{i,t}}{P_{F,t}}\right)^{-\gamma} C_{F,t} \tag{3.49}$$

The expenditures allocated optimally between domestically produced goods and imported goods can be written as

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t \text{ ; and } C_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t \tag{3.50}$$

Where

$$P_t = \left[(1-\alpha)\left(P_{H,t}\right)^{1-\eta} + \alpha\left(P_{F,t}\right)^{1-\eta}\right]^{1/_{1-\eta}} \tag{3.51}$$

The overall consumption expenditures made by the households living in the domestic economy are written as

$$P_{H,t}C_{H,t} + P_{F,t}C_{F,t} = P_tC_t \tag{3.52}$$

Maximization of households' utility is subject to the following budget constraint

$$\int_0^1 \left(P_{H,t}(i)C_{H,t}(i) + P_{F,t}(i)C_{F,t}(i)\right) di + M_t + E_t\left(\vartheta_{t,t+1}D_{t+1}\right) \leq D_t + M_{t-1} + W_tN_t + \Gamma_t$$

$$P_tC_t + M_t + E_t\left(\vartheta_{t,t+1}D_{t+1}\right) \leq D_t + M_{t-1} + W_tN_t + \Gamma_t \qquad (3.53)$$

This budget constraint reflects the expenditures made on domestic and foreign goods. Households have also access to a complete set of contingent claims which are traded internationally. Money holdings and expenditures on buying securities (both domestic and foreign) are denominated in domestic currency units as the representative agent made his expenditures in domestic currency which is actually the realistic scenario. Most of the literature on NK DSGE models surrounds the same concept.

Households' maximization their utility based on the budget constraints prescribed above and the first order condition gives the following Euler equations.

$$C_t^{-\sigma} = \beta(1 + i_t)P_tE_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\right]$$

$$lnC_t = -\frac{1}{\sigma}ln\beta - \frac{1}{\sigma}lni_t + \frac{1}{\sigma}E_t\pi_{t+1} + \sigma E_tlnC_{t+1}$$

$$\hat{c}_t = E_t\hat{c}_{t+1} - \frac{1}{\sigma}\left(\hat{\imath}_t - E_t\pi_{t+1} - \rho\right) \qquad (3.54)$$

In equation (3.23), $\rho = -ln\beta$, the time discount rate, $\hat{\imath}_t$ represents the short term nominal interest rate and π_t represents the consumer price inflation rate. $\frac{1}{\sigma}$ is the inverse of degree of relative risk aversion.

$$\frac{N_t^{\varphi}}{C_t^{-\sigma}} = \left(\frac{W_t}{P_t}\right)$$

Log-linearizing equation the above equation gives

$$\varphi n_t + \sigma c_t = w_t - p_t \tag{3.55}$$

It represents that $MRS_{L,C}$ is equal to real wage.

LM equation can be retrieved as follows

$$\frac{\gamma\left(\frac{M_t}{P_t}\right)^{-b}}{C_t^{-\sigma}} = \left[\frac{i_t}{(1+i_t)}\right] \tag{3.56}$$

Relationship between Domestic Inflation, Consumer Price Inflation, the Terms of Trade and the Real Exchange Rate

Bilateral terms of trade between domestic country and country i can be defined as

$$S_{i,t} = \frac{P_{i,t}}{P_{H,t}}.$$

The effective terms of trade are given as:

$$S_t \equiv \frac{P_{F,t}}{P_{H,t}}$$

The effective terms of trade can be approximated around symmetric steady state as

$s_t = \int_0^1 s_{i,t}\, di$ where

$$s_t \equiv p_{F,t} - p_{H,t}\,. \tag{3.57}$$

Similarly, log-linearization of the CPI formula around its symmetric steady state yields

$$p_t = (1-\alpha)p_{H,t} + \alpha p_{F,t}$$

$$p_t = p_{H,t} + \alpha(p_{F,t} - p_{H,t})$$

$$p_t = p_{H,t} + \alpha s_t \tag{3.58}$$

It implies that the above equation can be translated into equation for inflation as

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t \tag{3.59}$$

Assuming validity of law of one price for individual goods implies that

$$P_{i,t}(j) = \varepsilon_{i,t} P_{i,t}^{i}(j) \qquad \forall\, i, j \in [0,1] \tag{3.60}$$

$\varepsilon_{i,t}$ is the bilateral nominal exchange rate and $P_{i,t}^{i}(j)$ is the price of country $i's$ good j expressed in terms of its own currency.

Incorporating the assumption of law of one price into the definition of $P_{F,t}$ yields

$$P_{F,t} = \varepsilon_{i,t} P_{i,t}^{i} \tag{3.61}$$

The law of one price applies to individual commodities whereas PPP applies to the general price level. Assuming validity of law of one price implies that

$$P_{i,t}(j) = \varepsilon_{i,t} P_{i,t}^{i}(j) \qquad \forall\, i, j \in [0,1]$$

$\varepsilon_{i,t}$ is the bilateral nominal exchange rate and $P_{i,t}^{i}(j)$ is the price of country $i's$ good j expressed in terms of its own currency. The law of one price allows the domestic currency price of foreign goods to be expressed as $p_{F,t} = e_{i,t} + p_t^*$ and if law of one price does not hold (incomplete pass-through) then $p_{F,t}$ and $e_{i,t} + p_t^*$ can differ. This difference measures the deviation from Law of One Price. Invalriditity of Law of One Price may be due to nominal rigidity in the price of imports considering Calvo-type model of price adjustment. In this situation, marginal cost will comprise of output gap and the difference between $p_{F,t}$ and $e_{i,t} + p_t^*$ as shown by Monacelli (2005) and explained by Walsh (3rd edition, pages 442-43). Adolfson (2001), Corsetti and Presenti (2002), and Monacelli (2005) provided examples of models that allow for incomplete exchange rate pass-through. When the pass-through is incomplete, the law of one price no longer holds. Following Monacelli (2005), the real exchange rate can be written as $q_t = e_t + p_t^* - p_t$

The law of one price allows the domestic currency price of foreign goods to be expressed as $p_{F,t} = e_{i,t} + p_t^*$ and if law of one price does not hold (incomplete pass-through) then $p_{F,t}$ and $e_{i,t} + p_t^*$ can differ. This difference measures the deviation from Law of One Price. Invaliditity of Law of One Price may be due to nominal rigidity in the price of imports considering Calvo-type model of price adjustment. In this situation, marginal cost will comprise of output gap and the difference between $p_{F,t}$ and $e_{i,t} + p_t^*$ as shown by Monacelli (2005) and explained by Walsh (3rd edition, pages 442-43).

The cost of reducing exchange rate volatility may be a function of the lags with which exchange rate movements affect prices, i.e., of the degree of pass-through. Intuitively, the lower the degree of pass-through, the smaller (ceteris paribus) the cost of short-run relative price sluggishness.

The standard version of the PPP theory implies that a country with an appreciating (depreciating) currency should experience a proportional decrease (increase) in prices in the long run (Rogoff, 1996) and the pass-through effect is equal to unity. However, empirical studies rarely confirm the standard version of the PPP theory. On the other hand, the relative version of the PPP theory assumes that the relation between price levels of baskets of similar goods across countries should be constant and not necessarily equal to one. PPP states that percentage change in the nominal exchange rate between two currencies should just offset the inflation differential between these countries thus the relative purchasing power of the two currencies kept constant. The basic idea is that international goods arbitrage leads to equalization of the prices of tradable goods which empirically seem to be relevant in the long run only (for an overview see, e.g., Taylor and Taylor (2004)).

The purchasing power parity puzzle in this context refers to the surprisingly weak empirical connection between exchange rates and national price levels (Rogoff, 1996). Reasons for the empirical failure of holding the PPP are obvious for the short time horizon, e.g. nominal rigidities are combined with highly volatile nominal exchange rates as in Dornbusch's (1976) overshooting model and differences in productivity growth between countries as captured in the Balassa-Samuelson effect[6].

When PPP does not hold, real exchange rate changes affect the aggregate demand. So, it also affects the interest rate reaction function accordingly.

Notwithstanding their empirical weaknesses, PPP and/ or UIP are frequently used as concepts in monetary policy analysis in open economies. The researcher contributes in the present literature of Pakistan by analyzing in a unified framework as to how these two concepts and possible alternatives used in the literature affect monetary policy. More

[6] An economic model which predicts the Penn effect (consumer price levels are systematically higher in rich countries) considering the assumption that productivity vary more by country in the sectors of traded goods than in other sectors.

specifically, the implications for the interest rate reaction function describing monetary policy responses to shocks under flexible inflation targeting are examined, thereby, useful insights into the consequences of using the simple but empirically problematic concepts of PPP and UIP in monetary policy analysis are provided.

The main insight is that the interest rate reaction function is affected when PPP and UIP are relaxed. As long as PPP holds, monetary policy reacts only to cost-push shocks and excess-demand shocks.

If, however, PPP does not hold, monetary policy also fully offsets the effects of foreign shocks. Furthermore, not the direction but the strength of the inter-state response to cost-push shocks and excess-demand shocks are affected. Whether the relation between interest rates and exchange rates is described by uncovered inter-state parity or in the more generic way, as proposed by Ball (1999), exchange rate does affect both to which type of shocks monetary policy responds and how strong the response is.

where, $P_{i,t}^{i} = \left(\int_0^1 P_{i,t}^{i}(j)^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}$ is the country $i's$ domestic price index. Substitute into equation (3.61) and then log-linearizing gives

$$p_{F,t} = \int_0^1 \left(e_{i,t} + p_{i,t}^{i}\right) di$$

$$p_{F,t} = e_{i,t} + p_t^* \tag{3.62}$$

p_t^* is the world price index

Plugging equation (3.62) into equation (3.57)

$$s_t = e_{i,t} + p_t^* - p_{H,t} \tag{3.63}$$

Bilateral real exchange rate can be defined as $Q_{i,t} \equiv \frac{\varepsilon_{i,t} P_t^i}{P_t}$.

Let $q_t \equiv \int_0^1 q_{i,t}\, di$ be the effective real exchange rate, where $q_{i,t} = logQ_{i,t}$

It follows that

$$q_t \equiv \int_0^1 \left(e_{i,t} + p_t^i - p_t\right) di$$

$$q_t = e_t + p_t^* - p_t$$

From equation (3.63), we know that

$$s_t + p_{H,t} = e_{i,t} + p_t^*$$

Hence

$$q_t = s_t + p_{H,t} - p_t$$

As from equation (3.58) $-\alpha s_t = p_{H,t} - p_t$ so

$$q_t = (1-\alpha)s_t \tag{3.64}$$

$$s_t = \left(\frac{1}{1-\alpha}\right) q_t \tag{3.65}$$

Adolfson (2001), Corsetti and Presenti (2002), and Gali and Monacelli (2005) provided examples of models that allow for incomplete exchange rate pass-through. When the pass-through is incomplete, the law of one price no longer holds.

Net exports in terms of s_t can be expressed as

$$nx_t = \alpha\left(\frac{\omega}{\sigma} - 1\right)s_t \tag{3.66}$$

Substituting value of s_t from equation (3.65) in equation (3.66) yields

$$nx_t = \alpha\left(\frac{\omega}{\sigma} - 1\right)\left(\frac{1}{1-\alpha}\right)q_t \tag{3.67}$$

As discussed by Gali and Monachelli (2005), net exports depend negatively on the real exchange rate

$$E_t(nx_{t+1}) = \alpha\left(\frac{\omega}{\sigma} - 1\right)\left(\frac{1}{1-\alpha}\right)E_t(q_{t+1}) \tag{3.68}$$

Now subtract equation (3.67) from equation (3.68)

$$E_t(\Delta nx_{t+1}) - nx_t = \alpha\left(\frac{\omega}{\sigma} - 1\right)\left(\frac{1}{1-\alpha}\right)[E_t(q_{t+1} - q_t]$$

$$E_t(\Delta nx_{t+1}) = -\alpha\left(1 - \frac{\omega}{\sigma}\right)\left(\frac{1}{1-\alpha}\right)[E_t(\Delta q_{t+1}]$$

$$E_t(\Delta nx_{t+1}) = -\upsilon[E_t(\Delta q_{t+1})] \tag{3.68}$$

3.3.2 International Risk Sharing

The Euler equation for the household representing any other country, assuming securities market is complete. Since households in the rest of the world also have access to these same financial securities, therefore, intertemporal optimization condition implies that

$$\frac{1}{(1+i_t)} = \beta\left(\frac{P_t}{P_{t+1}}\right)\left(\frac{Q_{i,t}}{Q_{i,t+1}}\right)\left[\frac{C^f{}_{t+1}}{C^f{}_t}\right]^{-\sigma} \quad (3.69)$$

Reproducing equation (3.22) as equation (3.70) below for ready reference:

$$\frac{1}{(1+i_t)} = \beta\left(\frac{P_t}{P_{t+1}}\right)\left[\frac{C_{t+1}}{C_t}\right]^{-\sigma} \quad (3.70)$$

Equating equations (3.69) and (3.70)

$$\beta\left(\frac{P_t}{P_{t+1}}\right)\left[\frac{C_{t+1}}{C_t}\right]^{-\sigma} = \frac{1}{(1+i_t)} = \beta\left(\frac{P_t}{P_{t+1}}\right)\left(\frac{Q_{i,t}}{Q_{i,t+1}}\right)\left[\frac{C^f{}_{t+1}}{C^f{}_t}\right]^{-\sigma}$$

$$\left[\frac{C_t}{C_{t+1}}\right]^{\sigma} = \left(\frac{Q_{i,t}}{Q_{i,t+1}}\right)\left[\frac{C^f{}_t}{C^f{}_{t+1}}\right]^{\sigma}$$

$$\left[\frac{C_t}{C_{t+1}}\right] = \left(\frac{Q_{i,t}}{Q_{i,t+1}}\right)^{\frac{1}{\sigma}}\left[\frac{C^f{}_t}{C^f{}_{t+1}}\right]$$

$$C_t = C^f{}_t\, Q_{i,t}{}^{\frac{1}{\sigma}}\left(\frac{C_{t+1}}{Q^{\frac{1}{\sigma}}{}_{i,t+1}C^f{}_{t+1}}\right)$$

$$C_t = \tau C^f{}_t\, Q_{i,t}{}^{\frac{1}{\sigma}}$$

If we impose zero net foreign asset holdings condition, then $\tau = 1$

Linear approximation around the steady state gives

$$c_t = c_t^* + \left(\frac{1}{\sigma}\right) q_t \qquad (3.71)$$

International risk sharing condition links the domestic consumption to world consumption and terms of trade or authentic efficacious exchange rate. It implicatively insinuates that domestic consumption is a function of international consumption instead of economy's own current, lagged or lead income due to consummate financial markets. It signifies that in distress (Recession) economic agents can borrow from rest of the world through financial institutions to finance consumption and recompense in good days (Boom).

3.3.3 Uncovered Interest Parity

It is derived from arbitrage in international financial markets and can be written as.

$$q_t = (i^*_t - E_t \pi^*_{t+1}) - (i_t - E_t \pi_{t+1}) + E_t q_{t+1} \qquad (3.72)$$

Thus UIP yields the equality between domestic nominal interest rate and the foreign nominal interest rate given that the expected rate of depreciation in the domestic currency is added with the foreign nominal interest rate.

As the underlying assumptions of risk neutral investors and no country specific risk may be too restrictive, in general, a time-varying risk premium is included.

3.3.4 Relaxing Uncovered Interest Rate Parity

UIP makes a seemingly innocent claim: expected rates of return on interest-bearing assets (taking into account exchange rate movements) across countries must be equal (complete international capital markets). If not, this sets into motion forces that restore the equality. But, despite the simplicity and elegance of this theory, empirical tests have shown little support for this pillar of the Neo Classical approach to global capital flows. McCallum (1994) explains the apparent empirical failure of uncovered interest rate parity based on the hypothesis that interest rate differential is managed by central banks to avoid frequent exchange rate fluctuations. So it is likely to be more preferable to use more common approach to describe the relationship between exchange rate and the interest rate.

Despite the fact that uncovered interest rate parity is frequently rejected in empirical studies; an overview is provided by Froot and Thaler (1990) and McCallum (1994). In this context, the exchange rate disconnect puzzle describes the more general, weak relation between the exchange rate and virtually any domestic macroeconomic variable. The related forward premium puzzle states that the forward premium incorrectly predicts the direction of future changes in the exchange rate, implying that UIP does not hold (holds only if individuals are risk neutral), Obstfeld and Rogoff (2000) and McCallum (1994).

Abstracting from rational expectations or assuming that the time-varying risk premium is negatively correlated with an expected depreciation may explain the empirical facts; see Froot and Thaler (1990). McCallum (1994) explains the apparent empirical failure of uncovered interest rate parity based on the hypothesis that interest rate differential is managed by central banks to avoid frequent exchange rate fluctuations. So it is likely to be more preferable to use more common approach to describe the relationship between exchange rate and the interest rate. Following Ball (1999), it may be proposed that we may ease the UIP condition and apply simple approach that just shows the proportionate relation between exchange rate and real interest rate. $\epsilon_t^{rp}$is a random shock which captures the effect of every exogenous variable that can affect the real exchange rate, like confidence on the part of investors, expectations, foreign interest rate etc.

$$q_t = E_t q_{t+1} - \omega_1(i_t - E_t \pi_{t+1}) + \epsilon_t^{rp} \tag{3.73}$$

A rise in real interest rate will lead to appreciation in real exchange rate making domestic assets more attractive for the foreign and domestic investors. ϵ_t^{rp} is autoregressive term. Equation (3.73) may also be criticized due to insight that random term captures the effect of many terms thus emerges with no possibility of extracting the influence of factors moving the random term. But in spite of all this, worth noting is the equation that seems to be a good option where UIP does not hold.

3.3.5 Relaxing Purchasing Power Parity Condition

PPP states that percentage change in the nominal exchange rate between two currencies should just offset the inflation differential between these countries thus the relative purchasing power of the two currencies kept constant. The basic idea is that international goods arbitrage leads to equalization of the prices of tradable goods which empirically seem to be relevant in the long run only (Taylor and Taylor, 2004).

The purchasing power parity puzzle in this context refers to the surprisingly weak empirical connection between exchange rates and national price levels (Rogoff, 1996). Reasons for the empirical failure of holding the PPP are obvious for the short time horizon, e.g. nominal rigidities are combined with highly volatile nominal exchange rates as in Dornbusch's (1976) overshooting model and differences in productivity growth between countries as captured in the Balassa-Samuelson effect.

When PPP does not hold, real exchange rate changes affect the aggregate demand. So, it also affects the interest rate reaction function accordingly.

Notwithstanding their empirical weaknesses, PPP and/ or UIP are frequently used as concepts in monetary policy analysis in open economies. The researcher contributes in the present literature of Pakistan by analyzing in a unified framework as to how these two concepts and possible alternatives used in the literature affect monetary policy. More specifically, the implications for the interest rate reaction function describing monetary policy responses to shocks under flexible inflation targeting are examined, thereby, useful insights into the consequences of using the simple but empirically problematic concepts of PPP and UIP in monetary policy analysis are provided.

The main insight is that the interest rate reaction function is affected when PPP and UIP are relaxed. As long as PPP holds, monetary policy reacts only to cost-push shocks and excess-demand shocks.

If, however, PPP does not hold, monetary policy also fully offsets the effects of foreign shocks. Furthermore, not the direction but the strength of the inter-state response to cost-push shocks and excess-demand shocks are affected. Whether the relation between interest rates and exchange rates is described by uncovered inter-state parity or in the more generic way, as proposed by Ball (1999), exchange rate does affect both to which type of shocks monetary policy responds and how strong the response is.

3.3.6 Firms' Decision

Inflation dynamics play an important role in the NK paradigm thus it is the most distinguishing feature which is incorporated in the NK Phillips curve and is based on the model presented by Calvo (1983). It demonstrates that inflation is determined on the basis of two factors, that is, the expected future inflation and firm's real marginal costs. Clarida *et al.* (1999) extended Calvo's model to hybrid NK Phillips Curve (HNKPC). They allowed a specific percentage of firms to be backward looking.

Literature on NK Phillips Curve centered around two main issues. First, which measures can be appropriate in order to account for real activity. Second, expectations are a crucial element which can affect the results.

Firms maximize their profits, subject to three constraints. The first is the demand function, given in equation (3.50), the second is the production function and the third constraint is that in every period, not all firms adjust their prices. Consider that labor is the only variable factor of production. Thus $Y_{j,t} = Z_t N_{j,t}$

$Z_t$is the country specific aggregate productivity disturbance which is assumed to be stochastic with constant returns to scale, that is, $E(Z_t) = 1$

Aggregate output can be defined as

$$y_t = z_t + n_t$$

Firm j minimize cost subject to producing the firm specific good $Y_{j,t}$. First order condition yields the following

$$MC_t = \varphi_t = \frac{\left(\frac{W_t}{P_{H,t}}\right)}{Z_t}$$

$$mc_t = \widetilde{w}_t - \widetilde{p}_{H,t} - \widetilde{z}_t \qquad (3.74)$$

Firms who maximize their profits set the new price $P^*_{j,t}$ in period t base their decision on the following demand function.

$$Y_{H,t} \leq \left(C_{H,t+k} + C_{F,t+k}\right) \leq C_{t+k}\left[\frac{P^*_{j,t}}{P_{t+k}}\right]^{-\eta} \qquad (3.75)$$

Calvo price assumption prevails.

The discount factor

$$\Delta_{K,t+1} = \frac{1}{(1+i_t)} = \beta E_t\left[\frac{C_{t+1}^{-\sigma}}{C_t^{\ -\sigma}}\right]\left[\frac{P_t}{P_{t+1}}\right]$$

Setting $\left(\frac{P_t}{P_{t+1}}\right) = 1$

$$\Delta_{K,t+k} = \frac{1}{(1+i_t)} = \beta E_t\left[\frac{C_{t+1}^{-\sigma}}{C_t^{\ -\sigma}}\right] \qquad (3.76)$$

Firms have to take into account the future demand elasticities when setting prices.

Now substitute demand function presented in equation (3.74) in profit function

$$\sum_{k=0}^{\infty} E_t\left[(\theta_t)^k\left\{\Delta_{k,t+k}\left(C_{t+k}\left[P^*_{j,t}{}^{(1-\eta)}\left(\frac{1}{P_{t+k}}\right)^{1-\eta}-\varphi_{t+k}P^*_{j,t}{}^{-\eta}\left(\frac{1}{P_{t+k}}\right)^{-\eta}\right]\right)\right\}\right]=0$$

First order condition, with respect to $P^*_{j,t}$, gives

$$\sum_{k=0}^{\infty} E_t\left[(\theta_t)^k\Delta_{k,t+k}\left(C_{t+k}\left[(1-\eta)\left(\frac{P^*_{j,t}}{P_{t+k}}\right)+\eta\varphi_{t+k}\right]\left(\frac{1}{P^*_{j,t}}\right)\left(\frac{P^*_{j,t}}{P_{t+k}}\right)^{-\eta}\right)\right]=0 \tag{3.77}$$

Put value of $\Delta_{k,t+k}$ from equation (3.76) and rearranging the above equation will gives

$$\frac{P^*_{j,t}}{P_t}=\left(\frac{\eta}{1-\eta}\right)\frac{E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k(C_{t+k})^{1-\sigma}\varphi_{t+k}\left(\frac{P_{t+k}}{P_t}\right)^{\eta}}{E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k(C_{t+k})^{1-\sigma}\left(\frac{P_{t+k}}{P_t}\right)^{\eta-1}} \tag{3.78}$$

This is optimal price setting rule for firms facing sticky price where $\left(\frac{\eta}{1-\eta}\right)$ the mark is up. Now consider the case where all firms adjust their prices thus $\theta_t = 0$, Equation (3.78) reduces to the following

$$\frac{P^*_{j,t}}{P_t}=\left(\frac{\eta}{1-\eta}\right)\varphi_t \tag{3.79}$$

Keeping into consideration the definition of $P_{H,t}$ and the assumption of Calvo pricing, price index in log-linearized form is the average of the price $P^*_{j,t}$ adjusted in period t and the price index from the prior period as

$$p_t=(1-\theta_t)p^*_{j,t}+\theta_t p_{t-1} \tag{3.80}$$

The above equation shows the general price level in steady state which is weighted average of the firms which adjust their prices each period, $(1-\theta_t)$ and θ_t firms do not adjust their price. Out of $(1-\theta_t)$ firms that do adjust their price, $(1-\omega)$ firms set price in forward looking manner and the remaining ω firms behave in a backward looking way toward price adjustment. So

$$p^*_t = (1-\omega)p^f_t + \omega(p^*_{t-1} + \pi_{t-1})$$

$$1 = (1-\theta_t)\left(\frac{P^*_{j,t}}{P_t}\right)^{1-\rho} + \theta_t\left(\frac{P_{t-1}}{P_t}\right)^{1-\rho} \quad (3.81)$$

Log-linearizing gives

$$log\left(\frac{P^*_{j,t}}{P_t}\right) = \left(\frac{\theta_t}{1-\theta_t}\right)\pi_t \quad (3.82)$$

Firms' optimal price setting rule (equation 3.78) can now be rewritten as

$$\left[E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k(C_{t+k})^{1-\sigma}\left(\frac{P_{t+k}}{P_t}\right)^{\eta-1}\right]F_t = \mu\left[E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k(C_{t+k})^{1-\sigma}\varphi_{t+k}\left(\frac{P_{t+k}}{P_t}\right)^{\eta}\right] \quad (3.83)$$

Where $F_t = \left(\frac{P^*_{j,t}}{P_t}\right)$ and $\mu = \left(\frac{\eta}{1-\eta}\right)$

Both sides of equation (3.83) can be approximated by using Taylor series rule

$$\left(\frac{1}{1-\theta_t\beta}\right)\hat{f}_t = \sum_{k=0}^{\infty}(\beta\theta_t)^k\left[E_t\hat{\varphi}_{t+k} + E_t\hat{p}_{t+k} - \hat{p}_t\right]$$

$$\hat{f}_t = (1-\theta_t\beta)\sum_{k=0}^{\infty}(\beta\theta_t)^k\left[\left(E_t\hat{\varphi}_{t+k} + E_t\hat{p}_{t+k}\right) - \hat{p}_t\right]$$

Finally, it gives in a two period framework

$$\hat{f}_t = (1-\theta_t\beta)\hat{\varphi}_t + \theta_t\beta\left(E_t\hat{\varphi}_{t+1} + E_t\pi_{t+1}\right) \quad (3.84)$$

Variables with hat denote log-linear deviations from the steady state wherein $\pi_t = 0$, $f_t = 0, F = 1$

From equation (3.79), the situation where all firms adjust their prices, and equation (3.82)

$$log\left(\frac{P^*_{j,t}}{P_t}\right) = \left(\frac{\eta}{1-\eta}\right)\hat{\varphi}_t = \left(\frac{\theta_t}{1-\theta_t}\right)\pi_t \quad (3.85)$$

$$\left(\frac{\theta_t}{1-\theta_t}\right)\pi_t = (1-\theta_t\beta)\hat{\varphi}_t + \theta_t\beta\left(\left(\frac{\theta_t}{1-\theta_t}\right)E_t\pi_{t+1} + E_t\pi_{t+1}\right) \quad (3.86)$$

$$\left(\frac{\theta_t}{1-\theta_t}\right)\pi_t = (1-\theta_t\beta)\hat{\varphi}_t + \theta_t\beta\left(\left(\frac{1}{1-\theta_t}\right)E_t\pi_{t+1}\right) \quad (3.87)$$

$$\pi_t = \lambda\hat{\varphi}_t + \beta_1 E_t(\pi_{t+1}) \quad (3.88)$$

$$mc_t = (\widetilde{w}_t - p_t) + (p_t - \tilde{p}_{H,t}) - \tilde{z}_t + \epsilon_t^c$$

Using equation (3.55) and equation (3.58) gives

$$mc_t = \varphi n_t + \sigma c_t + \alpha s_t - z_t + \epsilon_t^c$$

$$mc_t = \varphi y_t + \sigma c_t + \frac{\alpha}{(1-\alpha)}q_t - (1+\varphi)z_t + \epsilon_t^c \quad (3.89)$$

Substituting the value of c_t and then using the concept of flexible output as discussed in open economy framework will give the following equation for marginal cost.

$$mc_t = \beta_2 x_t + \beta_3 q_t + \epsilon_t^c \quad (3.90)$$

It will finally give us the NK Phillips curve of the form

$$\pi_t = \beta_1 E_t\pi_{t+1} + \beta_2 x_t + \beta_3 q_t + \epsilon_t^c \quad \textbf{(3.91)}$$

Above equation shows that CPI inflation (π) depends on inflation expectations, domestic output gap (x_t) and ϵ_t^c is the cost-push shock, which can be described by $\epsilon_t^c = \mu\epsilon_{t-1}^c + \hat{e}_t$.

Inflation expectations play central role in the Phillips curve models. At long time horizons, inflation expectations may be a sign of monetary authority's credibility to the fulfillment of commitment to price stability.

Someone may speculate that increased trade boost productivity growth by increasing competition in foreign market for the domestic producers which in turn downshifts inflation which actually happens in America in the 1990's but this hypothesis may not be supported by the facts for all the other countries. In the same way, variations in net exports may influence the inflation and economic growth in the country. Kohn (2006) points out, "a more open economy may be more forgiving as shortfalls or excesses in demand are partly absorbed by other countries through adjustments in our imports and exports."

Equations (3.69) and (3.91) form aggregate demand-aggregate supply model which have been derived from the optimizing behavior of firms and households and the price adjustment mechanism. This is the central bank that controls interest rate. Further, interest parity condition and monetary policy rule or interest rate rule can be added to the model, which renders the system to be stable.

Deriving IS Equation

As $Y_t = C_t + NX_t + G_t$

$$\hat{c}_t = y_t - nx_t - g_t = E_t(y_{t+1} - nx_{t+1} - g_{t+1}) - \left(\frac{1}{\sigma}\right)(i_t - E_t\pi_{t+1} - \rho)$$

$$y_t = E_t(y_{t+1} - nx_{t+1} + nx_t - g_{t+1} + g_t) - \left(\frac{1}{\sigma}\right)(i_t - E_t\pi_{t+1} - \rho)$$

$$y_t = E_t(y_{t+1}) - E_t(nx_{t+1} - nx_t) - E_t(g_{t+1} - g_t) - \left(\frac{1}{\sigma}\right)(i_t - E_t\pi_{t+1} - \rho)$$

$$y_t = E_t(y_{t+1}) - E_t(nx_{t+1} - nx_t) - E_t(g_{t+1} - g_t) - \left(\frac{1}{\sigma}\right)(i_t - E_t\pi_{t+1} - \rho)$$

Using $x_t \equiv y_t - y_t^p$, where x_t is output gap, then the above equation can be written as

$$y_t - y_t^p = E_t(y_{t+1} - y_{t+1}^p) - E_t(\Delta nx_{t+1}) + E_t(\Delta y_{t+1}^p - \Delta g_{t+1})$$
$$- \left(\frac{1}{\sigma}\right)(i_t - E_t\pi_{t+1} - \rho)$$

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \upsilon E_t(q_{t+1} - q_t) + \epsilon_t^f \quad (3.92)$$

IS curve shows that domestic output gap depends inversely on the real interest rate, $[i_t - E_t\pi_{t+1}]$ directly to the future output gap $(E_t x_{t+1})$ and the differential between expected exchange rate and the current exchange rate $E_t(\Delta q_{t+1})$.

ϵ_t^f is excess fiscal (demand) shock which is described by $\epsilon_t^f = \mu\epsilon_{t-1}^f + \hat{e}_t$, where μ ranges from 0 to 1, and $\hat{e}_t$ is an independently and identically distributed random variable with expected value zero and constant variance. Real exchange rate is $q_t \equiv e_t + p_t^* - p_t$ where e_t represents the exchange rate in nominal terms, p_t^* is the log of foreign prices. This exchange rate channel is introduced to capture open economy aspects.

Depreciation of domestic currency increases exports and restrains imports thus depreciation in local currency is expected to increase aggregate demand of domestically produced goods (due to increase in exports). If a country has larger share of exports and imports, it reflects that greater change in net exports will lead to greater changes in GDP as a result of change in the exchange rate. So depreciation of exchange rate leads to high inflation rates. The reverse process will be true in case of contractionary monetary policy and depreciation of domestic currency.

Depreciation in domestic Currency $\rightarrow \uparrow$X, $\downarrow$ M $\rightarrow$ $\uparrow$Nx $\rightarrow$ $\uparrow$AgD $\rightarrow$ $\uparrow$Inf.

3.3.7 Monetary policy objective

Monetary policy, in the short run, aims to achieve stability in prices, reducing real economic fluctuations and stability in exchange rate. Thus an additional term may be added to the loss function described in equation (3.38). Following procedure described from equation (3.38) to equation (3.41), the following interest rate rule has emerged.

$$i_t = \gamma_4 + \gamma_1 E_t \pi_{t+1} + \gamma_2 x_t + \gamma_3 E_t(\Delta q_{t+1}) + \epsilon_t^i \quad \textbf{(3.93)}$$

3.4 SUMMARY

Closed economy and open economy models have been derived based on the optimization of households, firms and the central bank. New Keynesian perspective allowed the researcher to incorporate the expected price and expected exchange rate in a forward looking way. Thus derived models in the preceding pages avoid critique New Classical Economists of 1970s. Nominal rigidities both in goods and labour markets do prevail. PPP and UIP conditions are relaxed.

CHAPTER 4

METHODOLOGY AND IDENTIFYING RESTRICTIONS

4.1 INTRODUCTION

Structural Vector Autoregressive (SVAR) model, introduced in 1980, replaced the then prevailing large scale models which became doubtful and heavily criticized considering their theoretical and empirical foundations, poor prediction power, identification, dynamics, non-stationarity and modeling of the expectation on ad hoc basis. However, initially very little attention has been paid to identify the potential causal effects in the actual data thus theoretical foundations were weak in SVAR methodology. Due to this inability of the SVAR models literature continuously evolved since early 1990s. Considering the reduced form VAR models as a first step, various approaches have been adopted to identify the structural shocks using dynamics of models for short and long run.

Sims (1980) while stressing on the simultaneous equation models rather than single equation models proposed an alternative to the traditional dynamic simultaneous equation models and named it VAR model. There is bulk of research on specification and estimation of the VAR models wherein success of VAR models as forecasting tools is well established (see Luetkepohl, 2011).

Keating (1990) developed a two-step procedure, estimating unrestricted VAR model and then FIML estimation, and named this approach as SVAR that we followed here. Leu (2011) is the first one to follow this approach for estimation of NK model. Gali (1999)[7] viewed that SVAR models are as informative as DSGE modeling. Blanchard and Gali (2008) employ SVAR model to investigate the impact of oil price shocks. Canova (2005) in his book "Methods for Applied Macroeconomic Research" has discussed employing SVAR model on DSGE models and made deliberations on the cautions, for example, "...to give a structural interpretation to the estimated relationships, economic theory needs to be used..." SVARs solve the problem of interpreting VARs by introducing restrictions sufficient to identify the underlying shocks thus provide a coherent interpretation of the shocks to the system. SVARs are robust as this methodology provides efficient and consistent estimates.

Cooley and Leroy (1985) argue that VAR models can be used to describe the dynamic properties of the time series data only due to their atheoretical nature. These models are challenging to understand and interpret without revealing specific economic structure. Hence such coefficients are needed to relate to the deep structural parameters characterizing consumer preferences and state of the technology. In response, there comes the emergence of the structural or identified VAR models by Sims (1986), Shapiro and Watson (1988) and Bernanke (1986) wherein the focus remains on the VAR residuals. However, literature appears to be disagreed to recover the true structure from VAR residuals due to requiring various assumptions.

[7] Gali, Jordi, (1999). Technology, employment, and the business cycle: do technology shocks explain aggregate fluctuations?," *American Economic Review* 89(1), 249-271.

Moreover, a number of identification schemes have been proposed. The strategy regarding short-run restrictions includes choleski recursive scheme by Lutkepohl (1993) and Keating (1990, 2000) and Bernanke (1986). Similarly Blanchard and Quah (1989) introduced the concept of long-run restrictions. However, Christiano, Eichenbaum and Vigfusson (2006) among others found that the long-run restrictions are not suitable to identify the true dynamics of the economy due to truncation bias.

Canova and De Nicolo (2002) and Uhlig (2005) introduced the sign restrictions scheme on the structural shocks. After the introduction of restriction or qualitative restriction approach, the VAR and DSGE models become more compatible and comparable. However, this approach fails to bring a unique solution of the system and a range of responses can be obtained. Large uncertainties regarding estimates of the model make it least applicable for policy inferences.

Structural Vector Autoregressive (SVAR) model is often used to analyze the transmission of structural shocks. This is mainly due to the argument presented by Bernanke and Mihov (1998) that tracing the dynamic replication of the economy to a monetary policy innovation delivers an appropriate way of observing the effects of policy changes under minimal identifying posits justifies the prominence of the VAR-predicated approach on monetary policy shocks. Earlier VAR studies overlooked decomposition of forecast errors into mutually uncorrelated structural shocks which may have an economic explanation. These studies mainly relied on ad-hoc assumptions for identification purpose thus criticized due to the atheoretical nature (see, Cooley and Leroy, 1985). This flaw in reduced form VAR models motivated the researchers to develop SVAR approach as dictated by Bernanke (1986), Sims (1986) and Keating (1990) along with others. Main feature of the SVAR models is the use of economic theory to impose restrictions that end up with more reliable results than reduced form VAR models. With the passage of time various approaches have emerged to identify the structural shocks.

Keeping in view the short run dynamics of DSGE models, SVAR models have been considered as workhorse for estimation purpose. SVAR models have various applications. First, these are employed to investigate the average response of macroeconomic variables to a given structural shock. Second, these allow constructing variance decomposition which quantifies the contribution of structural shocks to the variations in the variables. Then, historical decomposition and forecast scenario of future structural shocks are also important applications of the SVAR models as used by Edelstein and Kilian (2009) and Baumeister and Kilian (2012a) respectively. SVAR models also furnish structural parameter estimates. However, most of the literature focused on the first two applications.

Section 4.2 reviews the conditions to make the SVAR models and DSGE models compatible and then proposes a procedure to follow for identifying the closed and open economy models derived in the previous chapter. In section 4.3, restrictions of the considered models are identified. Section 4.4 highlights the procedure to estimate the models. Section 4.5 concludes the chapter.

4.2 RELATIONSHIP BETWEEN SVAR AND DSGE MODELS

Both DSGE models and SVAR models emerged after the failure of large scale models in the 1970s and critique on the then prevailing models by Lucas and Dornbusch among others. DSGE models were developed on the basis of strong assumptions about the functional forms, exogeneity, market structure and dynamic structure of the constraints. SVAR models were initially proposed with minimal restrictions on the dynamics of the endogenous variables. SVAR models impose cross equation restrictions so that models may be robust enough to capture the true structure of the economy in comparison with the alternative ad hoc models.

A very logical question at this stage is how to make these two modeling approaches compatible with each other. Gali (1999) viewed that SVAR models are as informative as DSGE modeling. According to Fernandez-Villaverde, Rubio-Ramirez, Sargent and Watson (2007), every DSGE model may not have SVAR representation that may not be treated in a way that SVAR models are deficient of theoretical support. The existence of a reduced form VAR model of finite number of lags is a necessary condition. However, the existence of SVAR model is a sufficient condition along with the existence of equal number of shocks of the log-linearized DSGE models and shocks of SVAR models. Many of the RBC models have only one shock, that is, technology shock wherein these models responded to this deficiency by adding more economic shocks, like fiscal shocks, monetary shocks etc., on ad-hoc basis or with clear structural interpretation. Another condition to estimate DSGE models through employing SVAR model is to impose restrictions which must be consistent with the DSGE model so that structural shocks may be identified appropriately. Canova and Paustian (2011) stressed that one should not be too skeptical about the identification process.

This discussion highlights the importance of caution to be exercised in estimating DSGE models through SVAR approach. There is possibility of facing more complications in identifying the structural shocks where forward looking behavior is incorporated in the structure of DSGE models. Keating (1990) proposed a procedure based on two-step for estimating the structural model having forward looking components. First step requires estimating unrestricted (reduced form) VAR model and second step is to use the parameters and residuals estimated in the first step in identified restrictions and then estimate the model through following maximum likelihood estimation procedure. It has also been discussed in detail that over identified models can be estimated efficiently if the restrictions are imposed on the entire VAR model otherwise the estimates will be consistent but not efficient. Keating (1990) also proposed a procedure to identify the restrictions of the models comprising forward looking components with two elaborating examples to justify the proposed procedure.

The closed economy and open economy models derived in the last chapter witnessed that structural shocks have been originated from the structure of the model and not the ad-hoc solution. The structural shocks are equal in number to the shocks required for estimating the model through SVAR model. If restrictions on structural shocks are identified on the basis of structural model then SVAR can be taken as true theoretical model. The procedure prescribed by Keating (1990) follows the same concept of deriving the identified restrictions along with providing the method to treat the forward looking variables. Thus following procedure prescribed by Keating (1990) will help make the SVAR models and DSGE models compatible with each other and estimates will be thought of as deep structural parameters. Therefore, we follow Keating (1990) to further the estimation of the models derived in the last chapter. Keating (2000) prescribed asymmetric SVAR model by allowing different lag order for endogenous and exogenous variables which is followed to estimate the open economy model.

Leu (2011), by following Keating (1990, 2000), estimated the structural VAR model for the Australian economy based on NK model that accounts for the forwarded looking behavior on the part of economic agents.

4.3 IDENTIFICATION OF RESTRICTIONS UNDER FORWARD LOOKING BEHAVIOR

The Lucas critique initiated the innovations in literature by deriving the models based on utility functions and the profit functions of the economic agents in an environment where agents form their expectations in a forward looking manner. Economic agents reformulate their expectations as and when there are changes in the policy by the government or by the SBP. These changes in the expectations result in poor guides for the policy makers to evaluate the new regime thus there is need to estimate the deep structural parameters which have the feature to be invariant to policy changes. Models with rational expectations derived through optimization by the agents have the ability to identify the rational expectations restrictions. By employing which, deep structural parameters can be estimated through maximum likelihood estimation procedure. Impulse response functions and variance decomposition can also be generated using the restrictions and the model is named as structural VAR model. Keating (1990) prescribed this procedure which has an additional feature of not restricting the lag dynamics.

Following the procedure to identify the restrictions, the structural model is converted into a representation comprising the structural shocks and the residuals of unrestricted VAR model along with structural parameters. Forward looking expectations are formulated through innovations of the dynamic economic structure.

4.3.1 Closed Economy Model

DSGE model conforming NK framework in closed economic environment derived in the previous chapter (equation 3.18, 3.37, 3.41) is reproduced below.

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \epsilon_t^f \quad (4.1)$$

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda_0 x_t + \epsilon_t^c \quad (4.2)$$

$$i_t = \gamma_3 + \gamma_1(E_t\pi_{t+1}) + \gamma_2 x_t + \epsilon_t^i \quad (4.3)$$

Subtracting the all the variables in the above equations from their expected value at time $t-1$ yields the following set of equations

$$x_t - E_{t-1}x_t = -\varphi(i_t - E_{t-1}i_t) + \varphi(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + (E_t x_{t+1} - E_{t-1}x_{t+1}) + \epsilon_t^f$$

$$(4.4)$$

$$\pi_t - E_{t-1}\pi_t = \beta(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + \lambda_0(x_t - E_{t-1}x_t) + \epsilon_t^c \quad (4.5)$$

$$i_t - E_{t-1}\pi_t = \gamma_1(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + \gamma_2(x_t - E_{t-1}x_t) + \epsilon_t^i \tag{4.6}$$

In the above equations, $y_t - E_{t-1}y_t$ for all the variables represent the respective reduced form residuals. However, $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$ and $(E_tx_{t+1} - E_{t-1}x_{t+1})$ are the forward looking components in the model and need to be estimated on the basis of contemporaneous observations of the variables. The procedure to calculate these forward looking components is elaborated as follows:

$$\begin{bmatrix} y_t \\ y_{t-1} \\ y_{t-2} \\ \vdots \\ y_{t-q+1} \end{bmatrix} = \begin{bmatrix} A_1 & A_2 & \cdots & \cdots & A_q \\ I_n & 0_n & \cdots & \cdots & 0_n \\ 0_n & I_n & 0_n & \cdots & 0_n \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0_n & \cdots & 0_n & I_n & 0_n \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{t-2} \\ y_{t-3} \\ \vdots \\ y_{t-q} \end{bmatrix} + \begin{bmatrix} I_n \\ 0_n \\ 0_n \\ \vdots \\ 0_n \end{bmatrix} e_t \tag{4.7}$$

$$Y_t = AY_{t-1} + Qe_t \tag{4.8}$$

One step conditional expectation of equation (4.8) can be written in form as follows.

$$E_tY_{t+1} = AY_t \tag{4.9}$$

It may be considered that the expected value of residuals is equal to zero, i.e. $E_t(e_t) = 0$.

As Y vector consists of all the endogenous variables, therefore to locate the variable of interest (output gap and inflation), there is need to introduce vectors of length nq where n denotes the number of endogenous variables and q denotes their lag order.

$r'_x = (1,0,0,\ldots,0)$ for the output gap

$r'_\pi = (0,1,0,\ldots,0)$ for inflation

Pre-multiplying equation (4.9) with the above vectors results in the following expected values of forward looking output gap and inflation.

$$\left.\begin{aligned} E_t x_{t+1} &= \acute{r}_x A Y_t \\ E_t \pi_{t+1} &= \acute{r}_\pi A Y_t \end{aligned}\right\} \quad (4.10)$$

Solving set of equations (4.10) yields the following equations.

$$E_t x_{t+1} = a_{11}^x x_t + a_{12}^x \pi_t + a_{13}^x i_t \quad (4.11)$$

$$E_t \pi_{t+1} = a_{11}^\pi x_t + a_{12}^\pi \pi_t + a_{13}^\pi i_t \quad (4.12)$$

It helps to calculate the expectations revision process for output gap $(E_t x_{t+1} - E_{t-1} x_{t+1})$ and inflation $(E_t \pi_{t+1} - E_{t-1} \pi_{t+1})$.

$$E_t x_{t+1} - E_{t-1} x_{t+1} = \acute{r}_x A (Y_t - E_{t-1} Y_t)$$

$$E_t x_{t+1} - E_{t-1} x_{t+1} = a_{11}^x (x_t - E_{t-1} x_t) + a_{12}^x (\pi_t - E_{t-1} \pi_t) + a_{13}^x (i_t - E_{t-1} i_t) \quad (4.13)$$

$$E_t \pi_{t+1} - E_{t-1} \pi_{t+1} = \acute{r}_\pi A (Y_t - E_{t-1} Y_t)$$

$$E_t \pi_{t+1} - E_{t-1} \pi_{t+1} = a_{11}^\pi (x_t - E_{t-1} x_t) + a_{12}^\pi (\pi_t - E_{t-1} \pi_t) + a_{13}^\pi (i_t - E_{t-1} i_t) \quad (4.14)$$

Putting values of $(E_t x_{t+1} - E_{t-1} x_{t+1})$ and $(E_t \pi_{t+1} - E_{t-1} \pi_{t+1})$ in equations (4.4)-(4.6) results in the following set of equations

$$x_t - E_{t-1} x_t = -\varphi(i_t - E_{t-1} i_t) + \varphi(\acute{r}_\pi A (Y_t - E_{t-1} Y_t)) + (\acute{r}_x A (Y_t - E_{t-1} Y_t)) + \epsilon_t^f$$

(4.15)

$$\pi_t - E_{t-1}\pi_t = \beta(r'_\pi A(Y_t - E_{t-1}Y_t)) + \lambda_0(x_t - E_{t-1}x_t) + \epsilon_t^c \tag{4.16}$$

$$i_t - E_{t-1}i_t = \gamma_1(r'_\pi A(Y_t - E_{t-1}Y_t)) + \gamma_2(x_t - E_{t-1}x_t) + \epsilon_t^i \tag{4.17}$$

Now the step ahead is to replace the values of $(E_t x_{t+1} - E_{t-1}x_{t+1})$ and $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$ from equations (4.13) and (4.14) in equations (4.15)-(4.17) which yield the required rational expectation restrictions. These restrictions will be used to estimate the dynamic closed economy structural VAR model through maximum likelihood procedure as prescribed by Keating (1990) and described in the next section.

4.3.2 Open Economy Model

Open economy structural equations conforming NK framework (DSGE model) derived in the previous chapter (equation 3.73, 3.91, 3.92, 3.93) are reproduced below:

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \upsilon E_t(q_{t+1} - q_t) + \epsilon_t^f \tag{4.18}$$

$$\pi_t = \beta_1 E_t\pi_{t+1} + \beta_2 x_t + \beta_3 q_t + \epsilon_t^c \tag{4.19}$$

$$q_t = E_t q_{t+1} - \omega_1(i_t - E_t\pi_{t+1}) + \epsilon_t^{rp} \tag{4.20}$$

$$i_t = \gamma_4 + \gamma_1 E_t\pi_{t+1} + \gamma_2 x_t + \gamma_3 E_t(q_{t+1} - q_t) + \epsilon_t^i \tag{4.21}$$

Subtracting all the variables in the above equations from their expected value at time $(t-1)$ yields the following set of equations:

$$x_t - E_{t-1}x_t = -\varphi(i_t - E_{t-1}i_t) + \varphi(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + (E_t x_{t+1} - E_{t-1}x_{t+1}) + \upsilon(E_t q_{t+1} - E_{t-1}q_{t+1}) - \upsilon(q_t - E_{t-1}q_t) + \epsilon_t^f \tag{4.22}$$

$$\pi_t - E_{t-1}\pi_t = \beta_1(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + \beta_2(x_t - E_{t-1}x_t) + \beta_3(q_t - E_{t-1}q_t) + \epsilon_t^c \tag{4.23}$$

$$q_t - E_{t-1}q_t = (E_tq_{t+1} - E_{t-1}q_{t+1}) - \omega_1(i_t - E_{t-1}i_t) + \omega_1(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + \epsilon_t^{rp} \tag{4.24}$$

$$i_t - E_{t-1}\pi_t = \gamma_1(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + \gamma_2(x_t - E_{t-1}x_t) + \gamma_3(E_tq_{t+1} - E_{t-1}q_{t+1})$$

$$-\gamma_3(q_t - E_{t-1}q_t) + \epsilon_t^i \tag{4.25}$$

In the above equations, $y_t - E_{t-1}y_t$ for all the variables represent the respective residual form residuals which are residuals of reduced form VAR residuals. However, $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$, $(E_tq_{t+1} - E_{t-1}q_{t+1})$ and $(E_tx_{t+1} - E_{t-1}x_{t+1})$ are the forward looking components in the model. Following the procedure explained above to estimate the forward looking components results in the following equations.

$$E_tx_{t+1} = a_{11}^x x_t + a_{12}^x \pi_t + a_{13}^x q_t + a_{14}^x i_t \tag{4.26}$$

$$E_t\pi_{t+1} = a_{11}^\pi x_t + a_{12}^\pi \pi_t + a_{13}^\pi q_t + a_{14}^\pi i_t \tag{4.27}$$

$$E_tq_{t+1} = a_{11}^q x_t + a_{12}^q \pi_t + a_{13}^q q_t + a_{14}^q i_t \tag{4.28}$$

It helps to calculate the expectations revision process for output gap $(E_tx_{t+1} - E_{t-1}x_{t+1})$, $(E_tq_{t+1} - E_{t-1}q_{t+1})$ and inflation $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$.

$$E_tx_{t+1} - E_{t-1}x_{t+1} = \acute{r}_x A(Y_t - E_{t-1}Y_t)$$
$$E_tx_{t+1} - E_{t-1}x_{t+1} = a_{11}^x(x_t - E_{t-1}x_t) + a_{12}^x(\pi_t - E_{t-1}\pi_t) + a_{13}^x(q_t - E_{t-1}q_t)$$
$$+a_{14}^x(i_t - E_{t-1}i_t) \tag{4.29}$$

$$E_t\pi_{t+1} - E_{t-1}\pi_{t+1} = \acute{r}_\pi A(Y_t - E_{t-1}Y_t)$$

$$E_t\pi_{t+1} - E_{t-1}\pi_{t+1} = a_{11}^\pi(x_t - E_{t-1}x_t) + a_{12}^\pi(\pi_t - E_{t-1}\pi_t) + a_{13}^\pi(q_t - E_{t-1}q_t)$$

$$+a_{14}^\pi(i_t - E_{t-1}i_t) \tag{4.30}$$

$$E_tq_{t+1} - E_{t-1}q_{t+1} = \acute{r}_q A(Y_t - E_{t-1}Y_t)$$

$$E_tq_{t+1} - E_{t-1}q_{t+1} = a_{11}^q(x_t - E_{t-1}x_t) + a_{12}^q(\pi_t - E_{t-1}\pi_t) + a_{13}^q(q_t - E_{t-1}q_t)$$

$$+a_{14}^q(i_t - E_{t-1}i_t) \tag{4.31}$$

Putting values of $(E_tx_{t+1} - E_{t-1}x_{t+1})$, $(E_tq_{t+1} - E_{t-1}q_{t+1})$ and $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$ in equations (4.22)-(4.25) results in the following set of equations

$$x_t - E_{t-1}x_t = -\varphi(i_t - E_{t-1}i_t) + \varphi(\acute{r}_\pi A(Y_t - E_{t-1}Y_t)) + (\acute{r}_x A(Y_t - E_{t-1}Y_t)) +$$
$$\upsilon\big(\acute{r}_q A(Y_t - E_{t-1}Y_t)\big) - \upsilon(q_t - E_{t-1}q_t) + \epsilon_t^f \tag{4.32}$$

$$\pi_t - E_{t-1}\pi_t = \beta_1(\acute{r}_\pi A(Y_t - E_{t-1}Y_t)) + \beta_2(x_t - E_{t-1}x_t) + \beta_3(q_t - E_{t-1}q_t) + \epsilon_t^c \tag{4.33}$$

$$q_t - E_{t-1}q_t = \big(\acute{r}_q A(Y_t - E_{t-1}Y_t)\big) - \omega_1(i_t - E_{t-1}i_t) + \omega_1(\acute{r}_\pi A(Y_t - E_{t-1}Y_t)) + \epsilon_t^{rp} \tag{4.34}$$

$$i_t - E_{t-1}\pi_t = \gamma_1(\acute{r}_\pi A(Y_t - E_{t-1}Y_t)) + \gamma_2(x_t - E_{t-1}x_t) + \gamma_3\big(\acute{r}_q A(Y_t - E_{t-1}Y_t)\big)$$

$$-\gamma_3(q_t - E_{t-1}q_t) + \epsilon_t^i \tag{4.35}$$

Equations (4.32) to (4.35) represent the rational expectation restrictions if values of $(E_t x_{t+1} - E_{t-1} x_{t+1})$, $(E_t \pi_{t+1} - E_{t-1} \pi_{t+1})$ and $(E_t q_{t+1} - E_{t-1} q_{t+1})$ are replaced using equations (4.29) to (4.31). These equations are required to employ as per procedure prescribed by Keating (1990). The detailed econometric procedure is discussed in the next section.

4.4 ECONOMETRIC METHOD

Since Sims (1980), Vector Autorgressive (VAR) has been used by a number of studies in order to alternate the traditional less dynamic macroeconometric or reduced form single equation and overidentified models for measuring the monetary transmission mechanism. That is, to evaluate the magnitude and timing of monetary policy impacts on macroeconomic variables (output gap, interest rate, exchange rate and inflation). Impulse response analysis is also very significant in analyzing the interdependence among variables.

Initially various methods were employed to identify the restrictions. For example, the variables are ordered to be lower triangular (recursive) in the system and orthogonalizing the residuals across equations and Choleski decomposition of the covariance matrix is used to get the identifying restrictions as indicated by Cooley and Leroy (1985) and Leamer (1985). However, it has also been thought that in practice, prior beliefs play important role to order the variables in a recursive way. In response to these concerns, Sims (1986), Bernanke (1986) suggest that identification can rely on the assumption that distinct, mutually orthogonal shocks drive the economy. In addition, lagged relationships between the endogenous and exogenous variables (if any) have gone completely unrestricted but the identifying restrictions (unlike recursive restrictions) do not have to prevent simultaneity.

There is some controversy on the issue of non-stationarity of data series used in VAR models. Sims, Stock and Watson (1990) argue that if data is appeared to be integrated, transforming VAR models into a stationary cointegrated one is not necessary while Garratt et al., (1998) insist on transforming them into stationary cointegrated ones to avoid misspecification. Following Sims *et al.* (1990) and Sims (1992), VAR model can be estimated by using variables at level if cointegration test reveals long-term relationship between the variables. Thus it reflects that if variables have long-term relationship then transforming the data into stationary one is unnecessary. Residuals of the VAR model are required to be independently and identically distributed (IID) with expected value zero and constant variance (σ^2).

To provide meaningful relationship between observable reduced-form residuals and unobservable structural disturbances, identifying restrictions are imposed as derived in the previous section.

4.4.1 The SVAR Method

Suppose the economy evolves according to the following dynamic structural model presented in matrix form.

$$BY_t = \tau_0 + \tau_1(L)Y_{t-L} + \tau_2(L)Z_{t-L} + \varepsilon_t \tag{4.36}$$

Where Y_t is a vector of variables of size N×1 and τ_0 represents vector of intercept, $\tau_1(L)$ and $\tau_2(L)$ represent coefficient matrices for the endogenous variables and exogenous variables (if any) respectively. ε_t (summarized by i.i.d. random variable) is a vector comprising structural shocks and is a fundamental source of uncertainty in the economy with mean zero and variance-covariance matrix.

Estimating closed economy model is comprised of three variables, that is, output gap, inflation and interest rate and the open economy model includes an extra variable of exchange rate.

Pre-multiplying equation (4.36) by B^{-1} on both sides yields unrestricted VAR equation as follows.

$$Y_t = A_0 + A_1(L)Y_{t-L} + A_2(L)Z_{t-L} + e_t \qquad (4.37)$$

Where

$$A_0 = B^{-1}\tau_0 \qquad (4.38)$$

$$A_1(L) = B^{-1}\tau_1(L) \qquad (4.39)$$

$$A_2(L) = B^{-1}\tau_2(L) \qquad (4.40)$$

$$e_t = B^{-1}\varepsilon_t \qquad (4.41)$$

It implies that reduced form vectors are related to underlying shocks as under:

$$E(e_t e'_t) = B^{-1}(B^{-1})' = D \qquad (4.42)$$

A critical step in specifying VAR model is determining the lag length which in turn furnishes a model that can be used for forecasting purpose and in analyzing the effects of structural shocks thus helps in achieving reliable results. According to Braun and Mittnik (1993), VAR models that may have different lag length from the true lag length generate unreliable estimators. Selection of higher order lag length increase mean square forecast error and selection of lower order lag length results in autocorrelation in residuals of VAR (Lutkepohl; 1993). Forecasting accuracy differs for different lag lengths (Hafer and Sheehan; 1991).

Lag length for quarterly data is sometimes 4 lags and for monthly data, it is 12 lags but there are more rigorous criteria, such as, Akaike Information Criterion (AIC), Schwarz information criterion (SC), Hannan-Quinn information criterion (HQ) etc., for determining the accurate lag length. However, the only requirement is to ensure the residuals of unrestricted VAR model free from autocorrelation or serial correlation. If based on some criterion for example by focusing on SC, 4 lags are decided to include, check the residuals for autocorrelation by using any recommended test, if autocorrelation prevails then increase the lag length in steps until autocorrelation is removed.

There are two criteria, AIC and SC, which are normally used by the researchers and there are two factors to consider before adding one more lag. More lags reduce Residual sum of square but also lose degree of freedom, however, adding lag is beneficial if loss of degree of freedom is dominated by the reduction in residual sum of square but there should be no autocorrelation in residuals of VAR. There is no consensus as to which criteria is best but it is normally agreed that SC is consistent but not efficient and AIC produces more lags than that of SC but it is more efficient.

Most of the time, VAR models are estimated using symmetric lag length for all the variables in the model, whichever is decided on the basis of SC or AIC. As a matter of fact, economic theory does not compel to incorporate symmetric or asymmetric lag length. Keating (2000) uses 4 lags for endogenous variables and two lags for exogenous variables and term this approach as asymmetric VAR. This approach provides flexibility in specifying the lag length. The same approach of asymmetric lag order has been adopted here while estimating the open economy model.

Thus as a first step, estimation of reduced form VAR model with specific lag length is required by using variables at level subject to prevalence of long-term relationship among the variables wherein residuals of reduced form VAR model should be IID. Therefore, diagnostic testing to ensure the statistical adequacy of the estimated model is necessary. Tests for heteroskedasticity, serial correlation and normality are employed.

In second step, parameter values estimated in step one and the residuals of reduced form VAR are used along with rational expectation restrictions to estimate the structural equation (4.36) through maximum likelihood estimation.

The researcher is required to impose $n(n-1)/2$ number of restrictions to have the just identified system.

The impulse responses to shocks in ε_t can be calculated from the moving average representation of the system:

$$X_t = \varphi(L)\varepsilon_t = \sum_{i=0}^{\infty} \varphi_i \; \varepsilon_{t-i} \tag{4.43}$$

Where

$$\varphi(L) = A^{-1}[I - \tau_1(L)]^{-1} \tag{4.44}$$

It can also be calculated as:

$$Y_t = \bar{\varphi}(L)\gamma + \bar{\varphi}(L)e_t \tag{4.45}$$

Where

$$\bar{\varphi}(L) = [I - \tau_1(L)]^{-1} \tag{4.46}$$

Structural innovations from the VAR's residuals can be derived from equation (4.36) given that matrix B somehow be identified by imposing restrictions on the economic structure. Then this expression of equation (4.41) can be substituted into equation (4.45), which ultimately reveals the dynamics of the structural innovations.

Analysis of variance decomposition helps to identify the sources of variation in the underlying variables due to structural shocks. Therefore analysis of variance decomposition is also focused.

4.5 CONCLUSION

This chapter highlighted the importance of structural VAR model and its compatibility in estimating the models with DSGE (NK) models along with deriving the identifying restrictions through the method prescribed by Keating (1990). Determination of lag length and diagnostic testing of the residuals to ensure the statistical adequacy is well conversed. The focus remained on estimating the deep structural parameter estimates, generating the impulse response and variance decomposition.

CHAPTER 5

MAXIMUM LIKELIHOOD ESTIMATION AND ANALYSIS

5.1 INTRODUCTION

In this chapter, the researcher estimates the closed economy and open economy macroeconomic models, as derived in chapter 3, by adopting the methodology discussed in the previous chapter. Transformation of variables is a prerequisite to accomplish the estimation procedure of DSGE models as per theory. Descriptive analysis, however, has also been carried out to understand the dynamics of the data. After investigating the order of integration of all the variables and finding the long run relationship among them, both the models are estimated by adopting the two-steps procedure introduced by Keating (1990). Structural parameters are retrieved along with the graphical presentation of impulse response functions and the variance decomposition of the macroeconomic aggregates against the structural shocks.

5.2 TRANSFORMATION OF VARIABLES AND DESCRIPTIVE ANALYSIS

The study employs two versions of NK macroeconomic model i.e., closed economy model and open economy model. For the latter, PPP and UIP conditions were relaxed. Both the models incorporate four endogenous variables in total (three variables for closed economy model and four endogenous for open economy model) and two exogenous variables (federal fund rate and consumer price index of USA) in estimating the open economy model. Endogenous Variables are Output Gap (x), inflation (π), exchange rate (q) and interest rate (i).

5.2.1 Transformation of Variables and Descriptive Insight

Data for all the variables is obtained from State Bank of Pakistan and IFS (2012) except Quarterly GDP. The basic source of quarterly GDP is Arby (2005) which is extended for the remaining period. To calculate the output gap, real GDP is used as a basic measure and is calculated by using its basic definition of the differential between log of actual real GDP and potential GDP. There are various methods to get potential GDP, e.g. it can be measured through regressing the log of real GDP on its trend or through HP filter. However following Malik (2007), we use the former approach. Inflation is obtained from CPI in log form, adjusted quarterly. Real Effective Exchange Rate (REER) is used as a measure for exchange rate in the model as it is nearer to the theoretical concept used in the model. The call money rate (i) is used as a measure for interest rate.

As the data is not seasonally adjusted therefore we are forced to use seasonal dummies in the estimation process. Two exogenous variables, federal funds rate and CPI inflation for USA, are used to capture the effect of global economic activity in open economy model.

The data is employed for the period two years after the start of financial liberalization, i.e. from the 1st quarter of 1993 up to the 4th quarter of 2011. To get the visual impression on the behavior of all endogenous and exogenous variables, data is plotted below.

Figure 1 Representation of Output Gap

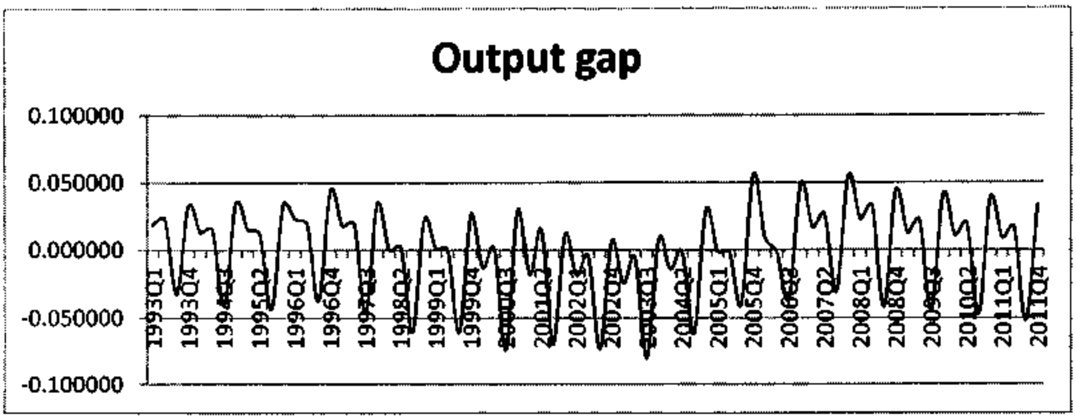


Figure 2 Representation of CPI Inflation Rate

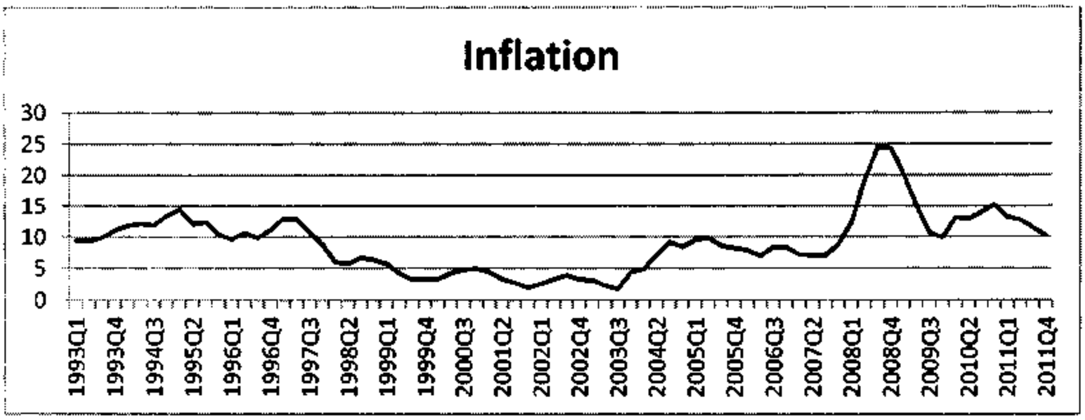


Figure 3 Representation of Real Effective Exchange Rate

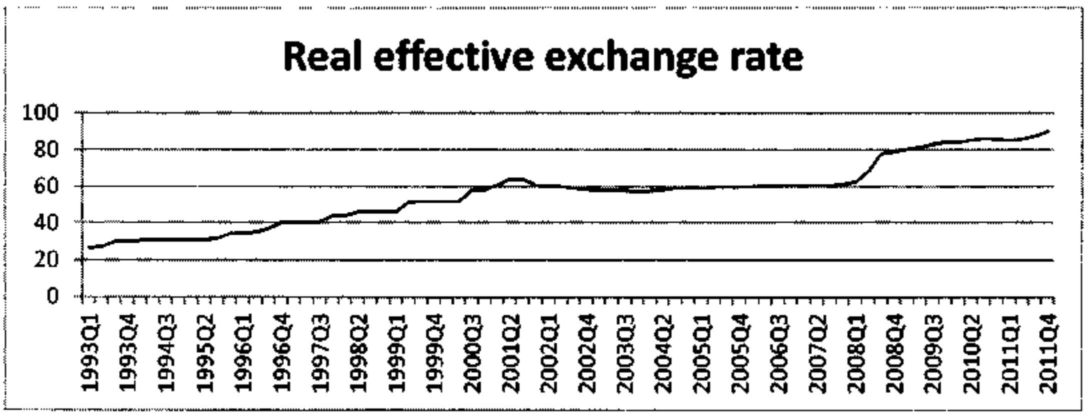


Figure 4 Representation of Call Money Rate

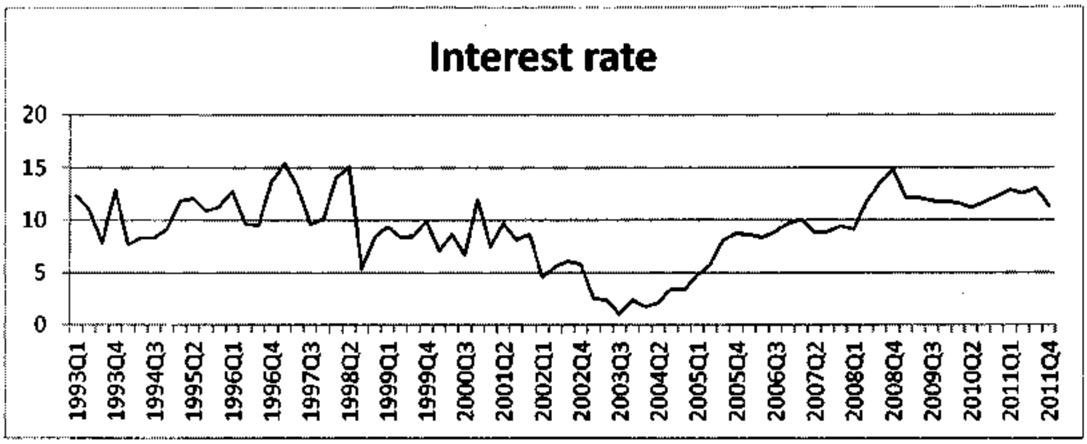


Figure 5 Representation of US Federal Funds Rate

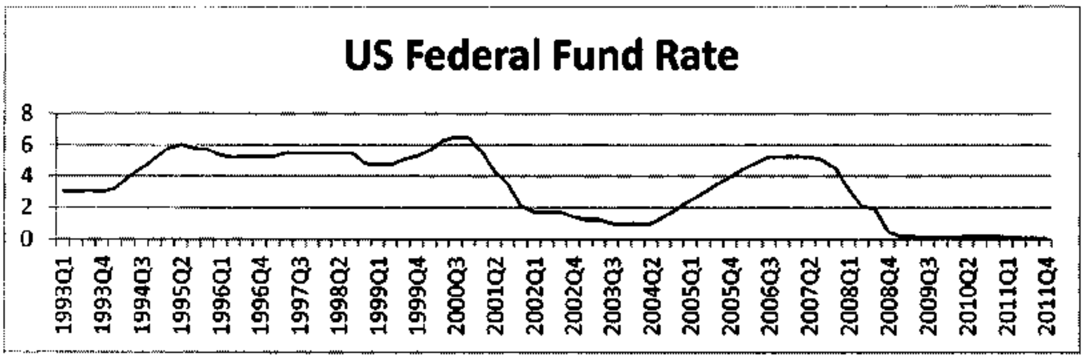
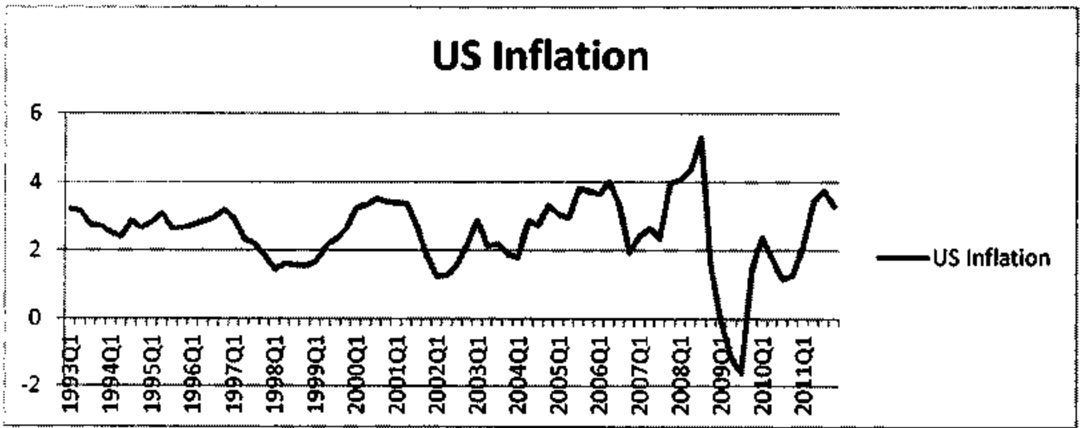


Figure 6 Representation of US Inflation



After getting visual impression on the data some basic statistics are given below for the period under study that may depict the basic characteristics of the basic data. Average for the output gap is zero with minimum value of -0.0799 and maximum value of 0.0343. It reflects that monetary policy during the period under study may be mostly successful to bridge the gap between actual GDP and the potential GDP. Inflation shows much higher average value of 9.08% with volatility of 4.796%. However, during the whole period inflation varies from 1.779% to 24.516%. If we focus on the graph of inflation, it shows that SBP was mostly successful in lowering the rise in price level during the period from 1993 to 2003. From the year 2004 to 2007, steady rise in inflation is witnessed and after 2007 high jump in inflation to 24.516% is observed. Thus monetary policy seems to be ineffective to stabilize prices after 2004 up to 2008. REER has an average of 56.085 with minimum value of 26.65 and maximum value of 89.97 for the period under study and has volatility of 17.45. It shows inability of the central bank to stabilize exchange rate for the whole period. However, visual impression shows that REER remained highly stabilized during the period 2001 to 2008 and after the year 2008, it jumped and settled at new higher average. Overall range from 26.65 to 89.97 shows failure of the central bank to stabilize the exchange rate. The call money rate (i) has an average of 9.9775% with standard deviation of 3.397%. Pertinent to mention here is that the US federal funds rate has an average of 3.367, that is almost 3 times less than the call money rate with a volatility of 2.12% which is also lower than that of domestic interest rate. Average US CPI inflation has a value of 93.546 with a standard deviation of 12.869.

Table 5.1: Descriptive Analysis

	X	INFLATION	REER	I	FFRATE	USInflation
Mean	-0.000566	9.079823	56.085	9.215395	3.366842	2.520766
Median	0.008762	9.056871	58.485	9.395	3.72	2.651086
Maximum	0.05612	24.5164	89.97	15.42	6.52	5.298696
Minimum	-0.079914	1.779955	26.65	1.05	0.07	-1.62094
Std. Dev.	0.034311	4.796213	17.44998	3.397035	2.12301	1.091312

The correlation analysis shows that output gap is positively correlated with inflation and interest rate. Inflation is strongly correlated with real effective exchange rate, interest rate and US price level. However, positive correlation between nominal interest rate and output gap does not mean in any way that it positively affects the real economic activity. It is the real interest rate that affects spending (Boivin, Kiley and Mishkin, 2010). Hence we require modeling the real interest rate in the aggregate demand equation to see the relation. Exchange rate is positively correlated with federal funds rate and US inflation. Interest rate has strong positive correlation with output gap, inflation and negatively correlated with REER. It shows that State Bank of Pakistan seems to focus both inflation and output gap but not the exchange rate stabilization.

Table 5.2 Correlation Analysis

	X	Inflation	REER	I	FFRate	USInflation
X	1					
Inflation	0.2621751	1				
REER	-0.027601	0.1848121	1			
I	0.3779478	0.5163906	-0.10524	1		
FFRate	-0.037228	0.0294751	0.224378	-0.37596	1	
USInflation	0.0462764	0.2801215	0.943664	-0.095749	0.209558	1

5.2.2 Unit Root

In order to employee maximum likelihood estimation through structural VAR model, restrictions identification based on structural macroeconomic model is required. To find out these restrictions, we need to estimate an unrestricted VAR model. According to Fabio Canova (2007), VAR model is also appropriate to employ even if the variables are non-stationary. Consistent parameter estimates are obtained even if unit roots are present in the variables (Sims, Stock and Watson, 1990). Following Sims *et al.* (1990) and Sims (1992), Cointegration test is applied here to investigate the long run relationship between variables for which testing the variables for unit root is a pre-requisite.

The primary condition for employing unrestricted VAR model is to ensure the stationarity of all variables at the first difference (Variables need to be I(1)). To assess the stationarity of the variables, Augmented Dickey Fuller test (ADF test) is incorporated for identifying unit root.

The results indicate that none of the variables is stationary at level but all of them turn out to be stationary at first difference which allows us to further the estimation process. Results can be seen at appendix 5.1 (Table A-5.1).

5.2.3 Cointegration

To empirically analyze the long run relationship between the macroeconomic aggregates, we used Johansen and Juselius's (1990, 1992, 1994) system Cointegration test. It has advantage of utilizing all the available information in the data set, thereby increasing reliability of the estimates. Gonzalo (1992) suggests that Johansen's maximum likelihood techniques perform better in finite samples than univariate methods. It also does not rely on arbitrary normalization Engle and Granger's (1987) method.

Test results show that all the variables in the closed economy and open economy models are cointegrated, i.e. long run relationship exists among all the variables. Results can be seen in Appendix 5.1 Tables A-5.2 to A-5.3. Thus we use the variables in level as described in the models derived in Chapter 3.

5.3 Closed Economy Model

In this section, the researcher attempts to estimate and analyze the closed economy model.

5.3.1 Lag Length Determination

Based on the results produced by AIC, FPE, LM (as can be seen at table 5.3 below), lag length is set to be 5. Although SC and HQ support lag length of 4 but ignored due to the presence of autocorrelation in the residuals of reduced form VAR model. AIC at fifth lag is minimized to -15.14961 as compared to SC of -13.41680 at fourth lag. However, following any of the lag length, the impulse responses qualitatively produce similar results which are witnessed by comparing the visual impression of impulse response in macroeconomic aggregates due to different structural shocks.

Table 5.3 VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	236.129	NA	1.82e-07	-7.004	-6.599	-6.844
1	420.486	328.385	7.62e-10	-12.484	-11.775	-12.204
2	473.715	89.824	1.92e-10	-13.866	-12.854	-13.467
3	482.325	13.7226	1.96e-10	-13.854	-12.538	-13.335
4	529.150	70.237	6.12e-11	-15.036	-13.416*	-14.398*
5	541.787	17.770*	5.59e-11*	-15.149*	-13.226	-14.392
6	546.307	5.933	6.64e-11	-15.009	-12.783	-14.132
7	551.303	6.088	7.86e-11	-14.884	-12.354	-13.887

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

5.3.2 Diagnostic Tests

Once the reduced form VAR model is estimated at lag length decided in the previous section, the residuals need to be statistically sound. For the purpose, diagnostic tests are required to test the hypothesis of no autocorrelation, no heteroskedasticity and normality. The results are presented in appendix 4. Results show that there is no evidence of serial correlation and heteroskedasticity both at 99% and 95% levels of significance in the reduced form residuals. The residuals are jointly normal at 99% level of significance.

5.3.3 Maximum Likelihood Structural Parameter Estimates

Conventionally, VAR studies along with studies based on DSGE framework focus on the mutual relationships of the endogenous variables (impulse response functions) rather than estimating structural parameters.[8] However, structural parameter estimates are discussed here to show the dimension and magnitude of the impact of different independent variables on the dependent variables (in the specific macroeconomic relationship) in simultaneous equations system. These estimates also help to understand the macroeconomic dynamics in response to different structural shocks.

The transformation of endogenous variables and identifying restrictions are largely different from the previous studies conducted using macroeconomic data for Pakistan. However, it is also a fact that there is no evidence of estimating NK macroeconomic model for Pakistan economy at least through maximum likelihood estimation method (or the two step-SVAR model). In this perspective, the estimated parameters are not comparable with any of the previous studies of Pakistan.

Structural parameters estimated through maximum likelihood estimation are presented in Table 5.4 below and the expected signs of the parameters can be seen from the structural equation model produced below Table 5.4.

All the parameters are significantly different from zero which reflects the significant impact of the variables on the corresponding dependent variables. In the Aggregate

[8] According to Joiner (2002), this is due to the underlying feature of the impulse responses to reflect the dynamic response of macroeconomic variables due to structural shocks and structural parameters do not reflect the same.

Demand equation, φ is significant even at 99% significance level which shows that reduction in real interest rate $[i_t - E_t\pi_{t+1}]$ increases the output gap thus the aggregate demand. φ is basically the elasticity of intertemporal substitution in consumption by the households and its significant impact on aggregate demand shows that due to increase in real interest rate, aggregate demand will decrease. Thus a significant share of consumption is deferred by the households and they are inclined to save more. The finding is in consonance with the theory as expounded by Gali and Gertler (2007) along with others.

The parameter of forward looking inflation, β, reflects the subjective discount factor of the forward looking firms which is highly significant showing that firms set their prices based on rational expectations. Its value 0.8469 indicates that the agents place larger weight to future expected inflation than the inflation for the past periods which is in line with the findings of Cho and Moreno (2002) and Gali and Gertler (1999). Literature indicates that if β has value greater than 0.5, firms behave in a forward looking way, i.e. firms adjust their prices keeping in view the future inflation tendency.

λ_0 indicates the effect of output gap on the inflation dynamics of a country. Majority of the literature for developed countries (Gali and Gertler, 2007 and Jondeau and Le Bihan, 2001 along with others) confirm the positive impact of output gap on inflation in the short run. However, it is also a fact that output gap may have negative impact on inflation for the developing countries like Pakistan where central banks deal with the dual mandate of not only controlling inflation but also achieving high economic growth in the country, as suggested by Akbari (2005) in case of Pakistan. Negative impact of output gap on inflation, as is obtained in our estimated model, shows that economic growth (increase in aggregate demand or output gap) helps to reduce inflation. In other words, evidence shows that Pakistan is facing stagflation since last many years (Amjad, 2012) which seems to be reflected in the negative impact of output gap on inflation.

Economists concur for policy rule instead of discretionary policy to improve the economic performance. In this regard, seminal paper by Barro and Gordon (1983) argue about the time inconsistency of discretion rather than rule. Among others, Walsh (1995) also argues for an independent central bank for reducing inflationary bias. Taylor (1993) formulated a very simple and practicable rule necessitating changes in short term policy rate in response to changes in inflation and output gap. It requires the inflation and output parameters should be positive. However, Taylor (1999) suggested more than one to one adjustment in policy rate due to changes in inflation and the parameter for output gap should not fluctuate significantly from 0.5 which otherwise indicates the instability of the system. If parameter values are negative then it simply shows that the central bank is not following the Taylor Rule pointing towards the discretionary monetary policy. This lack of transparency in the policy aggravates the macroeconomic performance rather than improving it. Since the era started after financial reforms in the country, SBP has followed discretionary monetary policy (Malik and Ahmed; 2010).

It is not surprising to see the negative signs for the estimated parameters of output gap and inflation in the interest rate rule because SBP has never claimed to follow the Taylor rule. The negative impact of inflationary expectations on the interest rate shows that the policy was both ineffective and not independent. The negative impact of output gap on interest rate indicates that SBP has either raised the interest rate in the recessionary periods or lowered the interest rate in the periods when aggregate demand was above from its potential level. One possibility might be that economy enjoyed better growth due to external factors and SBP allowed this momentum to go on. However, as a matter of fact, SBP has not used rule based policy during the period of investigation. The results are in line with the findings of Malik and Ahmed (2010).

Table 5.4 Maximum Likelihood Structural Parameter Estimates

	Coefficient	Std. Error	z-Statistic	Prob.
φ	0.314932	0.004489	70.15726	0.0000
β	0.846920	0.000374	2262.195	0.0000
λ_0	-0.035329	0.000647	-54.58125	0.0000
γ_1	-2.373551	0.015636	-151.8034	0.0000
γ_2	-0.430219	0.017151	-25.08434	0.0000

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \epsilon_t^f$$

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda_0 x_t + \epsilon_t^c$$

$$i_t = \gamma_3 + \gamma_1(E_t\pi_{t+1}) + \gamma_2 x_t + \epsilon_t^i$$

5.3.4 Impulse Response Functions

The effect of various macroeconomic shocks on macroeconomic aggregates is important to know to design monetary policy in an appropriate way. The past studies reveal that monetary policy affects the economy with lag(s) and also involves variability and uncertainty to achieve the targets. It entails SBP to be forward looking to stabilize the economy. Therefore, it is cardinal to assess the extent of monetary policy actions on the macroeconomic performance.

Two sets of Impulse responses - the response of macroeconomic variables to a monetary policy shock and the response of call money rate to macroeconomic variables - are focused upon along with fiscal shock and cost push (aggregate supply) shock.

The under discussion closed economy structural model have three equations (AD, AS and I-rule) thus have three structural shocks. To understand the macroeconomic dynamics of the economy under closed economic framework, one standard deviation shock is applied and 95% confidence bands of the standard errors are projected using analytical framework.

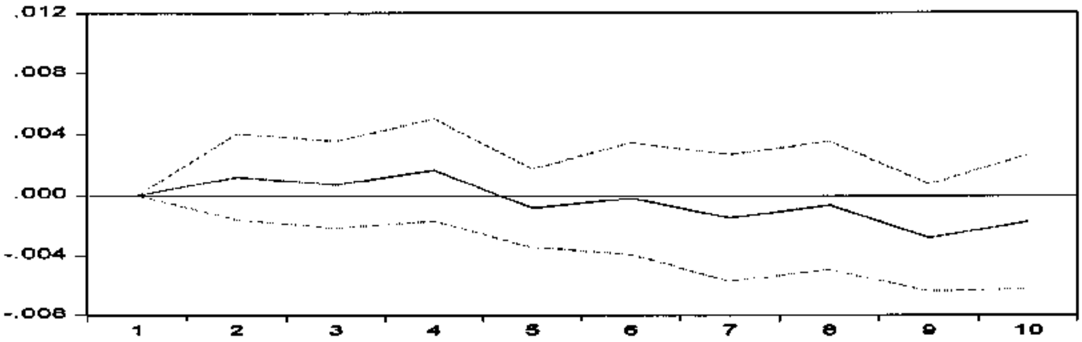
5.3.4.1 Contractionary Monetary Policy Shock

An unanticipated contractionary monetary policy shock demonstrates the increase in call money rate. An unanticipated innovation in the call money rate by the SBP results in an immediate increase in the output gap for the first three quarters then it started lowering in the fourth quarter. However, a large reduction in the output gap from below its long run stability path occurs in the fifth quarter and it continuously remains below than the stability path up to ten quarters. It has also been a fact that SBP, like any other central bank of a developing country, has the dual primary objective of not only achieving economic growth in the short run but also trying to stabilize prices. On the other hand, theory suggests that with an increase in interest rate by SBP there will be a decrease in consumption expenditures and investment spending. Therefore, aggregate demand should decrease but the impulse response apparently shows the otherwise situation. An important component of aggregate demand is government spending specifically in countries like Pakistan where fiscal dominance prevails (Choudri and Malik; 2012). An increase in the aggregate demand with a monetary tightening reflects an increase in spending by the government which contradicts the action taken by the SBP. A positive fiscal shock results in an increase in aggregate demand as can be seen in Figure 5.9. However, the results are consistent with the idea of 6-18 months lag in achieving reduction in the output to its long run stability path as discussed by Gali (1999).

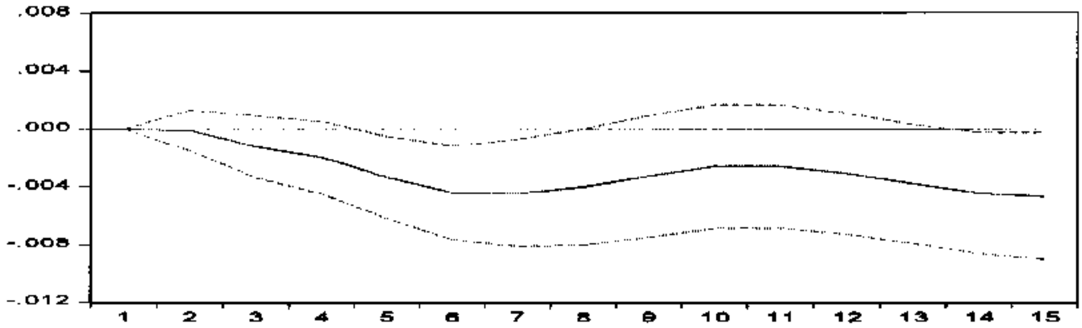
SBP is successful in lowering inflation in the country with a monetary policy tightening which is reflected in panel (b) of figure 5.7. Hence no evidence of price puzzle exists. Although there is no evidence of immediate significant impact on inflation but it started reducing at the end of second quarter which require forward looking monetary policy on the part of SBP. That is, if SBP is expecting that inflation will increase after the next two quarters then it should adopt contractionary policy today so that it can achieve stability in prices in the relevant period. The results depicted in figure 5.7 (c) below show that monetary shock immediately transmitted positively into interest rate which dies out to zero in the tenth quarter. The results show that the response of monetary policy to output and inflation is countercyclical.

Figure 5.7 Macroeconomic Dynamics in Response to Contractionary Monetary Shock in closed Economy Framework

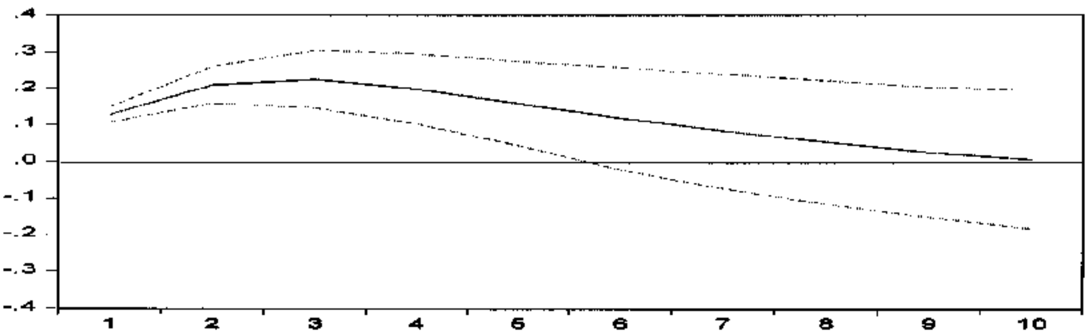
(a) Response of Output Gap to Monetary Shock



(b) Response of Inflation to Monetary Shock



(c) Response of Interest Rate to Monetary Shock



5.3.4.2 Assessing Reaction function

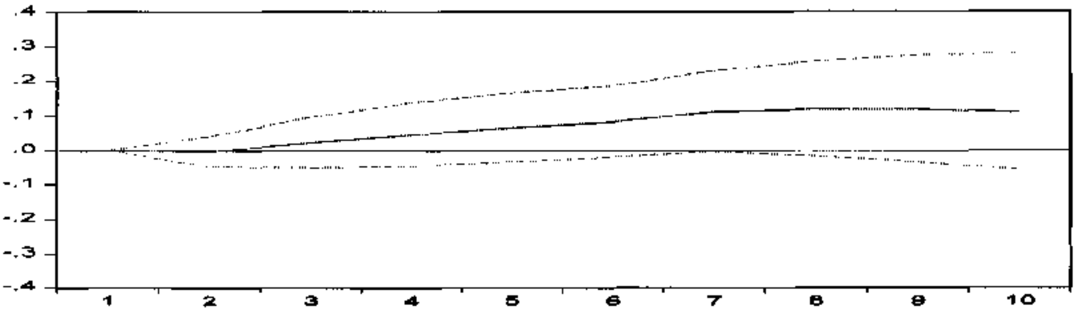
By focusing on the dynamics of interest rate to fiscal and cost push (aggregate supply) shocks, it can be indicated whether the policy reaction function is specified correctly or whether SBP has ever adopted the policy reaction function during the period of investigation. The responses can be seen in the figure 5.8 below.

The results show that in response to fiscal shock, interest rate increases after a lag of two quarters. It reflects that monetary authorities respond to fiscal shock but with a lag of two quarters. In response to positive fiscal shock, monetary authorities increase the interest rate to condemn the negative effects of fiscal shock to the economy but keep silent for two quarters to get the positive impact on output gap. This is mainly due to the objective of SBP to achieve high level of economic growth and due to prevalence of fiscal dominance in the country. Government of Pakistan sets the target level of economic growth and inflation after which monetary policy is controlled by SBP. However, government gets high borrowings from the SBP to finance the fiscal deficit which is normally not discouraged by the SBP.

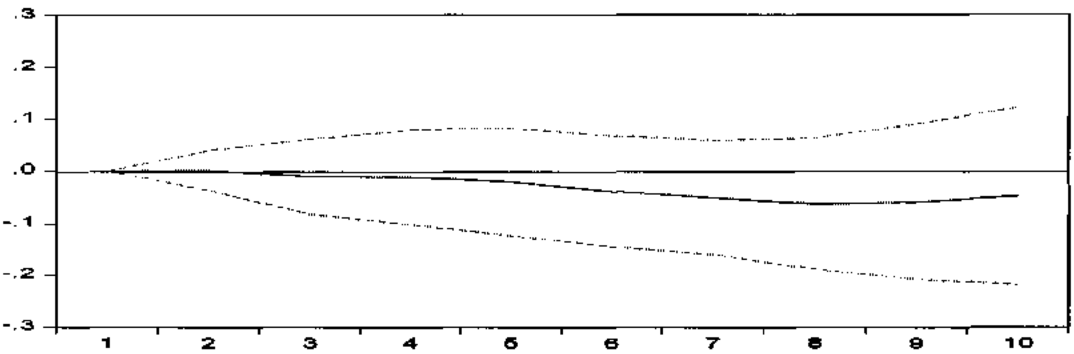
In response to positive cost push shock in the country, interest rate started lowering in the second quarter and kept lowering even up to ten quarters. The result shows that SBP is not following interest rate rule at least up to the extent of focusing on output gap and inflation. To curb the inflationary shock, as per theory, SBP should increase the interest rate. The ground reality, however, is converse.

Figure 5.8 Response of Interest Rate to Fiscal and Cost Push shocks

(a) Response of Interest Rate to Fiscal Shock



(b) Response of Interest Rate to Cost Push Shock

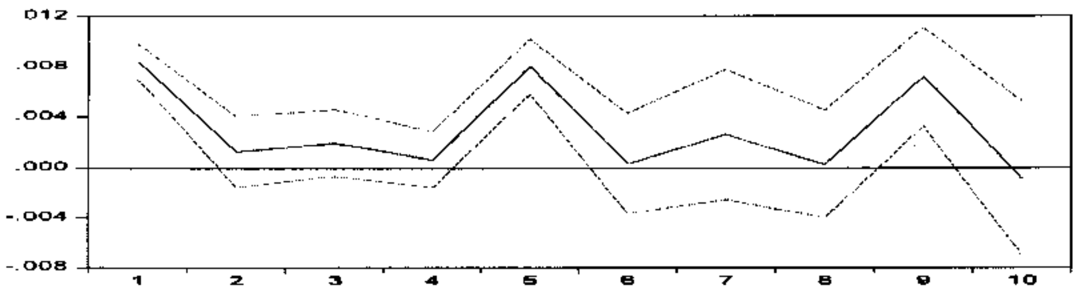


5.3.4.3 Impact of Fiscal and Cost Push Shocks on Macroeconomic Dynamics

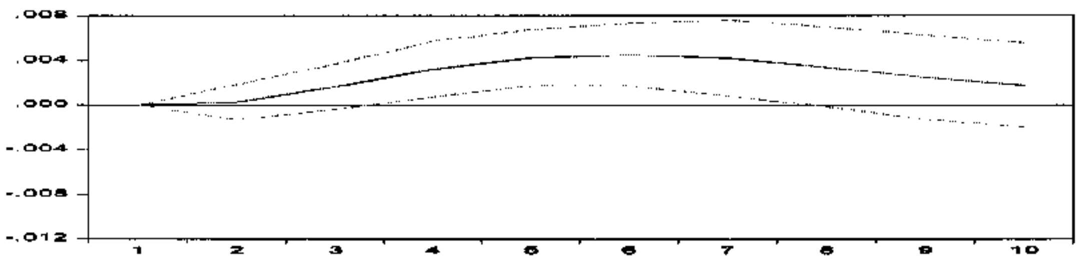
In response to positive fiscal shock, both output gap and inflation start rising. However, output gap increases immediately after the fiscal shock hits the economy and inflation started rising after two quarters. The apparent unusual response of output gap or the oscillatory nature of the aggregate demand shows that the economy is persistently experiencing the fiscal shock which divert us to discuss the persistence of fiscal shock later. However, we will discuss the accumulated or persistent shocks for the open economy model only as being the ultimate goal of the current research. This result confirms the crowding-in effect of fiscal policy in case of Pakistan. Hyder (2001), Khan and Gill (2009) and Shaheen and Turner (2010) found same results for Pakistan.

Figure 5.9 Macroeconomic Dynamics in Response to fiscal shock in Closed Economy Framework

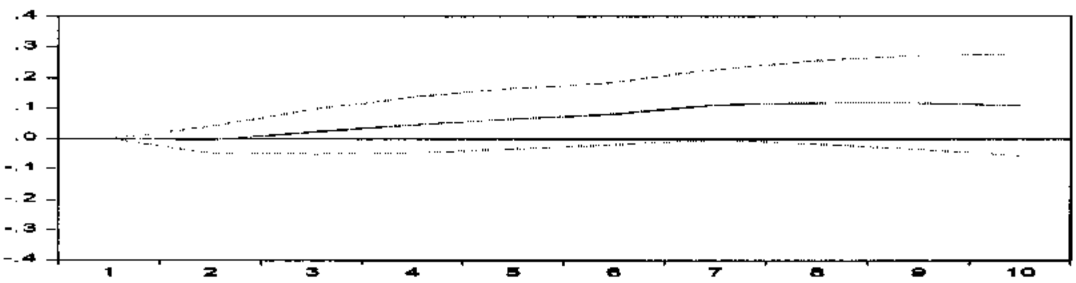
(a) Response of Output Gap to Fiscal Shock



(b)Response of Inflation to Fiscal Shock



(c) Response of Interest Rate to Fiscal Shock

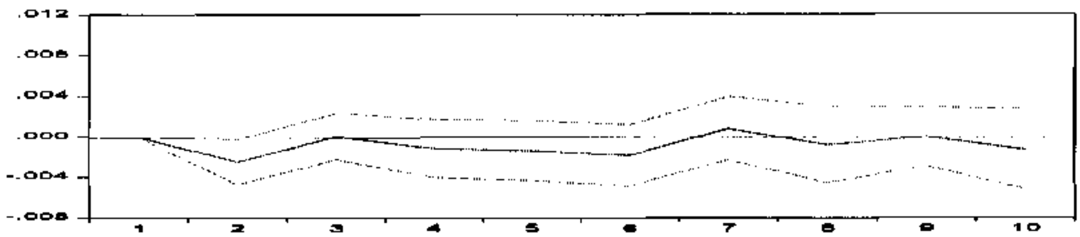


In response to fiscal shock, monetary authorities adopt contractionary monetary policy by increasing the interest rate but it responds after two quarters, i.e. at the same time when inflation starts rising. It reflects that monetary authorities do not immediately respond to positive output gap but discourage the inflation by increasing the interest rate which seems to be in-line with the dual mandate.

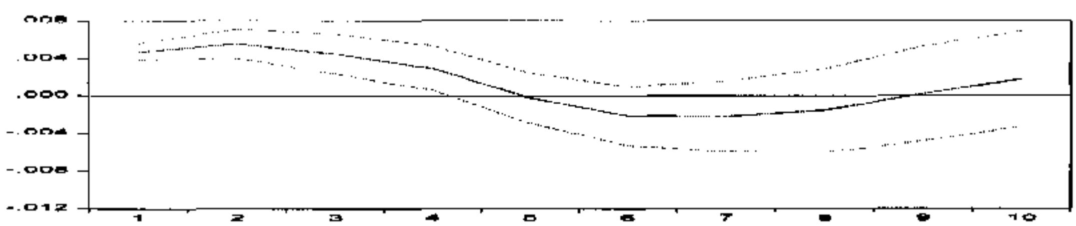
The cost push shock originates from the monopolistic behavior of the labor market.

Figure 5.10 Macroeconomic Dynamics in Response to cost Push Shock in closed Economy Framework

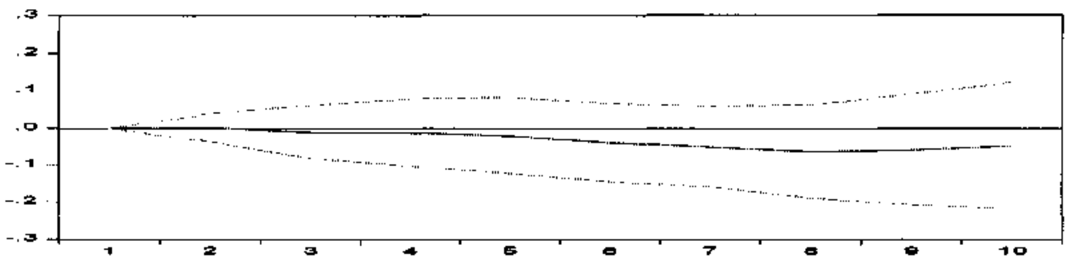
(a)Response of Output Gap to Aggregate Supply Shock



(b)Response of Inflation to Aggregate Supply Shock



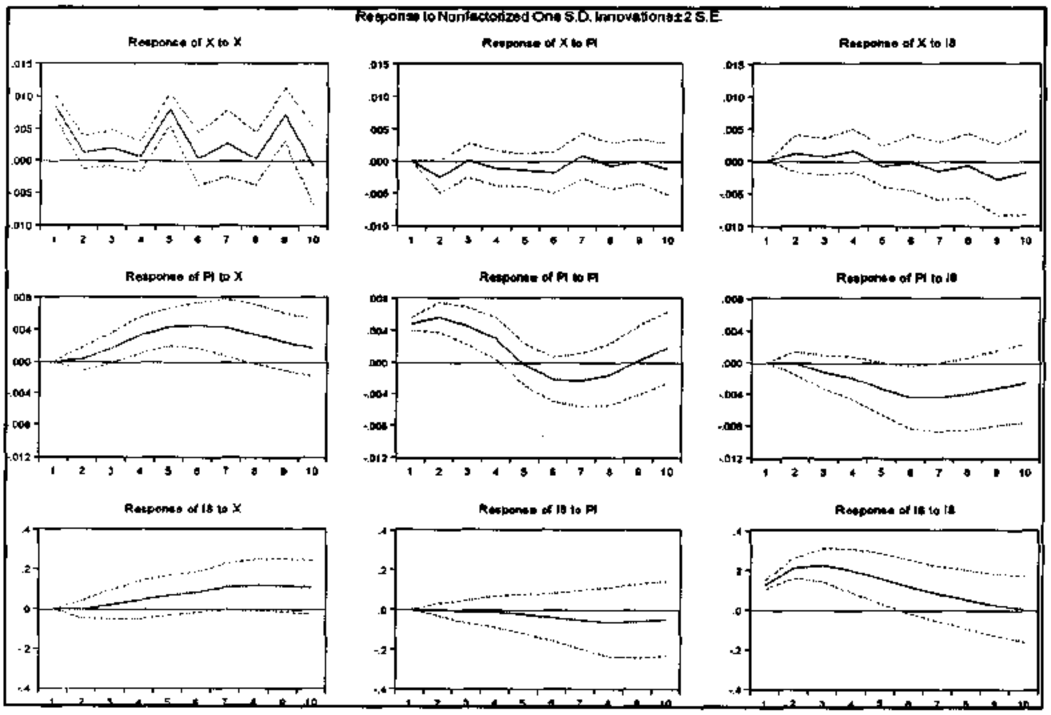
(c) Response of Interest Rate to Aggregate Supply Shock



Inflation started rising soon after the cost push shock hits the economy but output gap starts reducing during first quarter. This reduction in output gap is due to reduction in the consumption expenditures by the household due to rise in prices. The rise in prices is due to increase in production cost of the firms thus reducing the production in the country that is reflected in the impulse response of output gap.

Impulse response show that monetary authorities do not respond to the cost push shock for three quarters. The interest rate starts lowering at the time when output gap almost reaches at its long run stability level and inflation also approaches to its target level. This reduction in interest rate leads to fluctuations in the output gap and inflation thus create instability in the system.

Figure 5.11 **Impulse Response for the closed Economy**



5.3.5 Variance Decomposition

The relative importance of each structural shock can be examined by studying the variance of forecast error which is decomposed for each structural shock separately.

Table 5.5 Forecast Error Variance Decomposition

	Period	S.E.	Fiscal Shock	Supply Shock	Monetary Shock
	1	0.90445	85.59723	2.983548	11.41922
	5	1.26852	85.61888	2.948742	11.43238
	9	1.47852	85.69021	2.945301	11.36449
Output Gap	13	1.61565	85.74315	2.946413	11.31044
	17	1.74536	85.74457	2.960265	11.29517
	21	1.91165	85.7311	2.973752	11.29514
	25	2.11952	85.72221	2.985848	11.29194
	1	0.00741	43.42414	55.92579	0.650076
	5	0.5293	86.01231	3.118973	10.86872
	9	0.82916	86.32705	2.843831	10.82912
Inflation	13	0.88217	86.38525	2.871504	10.74325
	17	0.9104	86.48569	2.84362	10.67069
	21	0.91652	86.43089	2.842431	10.72668
	25	0.92435	86.37507	2.850015	10.77492
	1	2.63856	81.97948	3.665537	14.35498
	5	16.1685	83.8859	3.261168	12.85293
	9	30.7769	84.89693	3.014152	12.08892
Interest Rate	13	37.9468	85.2003	2.961876	11.83783
	17	40.4279	85.35989	2.936347	11.70376
	21	40.6235	85.38936	2.931584	11.67905
	25	40.8464	85.36174	2.934406	11.70385

The top panel of the above table depicts the variance of forecast error in the output gap for each structural shock separately for long horizon. It is witnessed that fiscal shock is the major contributor for variations in output gap which is around 85.65% for up to 25 quarters. Monetary policy shock is the second contributor which remained around 11.35% of the forecast error variance. Hence it is evident that fiscal shock plays significant role in affecting the output gap.

The second panel of the table displays the relative importance of the structural shocks in explaining inflation in the country. The results show that supply shock is most important in explaining inflation in the first quarter. However afterwards, supply shock is of less importance in this regard. From the remaining two shocks, fiscal shock is the major contributor for variations in the inflation which is more than 86% from 2nd to 25th quarter. Less than 11% of the variations for the same period are due to monetary shock.

Fiscal shock is most important determinant of variations in interest rate for the time horizon depicted in the above table. The second important determinant of variations in interest rate is monetary shock.

The results of variance decomposition shows that fiscal shock is the major contributor of explaining variations in macroeconomic aggregates and monetary shock is the second major contributor.

5.4 OPEN ECONOMY MODEL WITH RISK PREMIUM SHOCK

Open economy macroeconomic model has been estimated after relaxing PPP and UIP conditions. Thus exchange rate affects the output gap and inflation. Expected exchange rate changes are also a part of interest rate rule considering the fact that central banks of countries like Pakistan have an additional objective to stabilize the exchange rate though they have adopted flexible exchange rate regime formally. Risk premium shock has also been incorporated in UIP condition.

5.4.1 Lag Length Determination

We considered different criteria to decide the optimal lag length of the reduced form VAR model. The results indicate that the optimal lag length is 4 for endogenous variables following FPE and LR criteria.

Table 5.6 Lag Length Selection for Open Economy Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	590.9764	NA	2.38E-12	-15.41601	-14.27768	-14.96284
1	743.4785	249.934	5.44E-14	-19.20774	-17.56348*	-18.55315
2	773.8344	46.37714	3.72E-14	-19.60651	-17.45633	-18.75052*
3	786.8971	18.50548	4.18E-14	-19.52492	-16.86881	-18.46751
4	811.0392	31.51882*	3.50e-14*	-19.75109	-16.58905	-18.49227
5	828.8385	21.26024	3.59E-14	-19.80107*	-16.13311	-18.34084
6	839.0441	11.05607	4.66E-14	-19.64011	-15.46623	-17.97848
7	855.2684	15.77367	5.32E-14	-19.64635	-14.96653	-17.7833
8	865.9688	9.214175	7.42E-14	-19.49913	-14.31339	-17.43467

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

However, the number of lags included is 2 for exogenous variables hence we are following Keating (2000) who named it asymmetric VAR, that is, VAR (4,2). Moreover, we have used three dummies for capturing the seasonal variations in the data series and a constant.

5.4.2 Residual's Diagnostics

We run VAR (4,2) on the selected data series and checked the residuals for normality, serial correlation and hetroscedasticity.

LM test for serial correlation in the residuals shows that there is not enough evidence to reject the null hypothesis of serial correlation. Thus we conclude that there is no serial correlation found in the reduced form residuals.

White Heteroskedasticity test is used to assess the consistency in variances of residuals both separately for each equation and jointly with null hypothesis of heteroskedasticity in residuals. The results show that variances of residuals for all the equations are homoscedastic both separately and jointly as sufficient evidence is not found to reject the null hypothesis of no heteroskedasticity. Hence, the residuals are homoscedastic at 95% and 99% confidence level which concludes the efficiency of the estimated parameters.

Jarque-Bera test is used to check the residuals for normality. The results confirm the normality of residuals in output gap equation, Phillips curve equation and exchange rate equation. But, it does not support the assumption of normality in interest rate equation which is due to prevalence of skewness and kurtosis in residuals of interest rate equation.

However, the overall statistical adequacy of residuals of reduced form VAR model is ensured as the residuals are IID. The detailed results can be seen at Appendix 5.

5.4.3 Open Economy Structural Parameter Estimates

It has been observed that most of the studies on VAR and DSGE based models focused on the mutual relationships of the endogenous variables (impulse response functions) rather than focusing on estimating structural parameters. This is mainly due to the fact that impulse responses reflect the dynamic response of macroeconomic aggregates due to structural shocks in the economy and the structural parameter estimates only show the impact of one variable on the other (Joiner, 2002).

However, structural parameter estimates are discussed here to show the dimension and magnitude of the impact of different independent endogenous variables on the dependent endogenous variable (in the specific macroeconomic relationship) in simultaneous equations system.

The transformation of endogenous variables and identifying restrictions are largely different from the previous studies conducted using macroeconomic data for Pakistan. However, it is also a fact that there is no evidence of estimating NK macroeconomic model in an open economy framework for Pakistan's economy at least through maximum likelihood estimation method. Thus, the estimated parameters are not comparable with any of the previous studies of Pakistan.

Structural parameters estimated through maximum likelihood estimation are presented in table 5.7 below and the expected signs of the parameters can be seen from the structural model produced below the table 5.7.

Table 5.7 Structural Parameter Estimates

	Coefficient	Std. Error	z-Statistic	Prob.
φ	0.732735	0.125092	5.857568	0.0000
υ	2.144129	0.541927	3.956492	0.0001
β_1	0.829395	0.003609	229.7995	0.0000
β_2	-0.062163	0.006757	-9.200367	0.0000
β_3	0.018002	0.006209	2.899402	0.0037
ω_1	-0.124878	0.078256	-1.595757	0.1105
γ_1	2.679713	0.185616	14.43687	0.0000
γ_2	1.525343	0.229525	6.645642	0.0000
γ_3	-1.715947	0.549819	-3.120931	0.0018

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \upsilon E_t(q_{t+1} - q_t) + \epsilon_t^f$$

$$\pi_t = \beta_1 E_t\pi_{t+1} + \beta_2 x_t + \beta_3 q_t + \epsilon_t^c$$

$$q_t = E_t q_{t+1} - \omega_1(i_t - E_t\pi_{t+1}) + \epsilon_t^{rp}$$

$$i_t = \gamma_4 + \gamma_1 E_t\pi_{t+1} + \gamma_2 x_t + \gamma_3 E_t(\Delta q_{t+1}) + \epsilon_t^i$$

All the parameters except ω_1 are significantly different from zero which reflects the significant impact of the variables on the corresponding dependent variables. In the Aggregate Demand equation, φ is significant even at 99% significance level which shows that reduction in real interest rate $[i_t - E_t\pi_{t+1}]$ increases the output gap thus the aggregate demand. φ is basically the elasticity of intertemporal substitution in consumption by the households and theoretically its absolute value should be less than one. The estimated value of φ is 0.732735 thus it is feasible range theoretically. Its significant impact on aggregate demand shows that due to increase in real interest rate, aggregate demand will decrease. Thus a significant share of consumption is deferred by the households and they are inclined to save more. The finding is in consonance with the theory as explained by Gali and Gertler (2007) along with others.

v denotes the parameter of expected rise in exchange rate in the aggregate demand equation. The results suggest that expected rise in exchange rate, i.e. depreciation in the local currency, impact significantly positively the aggregate demand. Macroeconomic theory suggests that expected rise in exchange rate would encourage the country's exports raising the net exports fostering the aggregate demand. Economic integration has increased the importance of exchange rate as monetary transmission channel making the exchange rate channel important than the times when the economies were less tightly integrated. Due to greater economic integration, any changes in demand by the domestic consumers are offset by the foreign consumers slackening the role of interest rate channel. β_3 indicates the impact of exchange rate on inflation. It has significant positive impact on inflation as envisioned in the theory.

The parameter of forward looking inflation, β_1, reflects the subjective discount factor of the forward looking firms. It is highly significant showing that firms set their prices keeping in view the expected rise in price level for the next period, i.e. based on rational expectations. Its value 0.829395 indicates that the agents place greater weight to future expected inflation that is in line with the findings of Gali and Gertler (1999). Literature shows that the value of β_1 is less than one and if it has value greater than 0.5, it indicates that firms behave in a forward looking way.

β_2 indicates the effect of output gap on the inflation dynamics. Majority of the literature for developed countries (Gali and Gertler, 2007 and Jondeau and Le Bihan, 2001 along with others) confirms the positive impact of output gap on inflation in the short run. However, it is also a fact that for countries like Pakistan, where central bank opt to deal with the dual mandate, output gap may have negative impact on inflation. As suggested by Akbari (2005), negative impact of output gap on inflation, as is obtained in our estimated model, shows that economic growth (increase in aggregate demand or output gap) helps reduce inflation.

ω_1 shows that whenever there is a rise in real interest rate, the real exchange rate appreciates due to inflow of capital in the country. The estimate shows insignificant impact on real exchange rate even at 90% confidence level. It may reflect that there are some other important factors like security concerns, energy crisis and inconsistent policies that discourage the investors. The investors perceive their investment more at risk despite relative increase in the real interest rate.

Barro and Gordon (1983) argue about the time inconsistency of the discretion rather than rule. Taylor (1993) formulated a policy rule for the monetary authorities to stabilize the economy. Since then many of the central banks follow the Taylor rule and rejected the idea of discretionary policy or the money supply rule. Walsh (1995) also points out the importance of the existence of an independent central bank for reducing inflationary bias.

The Taylor rule suggests changes in short term policy rate as a result of changes in inflation and output gap in the country. It requires positive values of the parameters of inflation and output and suggests more than one-to-one adjustment in nominal interest rate due to changes in inflation. The parameter for output gap, however, should not fluctuate significantly from 0.5. Significant difference in the value parameters implies deviation by the central bank from the Taylor rule.

This lack of transparency in the policy aggravates the macroeconomic performance rather than improving it. However, SBP has, factually, never claimed to follow the Taylor rule as also contended by Malik and Ahmed (2010). The results here suggest positive signs and more than one-to-one adjustment of interest rate with both the expected inflation and output gap. The value of the parameter for expected rise in exchange rate (γ_3) is, however, negative and significant. The estimate of $\gamma_1 > 1$ suggest that SBP has been successful in stabilizing the inflation but destabilized the aggregate demand situation. The estimate of $\gamma_3 < 0$ suggests that SBP react negatively to exchange rate depreciation. The results show that the Taylor rule does not hold.

5.4.4 Macroeconomic Dynamics in Response to Structural Shocks

Stabilization of the economy is an important obligation on the part of every central bank. The central bank can achieve its target to stabilize the economy through formulating a policy by taking into account the macroeconomic dynamics in the presence of imperfections in the goods and labor market. NK framework rooted through the optimization behavior of all the stakeholders is important in this regard as it allows the imperfections. Most of the literature of the developing and developed countries focused on the NK framework and presented the impulse response to know the design of monetary policy. However, for Pakistan, there is hardly any study conducted in the area considering the structural facts of the economy. Four equations open economy model comprising AD, AS, interest parity and the augmented Expectations-type Taylor rule equations, estimated through two step procedure advised by Keating (1990), allow the researcher to generate structural impulse responses of key macroeconomic variables after any structural shock hits the economy.

Literature suggests that monetary policy affects the economy with lag. Therefore, forward looking behavior on the part of households, firms and central bank is considered. The Augmented Expectations type Taylor rule, hence, employed here consists of expected rise in price level and the expected rise in exchange rate along with contemporaneous output gap.

The objective here is threefold. First, understand the effect of monetary policy on macroeconomic variables to achieve the short run objectives. Second, investigate the importance of risk premium shock in dynamics of macroeconomic aggregates. Third, have better idea on the response of monetary authority to different shocks, therefore impact of fiscal and cost push shocks is necessary to discuss. Thus four sets of structural impulse responses are discussed separately. One standard deviation shock is applied and 95% confidence bands of the standard errors are projected using Monte Carlo framework with 1000 repetitions.

5.4.4.1 Monetary Policy Shock

The primary channel in the monetary transmission is the interest rate channel which describes the transmission of change in interest rate (by the central bank) in the deposit and credit rates in the commercial banking sector. The prevalence of rigidities affects the real interest rate affecting spending and inflation. For example, due to monetary tightening by the SBP, increase in the nominal interest rate in turn increases the real interest rate due to forward looking behavior on the part of households and firms. As a result, spending will be discouraged in the next period decreasing the aggregate demand. This decrease in aggregate demand helps to reduce inflation in the country.

An unanticipated contractionary monetary policy shock demonstrates the increase in call money rate. An unanticipated innovation in the call money rate results in decrease in the output gap but it responds in the next quarter. After output gap starts decreasing, it remains below the long run stability path in the short term. However, in the 25th quarter, output gap turns back toward the long term stability path which ensures the neutrality of money in the long run (evidence can be seen in figure 5.16). It has been witnessed that output gap respond in the second quarter after the monetary shock hits the economy. It shows that SBP should adopt forward looking policy, that is, if SBP wants to reduce the demand pressures in the country then it has to adopt tight monetary policy in the previous period so as to affect the demand in the current period. It also reflects that consumers do not disturb their spending decisions in the current period. Or, in other words, due to prevailing rigidities in the goods and labor market, there is no immediate impact on the spending decisions by the households and firms. However, after the wage contracts are renegotiated due to increase in the opportunity cost of consumption, rise in level of savings is obvious.

It also highlights the importance of expectations on part of all the stakeholders including the SBP. Indirectly, by increasing the short run interest rate, the central bank wants to affect the long run real interest rate which mainly depends on the expectations of households and firm about future inflation. These expectations are primarily based on the credibility of the monetary policy makers and their ability to control inflation.

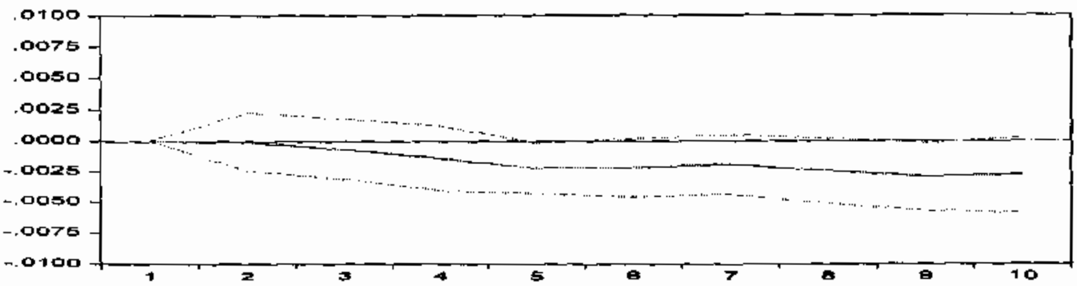
After the downward pressure on aggregate demand starts, there is downward trend in inflation which can be seen in panel (b) of figure 5.12. Inflation started decreasing in the second quarter in line with the decrease in aggregate demand and continuously remained below the long run trend up to 25 quarters (figure 5.16). It shows that in the presence of forward looking expectations, SBP should increase the policy rate in the previous period if it has the objective to decrease the inflation rate in the current period. Thus there is no evidence of price puzzle.

The seminal papers presented by Dornbusch (1976) on exchange rate overshooting and on sticky prices describe the behavior of exchange rate after an expansionary monetary policy is adopted by the authority. The essence of the model is that initially there is an increase in the exchange rate as compared to that of money stock generating the required level of expectations causing the exchange rate to appreciate. Thus expectations of the investors play prominent role in getting the required changes in the exchange rate. However, it is clear that the domestic currency should appreciate in comparison with the foreign currency as a result of contractionary monetary shock. The underlying phenomenon is obviously very clear, i.e. rise in interest rate will attract the foreign investors to invest in the domestic assets causing inflow of capital appreciate the value of local currency simply due to favorable demand supply position. Otherwise, it may reflect distorted beliefs of investors about the monetary authorities as observed by Gourinchos (2003). This is simply the case where there is lack of commitment by the monetary authorities.

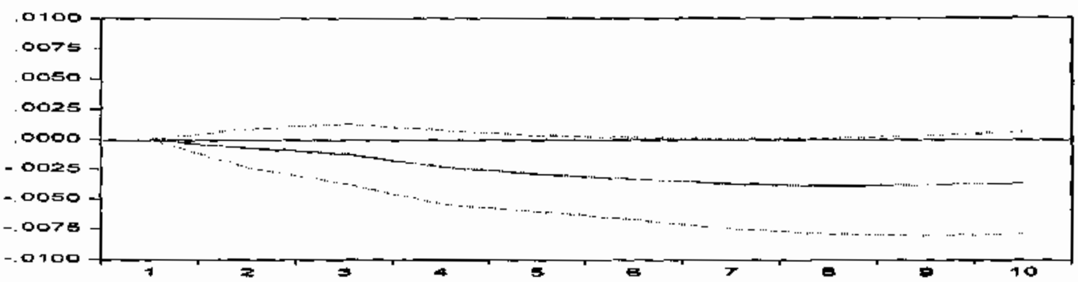
Panel (c) of figure 5.12 show that after the contractionary monetary shock hits the economy there is rise in the exchange rate in the second half of first quarter, i.e. instead of inflow of capital, the situation is otherwise. It continued to increase up to the end of second quarter then started decreasing and went below the long run path in the 4^{th} quarter temporarily. Up to tenth quarter, it fluctuates around the long run path and afterwards remains below the long run path by the end of 25^{th} quarter. However the changes in the exchange rate are negligible in response to increase in interest rate thus failure of SBP to attract foreign investment is obvious. The evidence reflects that SBP is unable to get the desired change in the exchange rate in the short run. This simply is the case of distorted beliefs by the investors about the stance of monetary authority that results in not achieving the targeted level of exchange rate as also described by Gourinchos (2003). Similar results are obtained by Javed and Munir (2010) where exchange rate puzzle is witnessed and worse than the situation prior to monetary shock. Javed and Munir (2010) point to the ineffectiveness of monetary policy to get stability in exchange rate. It also shifts our focus toward the role of expectations on the part of households and investors in stabilizing the economy highlighting SBP's commitment as the basic requirement.

Figure 5.12 Macroeconomic Dynamics in Response to contractionary Monetary Policy shock in Open Economy Framework

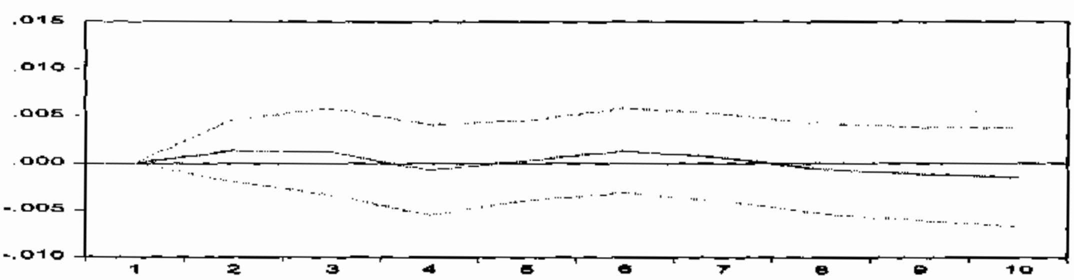
(a) Response of Output Gap to Monetary shock



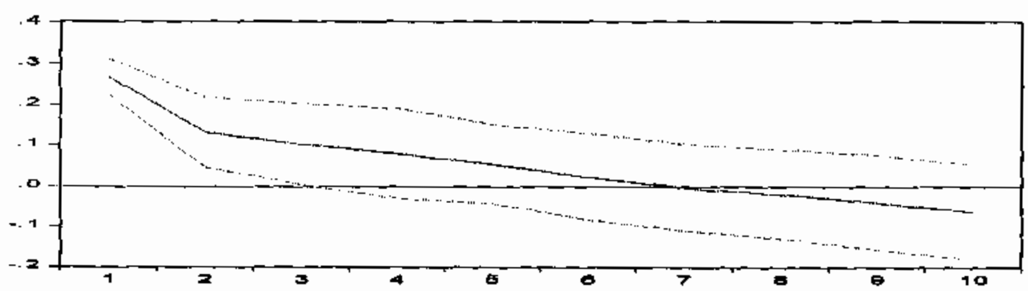
(b) Response of Inflation to Monetary shock



(c) Response of Exchange Rate to Monetary shock



(d) Response of Interest Rate to Monetary shock



Panel (d) of figure 5.12 depicts immediate reflection of monetary tightening in the call money rate which touches the long run path in the seventh quarter.

5.4.4.2 Risk Premium Shock

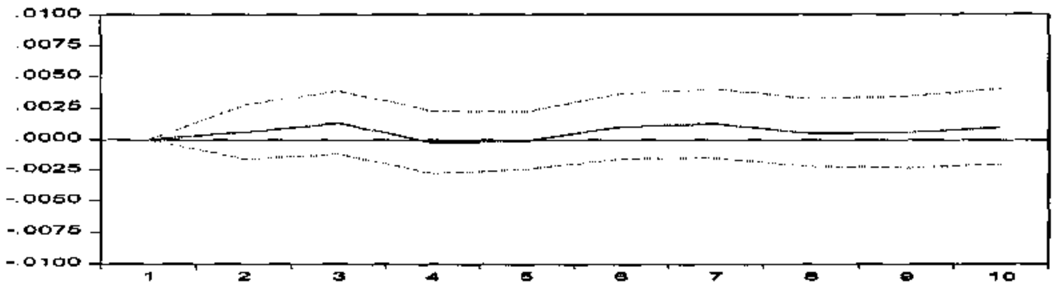
Due to unanticipated risk premium shock there is a subsequent sharp rise in the exchange rate which results in depreciation of the domestic currency. This depreciation in local currency decreases the price level of domestically produced goods in terms of foreign currency and raises the price level of imported goods in terms of domestic currency. It results in a rise in exports and fall in imports. Thus rise in net exports put upward pressure on the aggregate demand.

However, the estimated response of aggregate demand show that due to risk premium shock, aggregate demand started increasing in the second half of first quarter and continue to rise up to 3rd quarter then touches to long run equilibrium path in the 4th quarter.

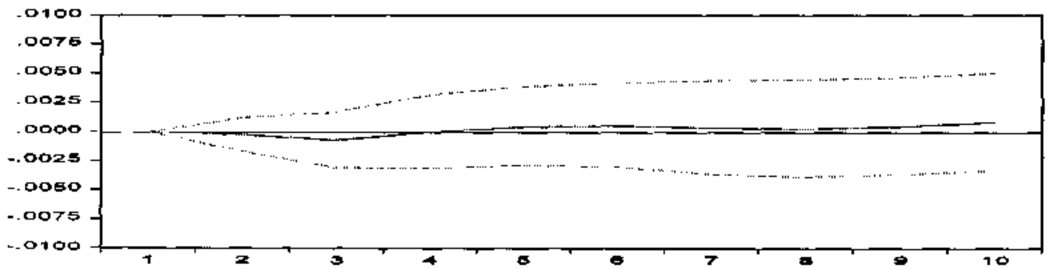
It can also be witnessed that risk premium shock does not cause significant change in the price level. There is immediate increase in the exchange rate but it slowly moves toward the long run path up to fourth quarter. Then afterwards it remained higher than the long run equilibrium path of exchange rate. However, the reaction of monetary authority is not significant in response to risk premium shock. It may be justified up to the extent that it does not have significant effect on aggregate demand or inflation.

Figure 5.13 Macroeconomic Dynamics in Response to Risk Premium shock

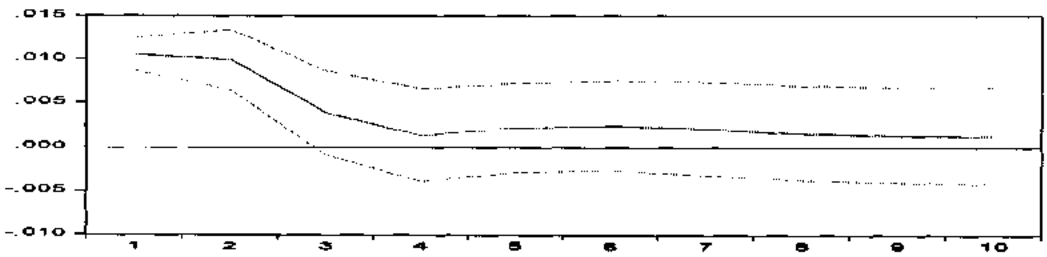
(a) Response of Output Gap to Risk Premium Shock



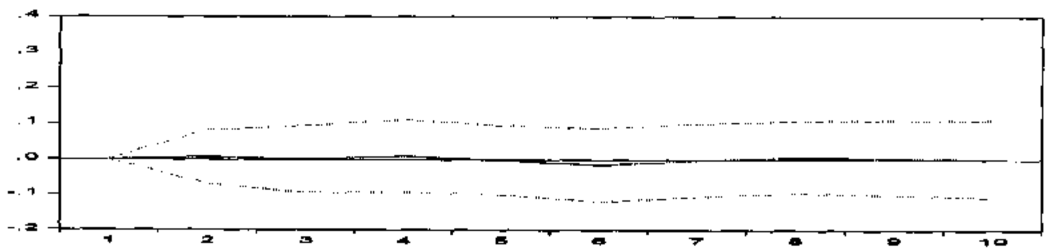
(b) Response of Inflation to Risk Premium Shock



(c) Response of Exchange Rate to Risk Premium Shock



(d) Response of Interest Rate to Risk Premium Shock



As a matter of fact, it is also evident that exchange rate has permanently been set at a higher level. Focusing on the impulse response provided in figure 5.16, it is witnessed that risk premium shock has permanent positive effect on aggregate demand, inflation, exchange rate and interest rate in the long run. Therefore, it seems to be justified here if SBP may address the concern to stabilize the economy by offering response in a forward looking way so that exchange rate may be stabilized leading to an overall stable economy.

5.4.4.3 Fiscal Shock

Aggregate demand raises as fiscal shock hits the economy. In the first quarter, aggregate demand starts lowering but remains higher than the long run stability path up to 25 quarters. Inflation starts increasing in the same period in which fiscal shock hits the economy which reflects that inflation is demand driven, that is due to rise in aggregate demand after fiscal shock, rise in price level is witnessed. Price level rises up to six quarters reaching at its peak then inflation starts decreasing but remains at higher level (than it was before the fiscal shock) up to 18^{th} quarters and hits the previous level in 19^{th} quarter. Afterwards it maintains the long run price level. The results reflect that although fiscal shock addresses the concerns of fiscal authorities to grow the economy by achieving high economic growth, at least, in the short run but actualizes at the cost of rise in price level.

rate moves back to the level prior to fiscal shock in the third quarter then afterwards it remains higher than the long run stability path.

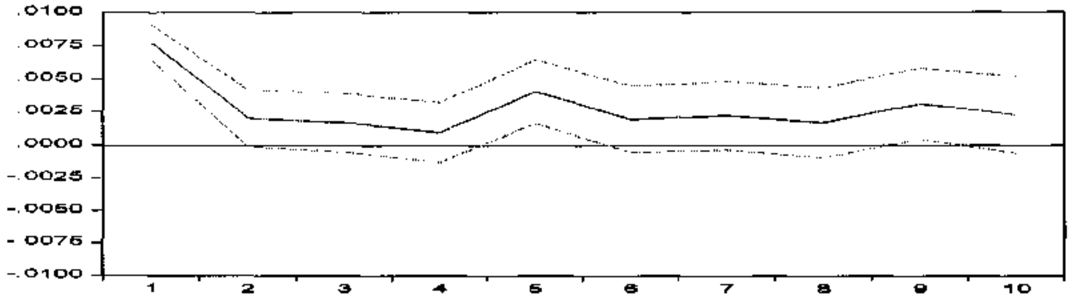
Interest rate increases in response to fiscal shock in the first quarter which may results in relaxing the pressure on demand. It shows increasing trend up to 3rd quarter then starts decreasing and touches the long run path in 4th quarter. After getting the long run path temporarily, it again starts increasing and attains a higher level in the seventh quarter onwards.

By focusing on the dynamics of interest rate to fiscal shock, it is clear that SBP responded to fiscal shock to stabilize the economy, that is, to compensate the impact of fiscal shock but failed to get the economy back to its long run equilibrium path. This situation indicates the inability of SBP to achieve its objective to stabilize the economy.

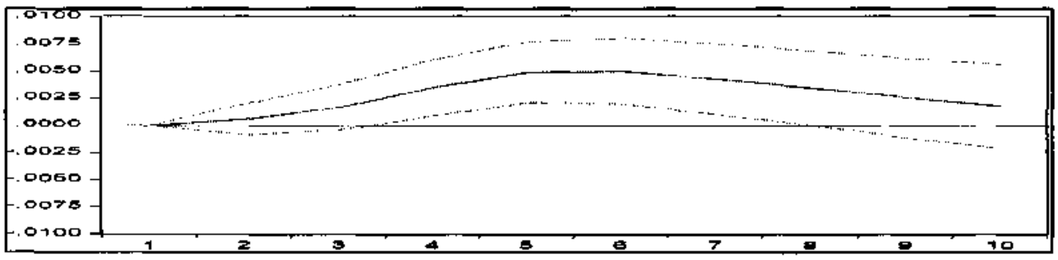
Before discussing further, it is important to see whether SBP has ever claimed to follow the policy reaction function during the period of investigation. The answer is 'No' as indicated by Malik and Ahmed (2010). Secondly, SBP may have wide range of objectives in its policy reaction function and the function employed here is miss-specified. However, more objectives lead the monetary authorities to divert their focus from basic objectives to secondary objectives like controlling the government borrowings from SBP which is in contravention to the true spirit of independence of monetary policy and the Taylor rule.

Figure 5.14 **Macroeconomic Dynamics in Response to Fiscal Shock in Open Economy Framework**

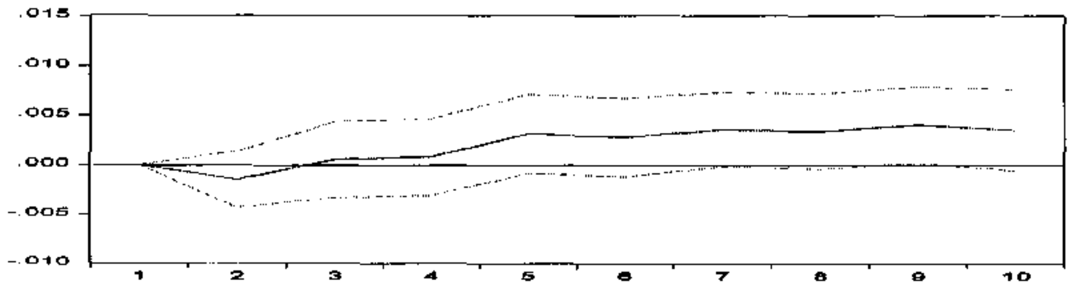
(a) Response of Output gap to aggregate demend shock



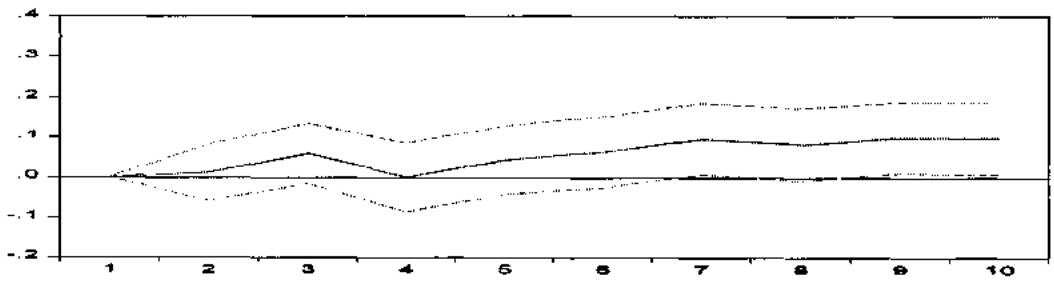
(b) Response of Inflation to aggregate demend shock



(c) Response of Exchange Rate to aggregate demend shock



(d) Response of Intrest Rate to aggregate demend shock



But it is generally acceptable that three macroeconomic variables are very important to focus as policy variables, that is, output gap which reflect the demand pressures, inflation and the exchange rate. Literature also emphasizes the importance of independent monetary policy by the SBP. The results shown here strongly recommend the adoption of forward looking policy in the country.

The estimated parameter of output gap in the reaction function, which is greater than one, show that there is more than one-to-one adjustment in the interest rate in response to changes in the aggregate demand. But, according to Taylor (1999), parameter of output gap should be less than one to ensure economic stability. Linking this result with the response of interest rate to fiscal shock shows that the response of SBP is not appropriate enough to stabilize the economy. It is pertinent to mention that SBP is not independent enough to set the targets of the relevant macroeconomic variables. Actually, it is fiscal authority that sets the targets of output gap and inflation and SBP announces merely the policy to achieve those targets. SBP has completely failed to stabilize the exchange rate as well.

5.4.4.4 Cost Push Shock

Inflation started rising and output gap started reducing in the second half of the first quarter, after cost push shock hit the economy which resulted in a rise in production cost leading to an overall price hike in the country. This hike led to a decrease in the demand of domestically produced goods. The downward trend in aggregate demand is observed to be temporary (for one quarter only). Aggregate demand started moving to its potential level during the second quarter and touched its potential level in the third quarter. Then it remained around the potential path and stabilized in the twentieth quarter which is evident in figure 5.16. After an initial increase in the inflation rate, it showed downward trend in the inflation rate from the second quarter. After touching the long run targeted level of inflation after ten quarters, it moved around the targeted level and stabilized in the twentieth quarter (in the same period when aggregate demand stabilized).

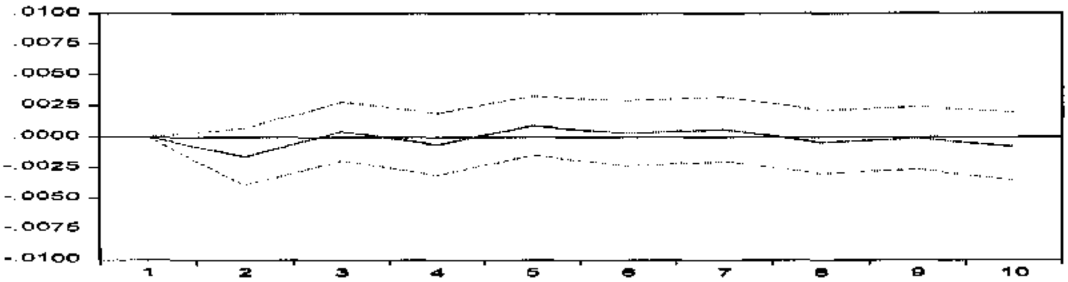
It is important to remember here that cost push shock is rooted in the minimum wage legislation enacted by the government or due to monopolistic competition in the labor market. Panel (c) of figure 5.15 show the response of exchange rate after cost push shock hits the economy. It is evident that exchange rate remains lower than its long run path for the first three quarters and higher for the next three quarters. After moving down and up almost in the same fashion, it remains lower than long run path from fifteenth quarter onwards.

Impulse response shows that monetary authorities do not respond to the cost push shock during the first quarter. However, interest rate starts rising in the second quarter, gets its peak in the fifth quarter and then starts lowering and touches the long run path at the end of ninth quarter. Then onwards, no significant change in interest rate is witnessed. One thing is clear that SBP did not react immediately to stabilize the economy in the short run.

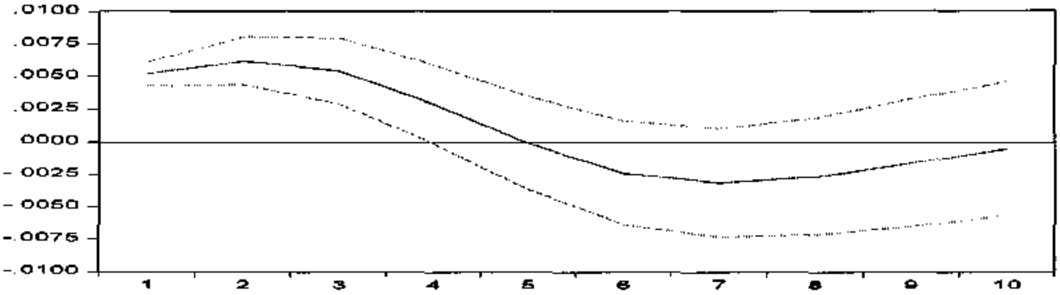
The deviation of the output gap and inflation in response of cost push shock in the economy reflects that cost push shock has significant impact on macroeconomic aggregates including exchange rate. The situation emerged after the cost push shock demands strong response by the monetary authorities to play their role.

Figure 5.15 Macroeconomic Dynamics in Response to Cost Push Shock in Open Economy Framework

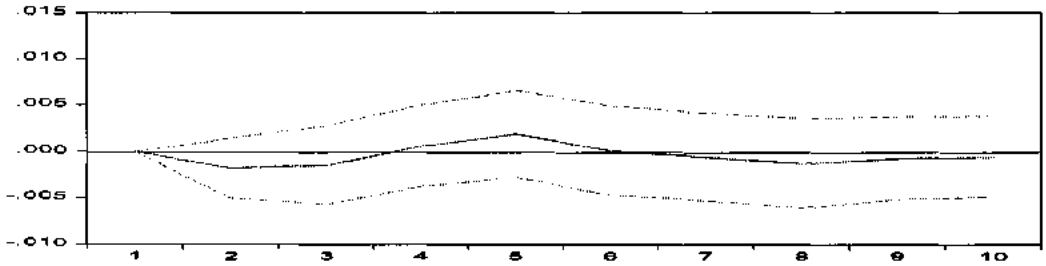
(a) Response of Output Gap to Cost Push Shock



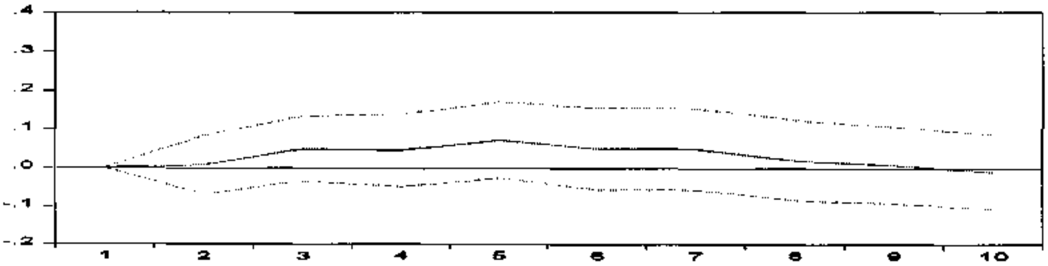
(b) Response of Inflation to Cost Push Shock



(c) Response of Exchange Rate to Cost Push Shock



(d) Response of Interest Rate to Cost Push Shock

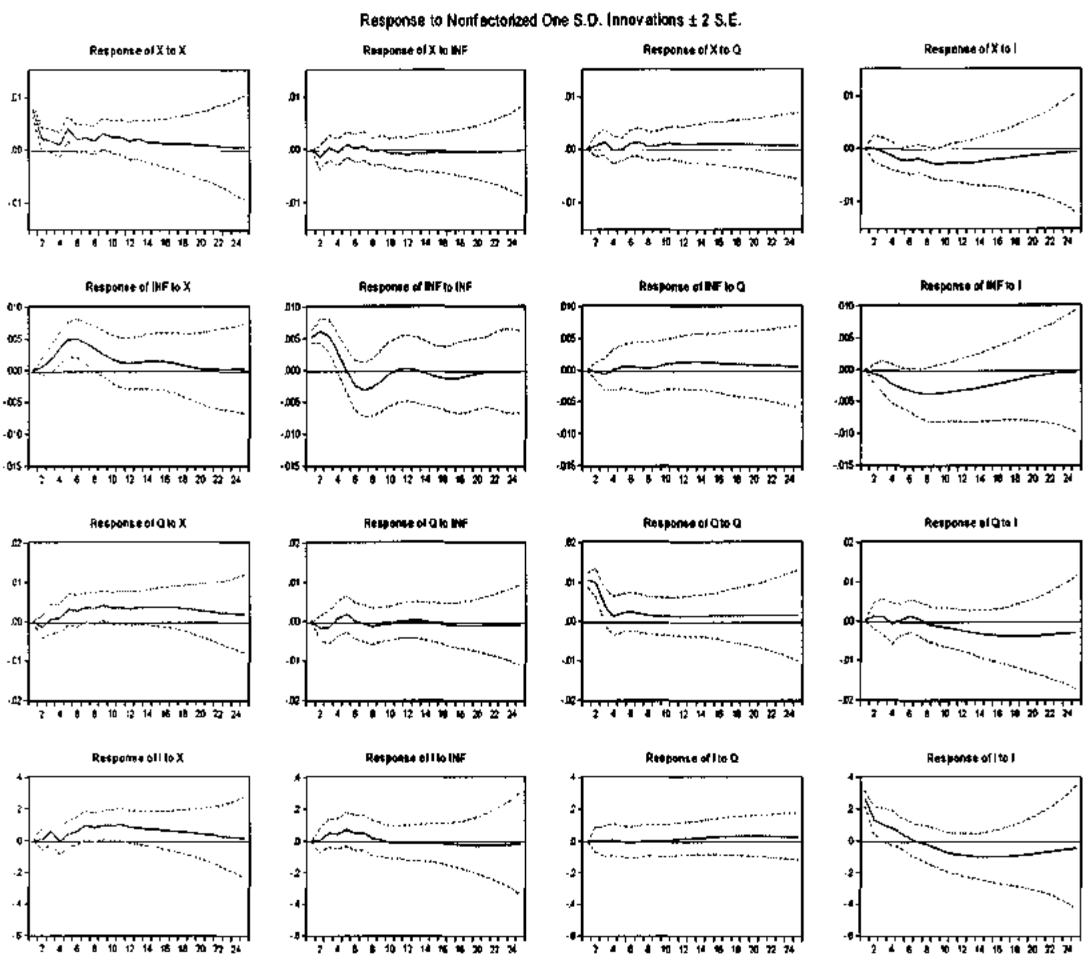


The results clearly indicate that SBP is not following the interest rate rule at least up to the recommendations put forward by Taylor (1999).

5.4.4.5 Macroeconomic Dynamics in the Long Run

The depiction below shows the response of macroeconomic aggregates to different structural shocks in the long run. Overall, the results show that economy achieves stability in the long run in response to any of the structural shock.

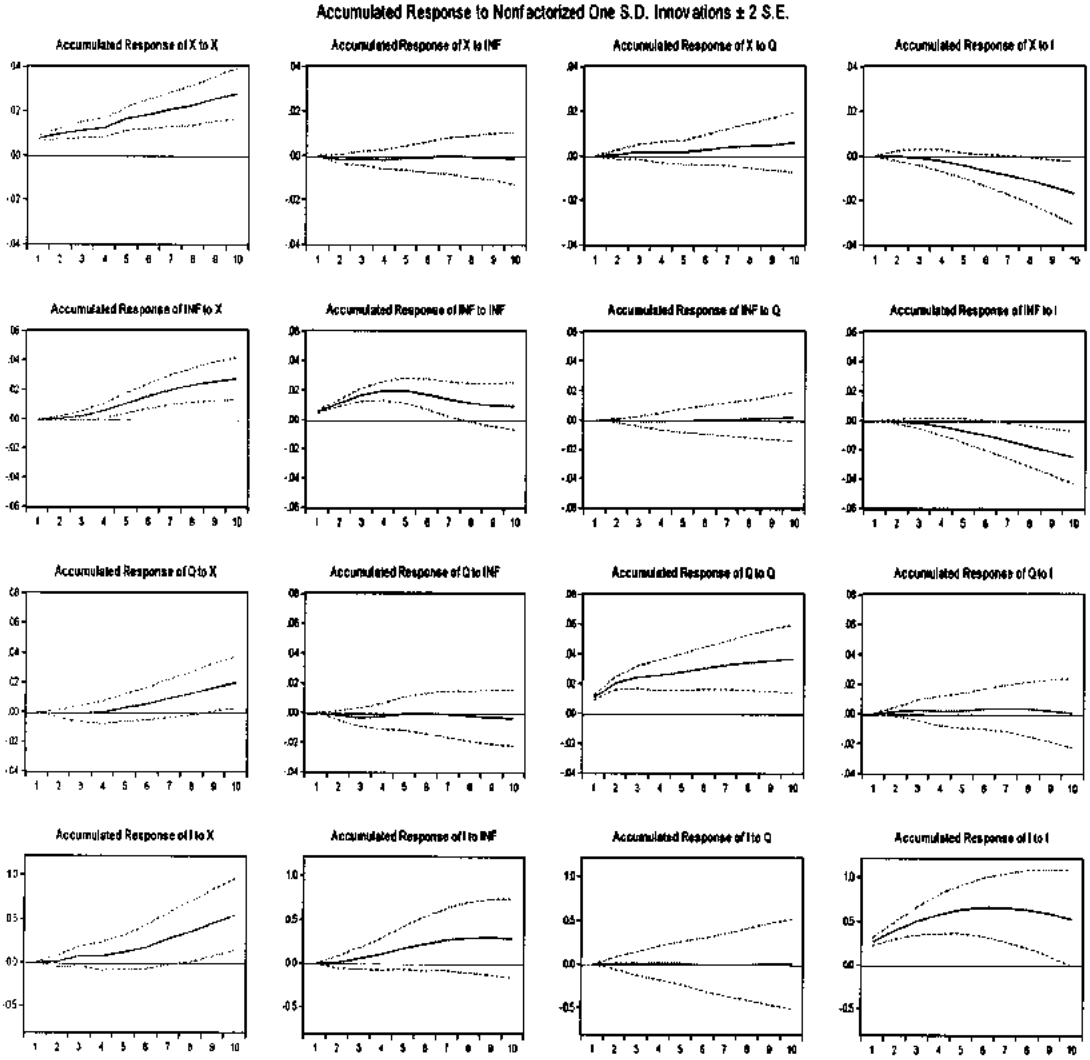
Figure 5.16 Response of Macroeconomic Aggregates to Structural shocks in the Long Run



5.4.4.6 Macroeconomic Dynamics in Response to Permanent Structural Shocks

The results show that permanent monetary shocks badly influence the macroeconomic aggregates, that is, economy deviates from its long run equilibrium, which results in depression in the economy.

Figure 5.17 Response of Macroeconomic Aggregates to Permanent Structural shocks



On the other hand, economy face more and more demand pressures and rise in price level if the economy faces permanent fiscal shocks. Permanent risk premium shocks influence only the output gap and exchange rate to move away from the long run stability path. Permanent cost push shock results in higher inflation rate and interest rate in the country on permanent basis. The results indicate that none of the structural shock is favorable if it hits the economy in every period.

5.4.4.7 Identifying the Source-wise Strength of Variations

Forecast error variance decomposition provides the opportunity to identify the sources of variation in the forecasts of macroeconomic variables and specify the proportional share of structural shocks in these variations. Thus complementing the impulse response it provides an insight to the policy makers to stabilize the economy.

The results, shown in Table 5.7, show that major source of variation in output gap, inflation, exchange rate and interest rate is the cost push shock which is followed by fiscal shock for all the variables. However, risk premium shock is least important in causing variations in the forecasts of macroeconomic aggregates thus diverting the focus of the policy makers to consider the fiscal and cost push shocks as the most important determinants of dynamics of the economy.

The most important source of variation in forecasting error of interest rate is the cost push shock which explains 69.90 percent variation in the first period and moves downward slightly to 65.15 percent by 5th quarter and remain at around 65.30 percent (on average) up to twenty five quarters. Fiscal shock explains 19.62 to 25.30 percent variations in forecasting interest rate from first to fifth quarter which moves to 24.71 percent by the twenty fifth quarter. Monetary shock determines 10.23 to 9.73 percent variations from first quarter to twenty fifth quarter. Variations in interest rate forecasts due to risk premium shock ranges from 0.25 percent to 0.048 percent.

The variance of forecast error in the output gap for each structural shock witnesses that cost push shock is the major contributor for variations in it which is around 65.35 percent up to 25 quarters and is followed by fiscal shock which causes variations in forecasts of output gap about 24.86 percent for the twenty fifth quarter. Monetary policy shock explains about 9.72% of the forecast error variance.

Exchange rate variations are mainly driven by cost push shocks and fiscal shock along with monetary shock. Investigation of the relative importance of the structural shocks in explaining inflation shows that in the first period of forecast 69.90 percent, 19.62 percent, 10.23 percent of the variations are sourced by cost push shock, fiscal shock and monetary shock respectively. The ratio of the structural shocks in forecast error variance do not disturb significantly up to twenty five quarters.

The results depict that monetary authorities should follow the Taylor rule so as to control the inflation and output gap in the country which will lead to economic stability and minimize the variations in forecasting the economy.

Table 5.7 (a) Forecast Error Variance Decomposition of Output Gap and Inflation

Variance Decomposition of Output Gap					
Period	S.E.	Fiscal Shock	Cost Push shock	Risk Premium shock	Monetary shock
1	2.38943	24.98349	65.25567	0.041854	9.718982
2	2.47684	24.96997	65.25751	0.043123	9.729394
3	2.5442	24.94732	65.28001	0.045548	9.727117
4	2.56183	24.94503	65.2807	0.045154	9.729118
5	2.85814	24.93469	65.30087	0.043152	9.721293
9	3.24552	24.86147	65.36881	0.045283	9.724439
13	3.53296	24.80456	65.4101	0.046965	9.738381
17	3.64725	24.77311	65.43431	0.048387	9.744191
21	3.7009	24.75647	65.44656	0.049419	9.747547
25	3.72222	24.74916	65.45179	0.049993	9.749049

Variance Decomposition of Inflation					
Period	S.E.	Fiscal Shock	Cost Push shock	Risk Premium shock	Monetary shock
1	0.01004	25.29269	69.68526	0.004926	5.017118
2	0.17459	25.42165	66.83774	0.010662	7.729944
3	0.52993	25.23858	65.79822	0.013844	8.949352
4	1.21938	24.9538	65.55558	0.031099	9.459519
5	1.98022	24.86623	65.46543	0.037665	9.630675
9	3.21681	24.77483	65.41693	0.038642	9.769595
13	3.36345	24.72455	65.46473	0.040709	9.770016
17	3.49298	24.68883	65.4901	0.04316	9.777908
21	3.51523	24.67832	65.4968	0.044068	9.78081
25	3.51947	24.67538	65.49905	0.044502	9.781066

Table 5.7 (b) Forecast Error Variance Decomposition of Exchange Rate and Interest Rate

Variance Decomposition of Exchange Rate					
Period	S.E.	Fiscal Shock	Cost Push shock	Risk Premium shock	Monetary shock
1	0.41879	20.62455	67.95967	1.813708	9.602074
2	0.42934	21.33687	66.42419	2.807523	9.431416
3	0.52081	21.84027	66.42816	2.131242	9.600327
4	0.60384	22.42439	66.34793	1.622923	9.604762
5	1.21643	24.12538	65.79678	0.467569	9.610265
9	2.59336	24.57949	65.53553	0.162894	9.722093
13	3.4711	24.62455	65.53318	0.115953	9.726313
17	4.23714	24.61483	65.55129	0.095821	9.738061
21	4.70327	24.5906	65.56982	0.088731	9.750855
25	4.92647	24.56867	65.58716	0.086981	9.757187

Variance Decomposition of Interest Rate					
Period	S.E.	Fiscal Shock	Cost Push shock	Risk Premium shock	Monetary shock
1	3.1234	19.62095	69.90496	0.24681	10.22728
2	3.9826	22.834	66.9871	0.368106	9.810802
3	17.4179	25.27418	65.12186	0.080377	9.523588
4	17.425	25.26649	65.12102	0.083306	9.529184
5	21.5462	25.30326	65.15528	0.072561	9.468897
9	57.5547	25.0183	65.30594	0.044105	9.631664
13	82.4811	24.8783	65.38323	0.042112	9.696353
17	94.5498	24.79067	65.44797	0.044114	9.717246
21	100.493	24.73908	65.48293	0.046307	9.731677
25	102.412	24.71566	65.49913	0.047801	9.73741

5.5 SUMMARY

Closed economy and open economy models are estimated using maximum likelihood procedure. The estimates of deep structural parameters suggest that expectations of economic agents play significant role in determining the macroeconomic dynamics of the economy and these expectations are mainly forward looking. Output gap is an important determinant of inflation in the country which reveals the fact that inflation is demand driven. Exchange rate is significant in determining the output gap even at 99% confidence level. The results of both models demonstrate that SBP is not using the Taylor rule. However, the augmented expectations type Taylor rule employed in the open economy model reveals that SBP do not consider the exchange rate as an objective to stabilize the economy.

The results of closed economy model show that SBP has adopted discretionary policy rather than a rule which is witnessed through the impulse response of macroeconomic variables to monetary shock. Fiscal shock is found to be the most important source of variations in forecast errors of output gap, inflation and interest rate.

Results of open economy model show that interest rate channel is important to control the dynamics of the economy in comparison to exchange rate channel which has the least impact on the macroeconomic dynamics. Impulse response of the reaction function shows that SBP respond to structural shocks after a lag of more than a period and the economy takes more than 25 quarters to move back to stability in many cases. The analysis of permanent shocks shows that permanent structural shocks depart the economy from the stability path permanently. Variance decomposition identify cost push shock as the most important source of error variance in forecasting the economic aggregates which is followed by fiscal shock and monetary shock respectively.

CHAPTER 6

CONCLUSION AND POLICY IMPLICATIONS

In a path breaking article Lucas (1976) highlighted the inability of macroeconomic models to forecast the consequences of unannounced policy changes. The NK macroeconomic models of recent years possess sundry features, the most consequential being the forward looking expectations modeling approach. The models developed in the present study have been adopted taking into account the NK perspective that incorporates the role of expectations and rigidities.

NK models include the role of expectations on the part of economic agents and require incorporating role of expectations by the policy makers to get the economy stable. NK models have advantage over the Real Business Cycle (RBC) models allowing the rigidities in the structure of the model hence provide built-in mechanism to incorporate the structural shocks.

We have also acquired a look into the literature that base the research on other than DSGE NK framework. The literature revealed no consensus about the impact of open economy factors on macroeconomic performance. Romer (1993), Lane (1997), and Rogoff (2003) suggest that globalization make the Phillips curve steeper and some other studies like Kuttner and Robinson (2010) suggest that with the increase in the role of global factors in the domestic performance of an economy, Phillips curve will become flatter. Ihrig *et. al* (2006) find little support for the increased role of globalization in determining domestic inflation. Wide range of methods have been used for the empirical estimation like Error Correction model, Panel data model, time series regression analysis, GMM, Probit model etc. The most important aspect is missing in the literature cited in chapter 2, i.e. absence of microeconomic foundations and realistic assumptions which results in contradictory findings.

Lucas (1976) pointed out the inability of macroeconomic models to forecast the consequences of unannounced policy changes. NK macroeconomic models possess sundry features among which the most consequential base line feature is the modeling approach. Closed economy and open economy models have been derived taking into account the NK perspective hence the role of expectations and rigidities have been incorporated. PPP and UIP conditions are relaxed.

Rather than relying on 'borrowed' values of parameters, the maximum likelihood estimation procedure through structural VAR model has been used to estimate these values. The researcher intended to formulate and estimate closed and open economy NK models using robust econometric model. SVARs solve the problem of interpreting VARs by introducing restrictions sufficient to identify the underlying shocks thus provide a coherent interpretation of the shocks to the system. SVARs are robust as this methodology provides efficient and consistent estimates. There is hardly any study on Pakistan's economy that developed and estimated the model under the NK framework. On the empirical side, we investigated the macroeconomic dynamics in response to unanticipated monetary shock. Assessment of the reaction of monetary authorities in response to internal and external structural shocks has also been accomplished. The role of forward looking expectations has also been explored wisely. We employ SVAR model to estimate the structural parameters, the impulse response functions and the forecast error variance decomposition.

Estimation of the formulated models is actualized by following Keating (1990, 2000). Structural parameters along with the graphical representation of impulse response functions and the variance decomposition of the macroeconomic aggregates against the structural shocks are retrieved.

The results revealed that output gap has negative influence on inflation during the period of investigation for both closed economy and open economy models. The result is in line with the findings of Akbari (2005) and Amjad (2012).

Investigation of the macroeconomic dynamics in response to unanticipated monetary shock has always been an area of interest for the economists that have normally been investigated by analyzing impulse response functions. Investigation of the closed economy model has shown that unanticipated contractionary monetary shock led to an increase in output gap for the first three quarters. It has also been seen that due to contractionary monetary shock, inflation reduced after 2 quarters which stressed the monetary authorities to adopt forward looking policy. Instead of decreasing, the aggregate demand increased. The reason may be the adoption of dual mandate by the SBP to achieve economic growth and controlling inflation. In response to monetary tightening by the authority, aggregate demand displayed rising trend in the initial periods.

The results are however consistent with the idea of 6-18 months lag in achieving reduction in the output to its long run stability point. There is no evidence of price puzzle.

In response to contractionary monetary policy both output gap and inflation respond with a lag hence SBP should adopt forward looking policy by taking into account the expectations and the prevailing market structure. However, SBP remained unable to get the desired change in the exchange rate in the short run rather the change is otherwise which indicates the exchange rate puzzle situation. It simply moved the attention toward the distorted beliefs of the investors about the stance of monetary policy as indicated by Gourinchos (2003). Javed and Munir (2010) also found similar results and pointed the ineffectiveness of monetary policy. Expectations of the economic agents are found to play prominent role in the prevailing market structure of the country. It also highlights the importance of SBP's commitment. Interest rate channel is found to be important to control the dynamics of the economy in comparison to exchange rate channel.

The parameter estimates of the close economy model confirmed that an increase in real interest rate results in subsequent decrease in output gap which is supported by the theory. The results also demonstrated that forward looking expectations played important role in determining inflation. Output gap favored the economy to lower the inflation.

For the closed economy model, the parameters of output gap and expected inflation have shown negative impact on interest rate which indicated that policy was both ineffective and not independent. Further, it reflects the lack of transparency thus SBP should follow the Taylor rule. The possibility of getting results contradictory to the theory may also reveal that SBP has either raised the interest rate in the recessionary periods or otherwise.

The results are in line with the findings of Malik and Ahmed (2010). Overall, the results show that the response of monetary policy to output and inflation is countercyclical when the closed economy model is estimated.

The estimates of reaction function of open economy indicated that SBP has been successful somehow in stabilizing the inflation but destabilized the aggregate demand situation. The parameter estimate of expected rise in exchange rate in the monetary reaction function is negative that suggested inappropriate response of monetary authority to exchange rate fluctuations.

Investigation of the macroeconomic dynamics in response to unanticipated monetary shock has always been an area of interest for the economists that have normally been investigated by analyzing impulse response functions. In response to positive fiscal shock, monetary authorities increased the interest rate to condemn the negative effects of fiscal shock to economy but kept silent for two quarters to get the positive impact on output gap. This is mainly due to the objective of SBP to achieve high level of economic growth and due to prevalence of fiscal dominance in the country. Government of Pakistan sets the target level of economic growth and inflation after which monetary policy was pretentiously controlled by SBP. However, government gets high borrowings from the SBP to finance the fiscal deficit which is normally not discouraged by the SBP.

Open economy structural impulse response analysis indicated that in response to cost push shock, monetary authorities dropped the interest rate instead of raising it. Thus, the results indicate that SBP has never exercised the interest rate rule comprising output gap and expected inflation during the period of investigation and left the policy at discretion.

By focusing on the dynamics of interest rate to fiscal shock, it is clear that SBP responded to fiscal shock to stabilize the economy to compensate the impact of fiscal shock but failed to get the economy back to its long run equilibrium path. This situation indicates the inability of SBP to stabilize the economy but is in-line with the objective to achieve growth in real economic activity. However, SBP responded to cost push shock though not immediately indicating time inconsistency problem.

The results exposed the importance of expectations of economic agents in determining macroeconomic dynamics of the economy which are found to be forward looking, both for closed and open economy models.

The parameter estimates for the closed economy model suggest that an increase in real interest rate will result in subsequent decrease in output gap which is supported by the theory. The results also demonstrated that forward looking expectations played important role in determining inflation. Output gap favored the economy to lower the inflation. The parameters of output gap and forward looking inflation suggested negative impact on the interest rate that matched the findings of Malik and Ahmed (2010).

The results suggested that expected depreciation in exchange rate impact significantly positively the aggregate demand. The exchange rate has significantly positive impact on inflation as envisioned in the theory.

SBP has never responded to risk premium shock that can be justified up to the extent that it does not have significant effect on aggregate demand or inflation in the short run. But as a matter of fact it has permanent positive effect on aggregate demand, inflation, exchange rate and interest rate in the long run. Therefore, SBP seems to be justified here to respond to exchange rate changes in a forward looking way so that exchange rate may be stabilized leading to an overall stable economy.

Analysis of closed economy model suggested that fiscal shock is the most important source of variation in forecast errors of output gap, inflation and interest rate. However, for the open economy model, variance decomposition identified cost push shock as the most important source of error variance in forecasting all the macroeconomic aggregates followed by fiscal and monetary shocks respectively.

The analysis of permanent shocks indicated that permanent structural shocks taken away the economy from the stability path permanently.

It is generally acceptable that three macroeconomic variables (output gap which reflect the demand pressures, inflation and the exchange rate) are very important to focus as policy variables for countries like Pakistan. SBP is not independent enough to set the targets of the relevant macroeconomic variables. Actually, it is the fiscal authority that sets the targets of output gap and inflation and SBP announces merely the policy to achieve those targets. SBP has completely failed to stabilize the exchange rate as well. The results suggest that independent and transparent monetary policy should be adopted by the SBP.

SBP did not react immediately to stabilize the economy in the short run. SBP may have wide range of objectives in its policy reaction function and the function employed here is miss-specified. However, more objectives lead the monetary authorities to divert their focus from basic objectives to secondary objectives like controlling the government borrowings from SBP which is in contravention to the true spirit of independence of monetary policy and the Taylor rule. It is, therefore, strongly recommended that SBP should follow the Taylor rule.

Distorted beliefs of the economic agents about the stance of monetary policy highlighted ineffectiveness of the monetary policy. Thus expectations play prominent role in the prevailing market structure in the country. It is therefore suggested that SBP should show commitment to meet the objective of controlling inflation in the country along with stabilizing the demand pressures which may result in confidence building between SBP and the other economic agents. It all requires implementing the financial liberalization regime in its true sense.

Future research in the area of modeling requires discussing optimal policy and its impact on the Taylor rule, adoption of the Expectations Taylor type rules and the time consistency of policy which should also discuss the determinacy or stability of the economy. Before closing the discussion, it may be useful to add that there are various methods to estimate DSGE models other than the SVAR model. These alternatives, however, require microeconomic survey based values of parameters which are seldom available. Hence, there has been a 'natural' limitation to rely only on SVAR model. Accordingly, future research in the area of modeling would require that microeconomic surveys are conducted to generate the values of microeconomic parameters. These surveys will also allow the possibility of inclusion of informal sectors of the economy in the modeling approach to have a holistic view of the economy.

APPENDICES

Appendix A-3.2

Procedure for Substitution of value of $\Delta_{k,t+k}$ in equation (3.24)

$$\sum_{k=0}^{\infty} E_t\left[(\theta_t)^k \Delta_{k,t+k}\left(C_{t+k}\left[(1-\varepsilon)\left(\frac{P_{j,t}}{P_{t+k}}\right)+\eta\varphi_{t+k}\right]\left(\frac{1}{P_{j,t}}\right)\left(\frac{P_{j,t}}{P_{t+k}}\right)^{-\varepsilon}\right)\right]=0 \tag{3.24}$$

Put value of $\Delta_{k,t+k}$ from equation (23)

$$\sum_{k=0}^{\infty} E_t\left[(\beta\theta_t)^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}\left(C_{t+k}\left[(1-\varepsilon)\left(\frac{P_{j,t}}{P_{t+k}}\right)+\varepsilon\varphi_{t+k}\right]\left(\frac{1}{P_{j,t}}\right)\left(\frac{P_{j,t}}{P_{t+k}}\right)^{-\varepsilon}\right)\right]=0$$

$$\Leftrightarrow \sum_{k=0}^{\infty} E_t\left[(\beta\theta_t)^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}\left(C_{t+k}\left(\frac{1}{P_{j,t}}\right)\left(\frac{P_{j,t}}{P_{t+k}}\right)^{-\varepsilon}\right)\left\{(1-\varepsilon)\left(\frac{P_{j,t}}{P_{t+k}}\right)\right\}\right]$$

$$=-\sum_{k=0}^{\infty} E_t\left[(\beta\theta_t)^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}\left(C_{t+k}\left(\frac{1}{P_{j,t}}\right)\left(\frac{P_{j,t}}{P_{t+k}}\right)^{-\varepsilon}\right)\varepsilon\varphi_{t+k}\right]$$

$$\Leftrightarrow \sum_{k=0}^{\infty} E_t\left[(\beta\theta_t)^k C_{t+k}{}^{(1-\sigma)} C_t{}^{\sigma}\left(\left(\frac{1}{P_{j,t}}\right)\left(\frac{P_{j,t}}{P_{t+k}}\right)^{-\varepsilon}\right)\left\{(1-\varepsilon)\left(\frac{P_{j,t}}{P_{t+k}}\right)\right\}\right]$$

$$=-\sum_{k=0}^{\infty} E_t\left[(\beta\theta_t)^k C_{t+k}{}^{(1-\sigma)} C_t{}^{\sigma}\left(\left(\frac{1}{P_{j,t}}\right)\left(\frac{P_{j,t}}{P_{t+k}}\right)^{-\varepsilon}\right)\varepsilon\varphi_{t+k}\right]$$

$$\Leftrightarrow \sum_{k=0}^{\infty} E_t\left[(\beta\theta_t)^k C_{t+k}{}^{(1-\sigma)} C_t{}^{\sigma}\left(\left(\frac{1}{P_{j,t}}\right)\left(\frac{P_{j,t}}{P_{t+k}}\right)^{-\varepsilon}\right)\left\{(1-\varepsilon)\left(\frac{P_{j,t}}{P_{t+k}}\right)\right\}\right]$$

$$=-\sum_{k=0}^{\infty} E_t\left[(\beta\theta_t)^k C_{t+k}{}^{(1-\sigma)} C_t{}^{\sigma}\left(\left(\frac{1}{P_{j,t}}\right)\left(\frac{P_{j,t}}{P_{t+k}}\right)^{-\varepsilon}\right)\varepsilon\varphi_{t+k}\right]$$

Rearranging the above equation will gives

$$P_t = \left(\frac{\varepsilon}{1-\varepsilon}\right)\frac{E_t \sum_{k=0}^{\infty}(\beta\theta_t)^k (C_{t+k})^{1-\sigma}\varphi_{t+k}(P_{t+k})^{\varepsilon}}{E_t \sum_{k=0}^{\infty}(\beta\theta_t)^k (C_{t+k})^{1-\sigma}(P_{t+k})^{\varepsilon-1}}$$

$$\left(\frac{P^*_{j,t}}{P_t}\right) = \left(\frac{\varepsilon}{1-\varepsilon}\right)\frac{E_t \sum_{k=0}^{\infty}(\beta\theta_t)^k (C_{t+k})^{1-\sigma}\varphi_{t+k}\left(\frac{P_{t+k}}{P_t}\right)^{\varepsilon}}{E_t \sum_{k=0}^{\infty}(\beta\theta_t)^k (C_{t+k})^{1-\sigma}\left(\frac{P_{t+k}}{P_t}\right)^{\varepsilon-1}} \qquad (3.25)$$

Appendix B-3.2

Taylor Series approximation of Equation (3.30)

The exponential form of left hand side of equation (3.30) is reproduced as under:

$$\left[E_t \sum_{k=0}^{\infty} (\beta\theta_t)^k e^{(1-\sigma)c_{t+k}} e^{(\varepsilon-1)(p_{t+k}-p_t)}\right] e^{f_t}$$

In the steady state, $\pi_t = 0,\ f_t = 0, F = 1$

$$E_t \sum_{k=0}^{\infty} (\beta\theta_t)^k e^{(1-\sigma)c} * 1 * 1 + E_t \sum_{k=0}^{\infty} (\beta\theta_t)^k e^{(1-\sigma)c} * 1 * (\varepsilon-1)(p_{t+k} - \bar{p}) +$$

$$E_t \sum_{k=0}^{\infty} (\beta\theta_t)^k e^{(1-\sigma)c} * 1 * (\varepsilon-1)(f_t - \bar{f}) - E_t \sum_{k=0}^{\infty} (\beta\theta_t)^k e^{(1-\sigma)c} * 1 * (\varepsilon-1)(p_t - \bar{p})$$

$$+E_t \sum_{k=0}^{\infty} (\beta\theta_t)^k (1-\sigma) e^{(1-\sigma)c} * 1 * (c_{t+k} - \bar{c})$$

Since $\sum_{k=0}^{\infty} (\beta\theta_t)^k$ can be approximated as $\frac{1}{1-\beta\theta_t}$

Thus the Taylor series approximation is

$$\frac{e^{(1-\sigma)c}}{1-\theta_t\beta} + \frac{e^{(1-\sigma)c}}{1-\theta_t\beta}\hat{f}_t + e^{(1-\sigma)c}\sum_{k=0}^{\infty}\left(\beta\theta_t\right)^k\left[(1-\sigma)E_t\hat{c}_{t+k} + (\varepsilon-1)\left(E_t\hat{p}_{t+k} - \hat{p}_t\right)\right]$$

The right hand side of equation (3.30) in exponential log form is

$$\mu\left[E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k e^{(1-\sigma)c_{t+k}}e^{\varphi_{t+k}}e^{\varepsilon(p_{t+k}-p_t)}\right]$$

$$E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k e^{(1-\sigma)c} * \varphi + E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k\varphi(1-\sigma)e^{(1-\sigma)c}(c_{t+k}-\bar{c}) +$$

$$E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k e^{(1-\sigma)c} * \varphi * (\varphi_{t+k}-\varphi) - E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k e^{(1-\sigma)c} * \varphi\varepsilon(p_t-\bar{p})$$

$$+E_t\sum_{k=0}^{\infty}(\beta\theta_t)^k e^{(1-\sigma)c} * \varphi\varepsilon(p_{t+k}-\bar{p})$$

<u>Taylor series approximation of right hand side of equation (3.30) is</u>

$$\left(\frac{e^{(1-\sigma)c}}{1-\theta_t\beta}\right)\varphi + e^{(1-\sigma)c}\varphi\sum_{k=0}^{\infty}\left(\beta\theta_t\right)^k\left[E_t\hat{\varphi}_{t+k} + (1-\sigma)E_t\hat{c}_{t+k} + \varepsilon\left(E_t\hat{p}_{t+k}-\hat{p}_t\right)\right]$$

Now equation (3.30) becomes

$$\frac{e^{(1-\sigma)c}}{1-\theta_t\beta} + \frac{e^{(1-\sigma)c}}{1-\theta_t\beta}\hat{f}_t + e^{(1-\sigma)c}\sum_{k=0}^{\infty}\left(\beta\theta_t\right)^k\left[(1-\sigma)E_t\hat{c}_{t+k} + (1-\varepsilon)\left(E_t\hat{p}_{t+k}-\hat{p}_t\right)\right]$$

$$= \mu\left[\left(\frac{e^{(1-\sigma)c}}{1-\omega\beta}\right)\varphi + e^{(1-\sigma)c}\varphi\sum_{k=0}^{\infty}(\beta\theta_t)^k\left[E_t\hat{\varphi}_{t+k} + (1-\sigma)E_t\hat{c}_{t+k} + \varepsilon(E_t\hat{p}_{t+k}-\hat{p}_t)\right]\right]$$

Noting $\mu\varphi = 1$ and $F = 1$

$$\left(\frac{1}{1-\theta_t\beta}\right)\hat{f}_t + \sum_{k=0}^{\infty}\left(\beta\theta_t\right)^k\left[(1-\sigma)E_t\hat{c}_{t+k} + (\varepsilon-1)\left(E_t\hat{p}_{t+k}-\hat{p}_t\right)\right]$$

$$= \left[\sum_{k=0}^{\infty}\left(\beta\theta_t\right)^k\left[E_t\hat{\varphi}_{t+k} + (1-\sigma)E_t\hat{c}_{t+k} + \varepsilon\left(E_t\hat{p}_{t+k}-\hat{p}_t\right)\right]\right]$$

Rearranging the above equation gives the following

$$\left(\frac{1}{1-\theta_t\beta}\right)\hat{f}_t = \sum_{k=0}^{\infty}(\beta\theta_t)^k\left[E_t\hat{\varphi}_{t+k} + E_t\hat{p}_{t+k} - \hat{p}_t\right]$$

$$\hat{f}_t = (1-\theta_t\beta)\sum_{k=0}^{\infty}(\beta\theta_t)^k\left[(E_t\hat{\varphi}_{t+k} + E_t\hat{p}_{t+k}) - \hat{p}_t\right]$$

Appendix-5.1

Checking the Variables for Stationarity

Table A-5.1 Unit Root Test

Variable	At	t-statistic	Prob	Order of integration
Output Gap	Level	-1.53157	0.512	
	1st Difference	-4.596069	0.0003	I(1)
Inflation	Level	-1.650408	0.4518	
	1st Difference	-3.947267	0.0029	I(1)
REER	Level	0.066842	0.9611	
	1st Difference	-6.656657	0.0000	I(1)
Interest Rate	Level	-3.088319	0.1166	
	1st Difference	-7.849211	0.0000	I(1)
FF Rate	Level	-1.983046	0.2936	
	1st Difference	-3.651307	0.0069	I(1)
US CPI	Level	0.722597	0.9919	
	1st Difference	-9.48928	0.0000	I(1)

* critical values at 1%, 5% and 10% level of significance are

-3.520307, -2.90067 and -2.587691 respectively.

Johanson Test of Cointegration

Closed Economy Model

The test results show that long run relation exists among all the variables employed for estimation of SVAR model. Therefore, we will use these variables at level as advised by Sims (1992) along with others.

Table A-5.2 Long run Relation among Variables of Closed Economy Model

Sample (adjusted): 1993Q2 2011Q4
Included observations: 75 after adjustments
Series: X PI I8
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.293385	38.59859	29.79707	0.0038
At most 1	0.111013	12.55342	15.49471	0.1322
At most 2	0.048491	3.727963	3.841466	0.0535

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.293385	26.04517	21.13162	0.0094
At most 1	0.111013	8.825461	14.2646	0.301
At most 2	0.048491	3.727963	3.841466	0.0535

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Open Economy Model

Test results show that long run relation exist among all the endogenous variables. However all the exogenous variables are also included in the estimation process as advised in the literature.

Table A-5.3 Long run Relation among Variables of Open Economy Model

Sample (adjusted): 1993Q2 2011Q4
Series: X INF Q I
Lags interval (in first differences): 1 to 4
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.394468	75.62952	63.8761	0.0038
At most 1	0.2629	38.00595	42.91525	0.1422
At most 2	0.146722	15.12853	25.87211	0.5639
At most 3	0.04213	3.228266	12.51798	0.8483

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.394468	37.62357	32.11832	0.0096
At most 1	0.2629	22.87742	25.82321	0.1168
At most 2	0.146722	11.90026	19.38704	0.4245
At most 3	0.04213	3.228266	12.51798	0.8483

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Estimated Results for Closed Economy Model

Table A-5.4 Unrestricted Closed Economy VAR Model with selected lag Variables

	X	Inflation	Interest Rate
X(-1)	0.151888	0.035953	-0.455842
	(0.15342)	(0.08657)	(2.33636)
	[0.99000]	[0.41529]	[-0.19511]
Inflation(-1)	-0.526022	1.174210	0.350240
	(0.23369)	(0.13187)	(3.55875)
	[-2.25089]	[8.90440]	[0.09842]
Interest Rate(-1)	0.009518	-0.000705	1.641777
	(0.00986)	(0.00556)	(0.15016)
	[0.96523]	[-0.12671]	[10.9334]
R-squared	0.959216	0.958634	0.970152
Adj. R-squared	0.942902	0.942087	0.958212
Sum sq. resids	0.003194	0.001017	0.740732
S.E. equation	0.008425	0.004754	0.128299
F-statistic	58.79794	57.93551	81.25681
Log likelihood	226.1576	262.7789	51.87592
Akaike AIC	-6.473674	-7.618092	-1.027373
Schwarz SC	-5.832756	-6.977174	-0.386454
Mean dependent	-0.001991	0.035434	2.159007
S.D. dependent	0.035259	0.019755	0.627625
Determinant resid covariance (dof adj.)		2.56E-11	
Determinant resid covariance		8.90E-12	
Log likelihood		541.7874	
Akaike information criterion		-15.14961	
Schwarz criterion		-13.22685	

Table A-5.5 VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.
1	-0.235302	0.590581	1	0.4422
2	0.159575	0.271617	1	0.6022
3	0.168957	0.304497	1	0.5811
Joint		**1.166695**	**3**	**0.7610**
Component	**Kurtosis**	**Chi-sq**	**df**	**Prob.**
1	2.995458	5.50E-05	1	0.9941
2	4.916145	9.790959	1	0.0018
3	3.884237	2.084998	1	0.1488
Joint		**11.87601**	**3**	**0.0078**
Component	**Jarque-Bera**	**df**	**Prob.**	
1	0.590636	2	0.7443	
2	10.06258	2	0.0065	
3	2.389495	2	0.3028	
Joint	**13.04271**	**6**	**0.0424**	

Table A-5.6 VAR Residual Serial Correlation Test

Lags	LM-Stat	Prob
1	7.460913	0.5892
2	5.492995	0.7894
3	6.562347	0.6826
4	9.398972	0.4013
5	8.953641	0.4416
6	9.735521	0.3723
7	5.852713	0.7546
8	20.54878	0.0148
9	5.450511	0.7934
10	3.967146	0.9136
11	6.172069	0.7226
12	6.974777	0.6397

Probs from chi-square with 9 df.

Table A-5.7 VAR Residual Heteroskedasticity Tests

Joint test:					
Chi-sq	**Df**	**Prob.**			
209.4519	**204**	**0.3819**			
Individual components:					
Dependent	R-squared	F(34,29)	Prob.	Chi-sq(34)	Prob.
res1*res1	0.548975	1.038175	0.4624	35.13438	0.4142
res2*res2	0.612395	1.347600	0.2079	39.19327	0.2482
res3*res3	0.678641	1.801230	0.0548	43.43304	0.1289
res2*res1	0.305818	0.375759	0.9966	19.57236	0.9773
res3*res1	0.607917	1.322467	0.2230	38.90667	0.2583
res3*res2	0.580018	1.177959	0.3286	37.12116	0.3271

Results for Open Economy Model

Table A-5.8 Unrestricted Open Economy VAR Model with selected lag Variables

	X	INF	Q	I
X(-1)	0.263931	0.068865	-0.190194	1.561598
	-0.1257	-0.08415	-0.17142	-4.33763
	[2.09977]	[0.81832]	[-1.10951]	[0.36001]
INF(-1)	-0.313909	1.195598	-0.345239	1.448431
	-0.20439	-0.13684	-0.27874	-7.05319
	[-1.53586]	[8.73733]	[-1.23858]	[0.20536]
Q(-1)	0.056079	-0.021787	0.9436	0.583405
	-0.0965	-0.06461	-0.1316	-3.33011
	[0.58113]	[-0.33722]	[7.16998]	[0.17519]
I(-1)	-0.000303	-0.002709	0.004893	0.489019
	-0.00418	-0.0028	-0.0057	-0.14421
	[-0.07261]	[-0.96834]	[0.85847]	[3.39098]
R-squared	0.965345	0.948194	0.930317	0.827737
Adj. R-squared	0.949037	0.923814	0.897526	0.746673
Sum sq. resids	0.00306	0.001372	0.005691	3.643808
S.E. equation	0.007746	0.005186	0.010563	0.267296
F-statistic	59.19401	38.89308	28.37044	10.21081
Log likelihood	276.7262	307.2187	253.1465	7.59343
Akaike AIC	-6.624373	-7.426807	-6.003854	0.458068
Schwarz SC	-5.857684	-6.660119	-5.237165	1.224756
Mean dependent	-0.000566	0.037339	2.02444	2.116103
S.D. dependent	0.034311	0.018788	0.032999	0.53107
Determinant resid covariance (dof adj.)		1.22E-14		
Determinant resid covariance		2.47E-15		
Log likelihood		846.7922		
Akaike information criterion		-19.65243		
Schwarz criterion		-16.58567		

Table A-5.9 VAR Residual Serial Correlation LM Tests

Lags	LM-Stat	Prob
1	12.52255	0.7073
2	9.428306	0.8947
3	22.00205	0.1431
4	18.8828	0.2748
5	11.95803	0.7469
6	13.02086	0.6712
7	8.274132	0.9403
8	22.40449	0.1306
9	12.82268	0.6857
10	17.50697	0.3535
11	7.256246	0.968
12	15.80143	0.4669

Probs from chi-square with 16 df.

Table A-5.10 VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)

Sample: 1993Q1 2011Q4

Included observations: 76

Joint test:		
Chi-sq	Df	Prob.
449.9377	450	0.492

Individual components:

Dependent	R-squared	F(45,30)	Prob.	Chi-sq(45)	Prob.
res1*res1	0.57272	0.89359	0.6401	43.5268	0.5345
res2*res2	0.50587	0.6825	0.8793	38.446	0.7442
res3*res3	0.68277	1.43486	0.1496	51.8905	0.2231
res4*res4	0.61569	1.06805	0.4312	46.7926	0.3987
res2*res1	0.47039	0.59212	0.9455	35.7497	0.8364
res3*res1	0.54385	0.79483	0.7615	41.3324	0.6281
res3*res2	0.62355	1.10426	0.3927	47.3897	0.3754
res4*res1	0.48572	0.62966	0.9216	36.9151	0.799
res4*res2	0.59503	0.97954	0.5334	45.2222	0.4627
res4*res3	0.60866	1.0369	0.4659	46.2584	0.4201

Table A-5.11 VAR Residual Normality Tests

Null Hypothesis: residuals are multivariate normal
Sample: 1993Q1 2011Q4
Included observations: 76

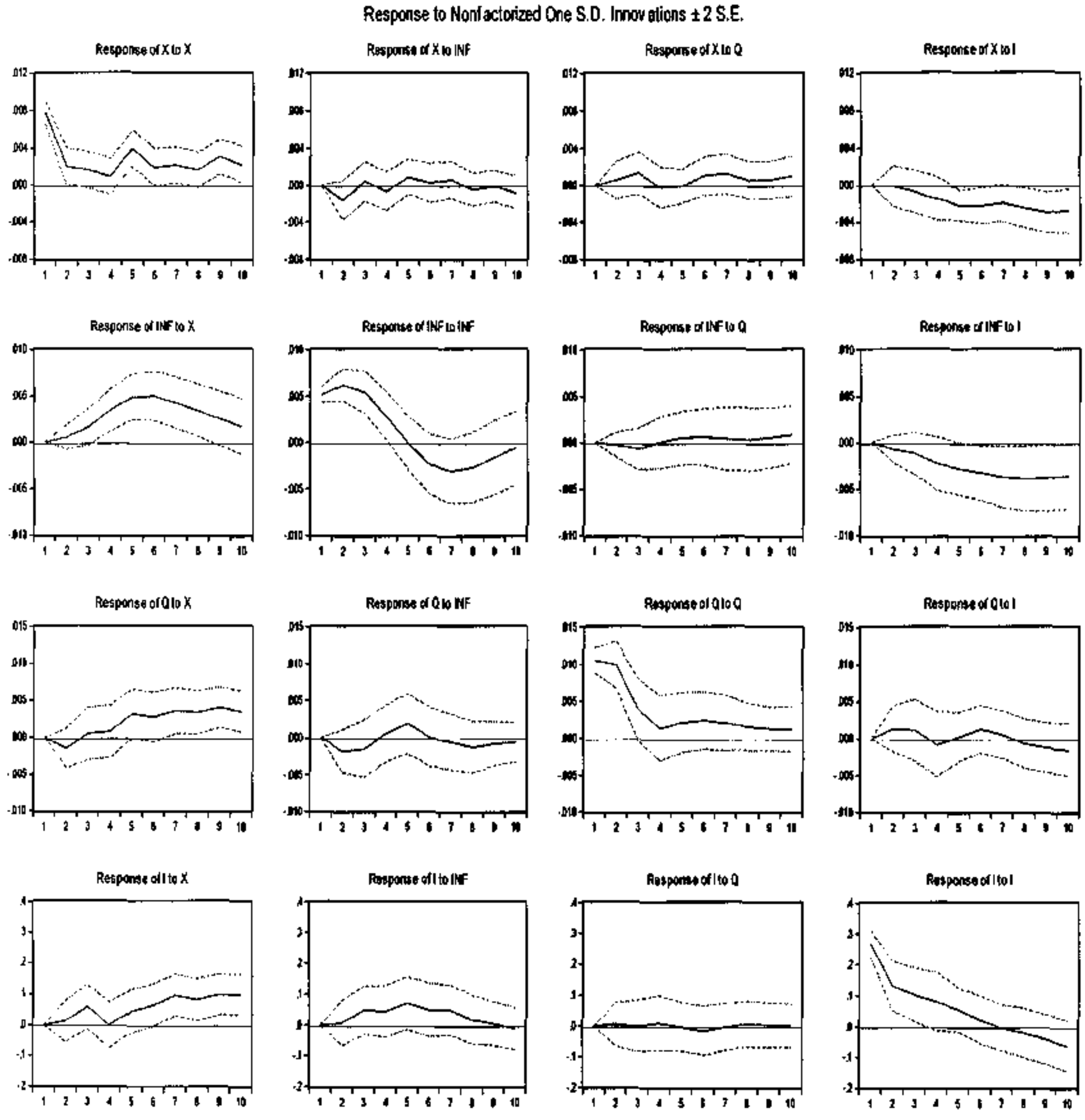
Component	Skewness	Chi-sq	df	Prob.
1	-0.208114	0.54861	1	0.4589
2	0.455627	2.62955	1	0.1049
3	0.197023	0.4917	1	0.4832
4	-0.891436	10.0657	1	0.0015
Joint		13.7355	4	0.0082

Component	Kurtosis	Chi-sq	df	Prob.
1	3.09786	0.03033	1	0.8618
2	2.839413	0.08166	1	0.7751
3	2.624457	0.4466	1	0.504
4	4.645086	8.56998	1	0.0034
Joint		9.12857	4	0.058

Component	**Jarque-Bera**	**df**	**Prob.**
1	0.57894	2	0.749
2	2.711215	2	0.258
3	0.938298	2	0.626
4	18.63564	2	1E-04
Joint	**22.86409**	**8**	**0.004**

Appendix 5.2

Figure A-6.1 Macroeconomic Dynamics of Macroeconomic Aggregates in Response to Structural Shocks (Open Economy Model)



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