PhD Dissertation

Three Essays on Monetary Policy in Pakistan

Submitted by

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Submitted in partial fulfillment of the degree of Doctor of Philosophy in Economics

Pakistan Institute of Development Economics

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Dedication

This dissertation is dedicated
to the memory of my late father

Who

inculcated in me the love for books

And

to the memory of my late mother

Whose

Love for me was constant, boundless and absolute

Acknowledgements

I am greatly thankful to my supervisors, Dr Mazhar Iqbal (main supervisor) and Dr Waseem Shahid Malik (co-supervisor), who always encouraged and motivated me to carry out this dissertation and provided valuable feedback on the content and the argument carried in this dissertation. Their insightful critiques of initial drafts enabled me to firm up my arguments and improve my thesis. I must also acknowledge the tireless support of Dr Ejaz Ghani, Dean Faculty of Economics and Business Studies, in accomplishing this work. These three figures have been constant source of inspiration, strength and guidance throughout this dissertation.

My gratitude also goes to the State Bank of Pakistan (SBP) for financing my PhD studies at PIDE. Special thanks to Dr Ishrat Husain, ex-Governor SBP, who took a number of initiatives, including domestic and overseas scholarships for pursuing a doctoral program, with a vision to turn SBP into a modern and dynamic central bank.

I feel a strong sense of appreciation for the countless people whose advice, guidance and encouragement facilitated my work. To begin with friends, Muhammad Waheed (Islamabad), Saghir Pervez Ghauri (Karachi), Husnul Amin (Berlin), Khalid Mahmood (Islamabad), Muhammad Khawar Mahmud (Maryland), Mazhar Khan (Karachi), Ahmad Bilal Ghauri (Tando Adam), Ghulam Saghir (Islamabad), Samina Shabbir (Islamabad), Shuaib Malik (Islamabad), Muhammad Ali (Islamabad), and Omer Javed (Barcelona).

I am also indebted to a number of PIDE staff members for their unceasing support and cooperation; words are indeed inadequate to thank all of them: Late Dr AR Kemal, Dr Ejaz Ghani, Dr Muslehuddin,, Dr Fazal, Dr Muhammad Iqbal, Dr Ather Maqsood Ahmed, Dr Rehana Siddiqui, Dr Idrees Khawaja, and all members of the PIDE library staff.

Indeed, I cannot forget to acknowledge all the support I received from my family: wife Husna and children Aafia, Vania, Ahmad and Ahmar. Finally, I am thankful to God Almighty for all His blessings.

Tasneem Alam

February 2014

List of Abbreviations

AD	Aggregate Demand
ADF	Augmented Dickey Fuller
Agr	Agriculture
AIC	Akaike Information Criterion
ARCH	Autoregressive Conditional Hetroscedasticity
AS	Aggregate Supply
BIC	Akaike Information Criterion
BOP	Balance of Payments
CMR	Call Money Rate
Con	Construction
CPI	Consumer Price Index
Egw	Electricity, Gas and Water Supply
ER	Exchange Rate
FEVD	Forecast Error Variance Decomposition
Fin	Finance and Insurance
GDP	Gross Domestic Product
HP	Hodrick-Prescott
IFS	International Financial Statistics
IMF	International Monetary Fund
IMF	International Monetary Fund
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LM	Lagrange Multiplier
LSTR	Logistics Smooth Transition Regression
M1	Base measure of Money Supply
Man	Manufacturing
Mnq	Mining and Quarrying
NLLS	Nonlinear Least Squares
OLS	Ordinary Least Squares
Ots	Other Services
PBS	Pakistan Bureau of Statistics
Pi	Price Inflation
S	Sectoral Output
SBA	Stand-by Arrangement
SBP	State Bank of Pakistan
SPI	Sensitive Price Index
STAR	Smooth Transition Autoregressive
STR	Smooth Transaction Regression
SVAR	Structural Vector Autoregressive
TAR	Threshold Autoregressive
Thr	Trade, and Hotels and Restaurants
Tsc	Transport, Storage and Communication
US	United States
USA	United States of America
VAR	Vector Autoregressive

VECM	Vector Error Correction Model
Y	Aggregate Output
y-o-y	Year-on-Year

List of Variables

Variables	Mean	Standard Deviation
Call Money Rate	8.75	2.68
Inflation	2.31	1.39
Nominal Effective Exchange Rate Index	228.78	119.35
Oil price	55.98	42.88
Aggregate GDP	1.041	0.083
Agriculture	1.026	0.201
Mining and Quarrying	1.050	0.076
Manufacturing	1.041	0.119
Electricity, gas and water supply	1.052	0.136
Construction	1.046	0.115
Trade, and hotels & restaurants	1.042	0.100
Transport, storage and communication	1.056	0.059
Finance and insurance	1.058	0.407
Other services	1.053	0.030
M1 growth	14.59	6.34

All variables are in quarterly frequency
Outputs are defined in terms of a ratio of 6-quarters average real output

CONTENTS

Part I

General Introduction and Summary of Three Essays

CHAPTER 1

INTRODUCTION

Though the recent global financial crisis has raised many doubts about the effectiveness of monetary policy, it is still used as the main policy tool for macroeconomic management by a vast majority of policy makers around the world. Early attempts to model monetary policy framework combined a linear dynamic system describing the economy and a quadratic loss function summarizing monetary policy objectives of the central bank. On the empirical side, vector autoregressive (VAR) methodology has been widely employed to analyze the impact of monetary policy actions on the macroeconomy. The linear-quadratic framework and the VAR methodology however embody certain implicit assumptions on the response of economic variables to the actions of monetary authority and on the nature of monetary authority's reaction function. Specifically, it assumes that economic aggregates (including output, inflation, and employment) respond symmetrically to same-sized tight and easy monetary policy shocks, and that the monetary authority also responds symmetrically to a given deviation of economic aggregates above or below their long run trend paths. Additionally, most of the empirical work regarding the impact of monetary policy has so far focused on the aggregate economy, ignoring its differential impact on sub-sectors of the economy. However, both the assumptions emanating from the linear-quadratic framework were subsequently challenged and a large body of empirical work emerged that supported asymmetries both in the response of aggregate economy and in the reaction of the monetary authority for a large number of countries. Likewise, the likelihood of variation in the effects of monetary policy at the disaggregated level was soon realized and was tested for many economies of the world.

This dissertation consists of three essays, aiming to verify each of the above three aspects of asymmetry related to monetary policy for the case of Pakistan. Hence, this dissertation explores the homogenous theme of asymmetric effects of monetary policy, differential impacts of monetary policy on various sectors of the economy and asymmetric behavior of the State Bank of Pakistan in their reaction to changes in macro-conditions. **Chapter 2** of the dissertation deals with the question of whether various sectors of Pakistan's economy exhibit any disparity in response to changes in monetary policy. The seemingly unequal effects of monetary policy on subcomponents of the economy underscores a major potential area of economic research not yet adequately explored in Pakistan, that is, the real effects of monetary policy on sectoral output. There are a number of reasons to look at the real effects of monetary policy at the disaggregated level. Firstly, in case interest rate sensitivity varies across sectors, monetary policy's effectiveness with respect to its impact on aggregate output hinges crucially on the share of interest elastic sectors in the overall GDP. Furthermore, assuming differential impact of monetary policy with respect to various sectors of the economy would entail consideration of distributional issues in the design of monetary policy by the State Bank of Pakistan.

Previously, Alam & Waheed (2006) have looked into the impact of monetary policy shock on seven major sectors of the Pakistani economy and found that SBP's policy actions had different impact on these sectors of the economy. Building upon their work, this paper improves in three major ways. First, Alam & Waheed (2006) used standard vector autoregression (VAR) framework, for which the identifying restrictions may not necessarily be consistent with economic theory. We instead develop a five-variable structural VAR model of Pakistan using the methodology presented in Sims (1986) and Bernanke (1986) and impose economic-theory based restrictions on the contemporaneous relationships of the model to generate monetary policy shocks and to estimate the dynamic impact of monetary policy on the sectoral outputs. Secondly, we correct for the misspecification detected in the model used in Alam & Waheed (2006) as it misses out aggregate output, an important variable in the reaction function of a typical central bank. Finally, we cover all the sectors of the economy in this paper in contrast to Alam & Waheed (2006) who estimated monetary policy's impact on seven major sectors of the economy, which contribute nearly 70 percent to Pakistan's total output. The results support evidence that a tight monetary policy is likely to produce varying responses across various sectors. Results on the dynamic responses of sectoral outputs establish that some sectors are highly sensitive to a policy change in interest rate. As one would expect, finance and insurance sector and the manufacturing sector demonstrate a large and fast reduction in their outputs. On the other hand, secors like services and utilities display a relatively mild response to changes in monetary policy.

The differences in the responses of various sectors of the Pakistan economy to a change in monetary policy have significant implications for the design of monetary policy. Traditionally, monetary policy in Pakistan has been geared towards supporting economic growth while also ensuring stability in prices. Thus, SBP has often followed an accommodative policy stance as long as rate of inflation is not high enough to threaten macroeconomic stability. However, given our findings of substantial variation in the impact of monetary policy at the disaggregated level, State Bank must fully assess the potential impact of its policy action on the distribution of income across various sectors. At the broader level, the economic policy makers need to recognize the distributional consequences of changes in monetary policy and therefore calibrate all policy tools available to them, such as tax and expenditure policies, for an equitable economic growth outcome.

Chapter 3 tackles the supposed symmetry in the preferences of the monetary authority in relation to its monetary policy objectives. The standard monetary policy framework assumes linearity of relationship among the variables and constancy of interest rate responses over time. Therefore, by implication, the response of SBP to an unanticipated decrease in output and inflation would be of same size as that for an unanticipated increase in output and inflation, but with the opposite sign. In other words, it presupposes that the reaction function of the SBP is neutral to the state of the economy as represented by the direction of change in macroeconomic variables; that is, SBP treats a 1 percent decline in GDP growth from the long-run trend and a 1 percent expansion in GDP growth from the long-run trend equally. Similarly, the SVAR methodology also implies that SBP treats a 1 percent appreciation and a 1 percent depreciation of rupee relative to baseline exchange rate in the same way, and so on. Obviously, this is a very strong assumption and needs to be checked empirically. Additionally, time-invariant reaction function implies that the parameters of the system remain constant over time.

Ahmed & Malik (2011) have previously found a more aggressive response of the State Bank for inflation rates above 6.4% than for inflation rates below it, thereby suggesting nonlinearity in the reaction function of SBP. They however used regime switching model which assumes that the threshold is sharp and therefore the transition from one regime to the other is abrupt. However, most macroeconomic processes are believed to undergo smooth transition between regimes. This paper adds to this literature by examining the possibility of nonlinear preferences of the policy-makers over inflation, output gap and lagged interest rate for the case of Pakistan while also checking for the change in coefficients of the reaction function since early 1970s. Contrary to the regime switching framework adopted by Ahmed & Malik (2011) that presupposes abrupt change from one regime to the other, we assume that the transition from one state of the economy to the other is smooth, and therefore, our estimation framework comprises of the smooth transition regression (STR) model, which, as the name suggests, allows for smooth transition between regimes.

Our findings reveal considerable evidence in support of asymmetry as well as parameter variability in the reaction function of the State Bank of Pakistan over 1973 onward. Estimation results further demonstrate that the asymmetry found in SBP's reaction function is mainly related to time and the inflation rate. We however do not find support for non-linearity in SBP's reaction function with respect to output gap or the interest rates. Thus, our model does not confirm asymmetry in the response of the State Bank with respect to phases of business cycle. With respect to parameter variability over the sample period, our model finds substantial evidence of shift in the parameters of SBP's reaction function around the year 1991. The presence of structural break in the reaction function of SBP has major implications for modeling the dynamics of monetary policy in Pakistan. Furthermore, our model finds support for asymmetry in the response of State Bank of Pakistan relating to inflationary regimes. Specifically, SBP is found to raises interest rates more aggressively during periods of high inflation than under conditions of low-inflation. Moreover, our results reveal that the transition between these two regimes is smooth around inflation rates of 10-11 percent per annum.

Chapter 4 looks into the question of asymmetric response of output to changes in monetary policy in a way that contractionary monetary policy of a known size is expected to have a larger and important effect on real economic activity compared to the effect of an expansionary monetary policy of the same magnitude on real output. The proposition that monetary policy shocks of different signs may impact the aggregate economic activity differently is based on two alternative theoretical frameworks, namely a convex aggregate supply curve and the nonlinear response of aggregate demand curve.

We follow Mishkin (1982) and estimate a system of interest rate and output equations using non-linear least squares (NLLS) for quarterly data spanning from 1972:3 to 2012:2. To check the robustness of the results from this model, we also estimated models with M1 as the indicator variable for the monetary policy and for a different lag length. Our results weakly supported the asymmetry proposition. In particular, the null hypothesis that the coefficients associated with tight monetary policy are jointly equal to the coefficients associated with easy monetary policy was rejected in all specifications, albeit at the 10%

significance level. While estimates from interest rate-output model also rejected the hypothesis that the coefficients related to tight monetary policy are jointly zero, similar hypothesis on the easy monetary policy could not be rejected. We also found that our results were robust to the selection of lag length.

Part II

Three Essays

CHAPTER 2

THE SECTORAL EFFECTS OF MONETARY POLICY IN PAKISTAN: A STRUCTURAL VAR ANALYSIS

2.1. Introduction

The last decade witnessed drastic variations in the monetary stance of the State Bank of Pakistan (SBP), as indicated by changes in its policy discount rate, and can be distinctly divided into three phases. In the first phase - starting from July 2001 - SBP, encouraged by historically low levels of inflation, made sharp reductions in its policy interest rate. More specifically, SBP cut the interest rate from 14 percent to 7.5 percent in just 16 months and then kept it at those exceptionally low levels until middle of 2005 (see Fig 2.1). That monetary easing helped lift GDP growth from 2% in 2000/01 to 9% in 2004/05 (see Fig 2.2). However, signs of overheating of the economy emerged as early as 2004 and by mid-2005 CPI inflation had moved to double digits from its lowest of 1.4 percent in July 2003. Compelled by the build-up of inflationary pressures, in the second phase, SBP gradually

Figure 2.1: SBP Policy Discount Rate

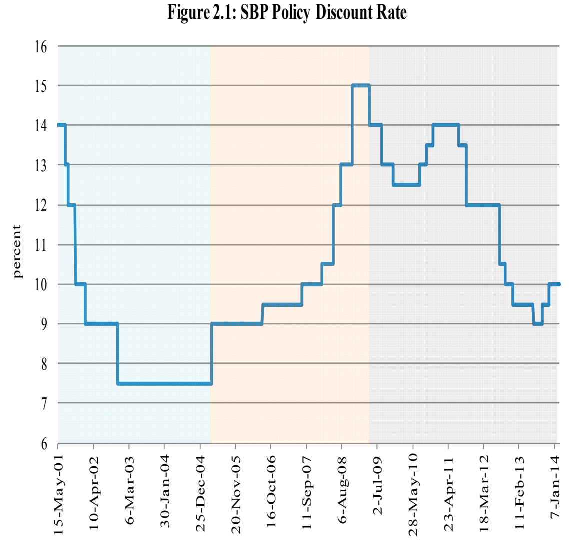
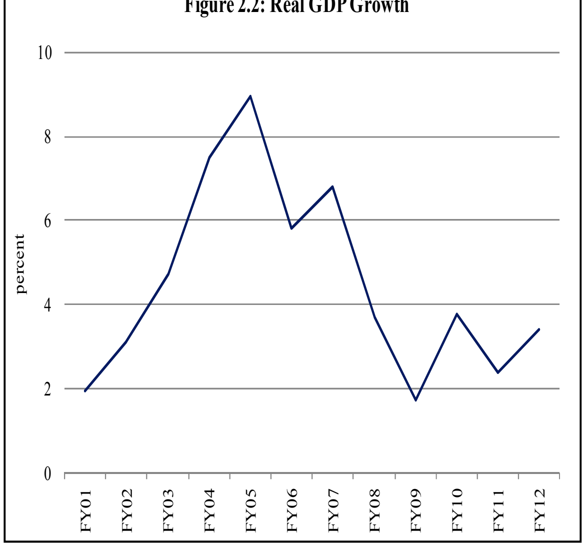


Figure 2.2: Real GDP Growth



started reversing its policy stance. A combination of extremely high inflation, fiscal mismanagement and deteriorating balance of payments position (which ultimately resulted in seeking $11.5 billion financing facility from the International Monetary Fund) forced twofold increase in SBP's policy rate by end-2008. As would be expected, economic growth in this period slowed down from the high of 9 percent in 2004/05 to 4 percent in 2007/08. In the third phase, starting from mid-2009 until this date, SBP acted to adjust the interest rate aiming at the difficult task of achieving a balance between the competing tasks of taming the persistently high inflation and boosting the economic activity.

While there is growing empirical literature on the influence of monetary policy on aggregate economy in Pakistan, its impact on the subcomponents of the economy has not remained largely unattended. There are a number of reasons to look at the real effects of monetary policy at the disaggregated level. Firstly, in case interest rate sensitivity varies across sectors, monetary policy's effectiveness with respect to its impact on aggregate output hinges crucially on the share of interest elastic sectors in the overall GDP. Furthermore, assuming differential impact of monetary policy with respect to various sectors of the economy would entail consideration of distributional issues in the design of monetary policy by the State Bank of Pakistan.

A cursory examination of Pakistan's national accounts reveals the very uneven growth pattern exhibited by the sectoral outputs during phases of monetary easing and tightening, thereby hinting at the possible underlying disparity in sectoral responses to changes in monetary policy. The seemingly unequal effects of monetary policy on subcomponents of the economy underscores a major potential area of economic research not yet adequately explored in Pakistan, that is, the real effects of monetary policy on sectoral outputs.

This study ascertains new evidence on the disaggregated real effects of monetary policy, for which we first outline a small-scale five-variable, open economy structural vector autoregression (SVAR) model of the Pakistani economy. Previously, Alam & Waheed (2006) have looked into the impact of monetary policy shock on seven major sectors of the Pakistani economy and found that SBP's policy actions had different impact on these sectors of the economy. Building upon their work, this paper improves in three major ways. First, Alam & Waheed (2006) used standard vector autoregression (VAR) framework, for which the identifying restrictions may not necessarily be consistent with economic theory. This paper develops a five-variable SVAR model of Pakistan using the methodology presented in Sims (1986) and Bernanke (1986) and impose economic-theory based restrictions on the contemporaneous relationships of the model to generate monetary policy shocks and to estimate the dynamic impact of monetary policy on the sectoral outputs. Secondly, a closer look at Alam & Waheed (2006) reveals their model is misspecified. In particular, VAR for each sector is estimated using the sectoral output, price level, and the call money rate and therefore the structural shocks associated with the equation for call money rate are not representative of monetary policy shocks. Since it is the aggregate output, rather than sectoral outputs, that enters the reaction function of a typical central bank, a true representation of the model would customarily include the aggregate GDP. This paper corrects for misspecification of their model so that shocks generated from the equation for call money rate are representative of the monetary policy shocks. Finally, we cover all the sectors of the economy in this paper in contrast to Alam & Waheed (2006) who estimated the impact of monetary policy on seven sectors of the economy, which contribute roughly 70 percent to Pakistan's total output.

The organization of this Essay is as follows. The next section provides a review of related literature. Then the following two sections discuss the estimation framework and specification of a small scale open economy SVAR model of Pakistan. We then discuss the estimation results. Finally, we provide concluding remarks with a summary of the main findings.

2.2. Review of Literature

Monetary policy is one of the major tools used by economic policy makers for macroeconomic management. However, academic and policy discussions have largely concentrated on the response of aggregate economy in the context of monetary policy objectives but have overlooked the dynamics at the disaggregated level. Theoretical and empirical work has suggested several ways through which monetary policy decisions affect inflation and economic growth. All these channels combined is termed as the transmission mechanism of monetary policy.

Broadly speaking, there are two main views on the transmission mechanism. The financial market price view focuses on the effects of monetary policy that work through prices of and rates of return on financial assets (i.e., interest rate, foreign exchange rate and other asset prices). The other, named credit view, stresses the impact of monetary policy working through the supply of bank loans or the borrowers' balance sheet [Taylor (2000)]. Indeed, the final impact of the monetary policy reflects the combined impact of all channels of monetary policy transmission.

Variations in the effects of monetary shock on the outputs of different sectors can arise because of relative strength of a particular channel of transmission mechanism for some sectors and not for others. This relative strength, in turn, depends crucially on the structure, dependence on and availability of bank credit, and openness of a particular sector. Several studies show that demand for durable goods is relatively more elastic with respect to interest rate and therefore researchers have generally detected a robust response by sectors producing such goods to a change in interest rate [e.g., Dedola & Lippi (2005)]. Likewise, capital intensive sectors are likely to be more influenced by changes in monetary policy since a change in interest rate directly affects the cost of capital. As a result, monetary policy decisions may induce a relatively strong effect with regard to investment decisions in the capital-intensive sector. In contrast, the exchange rate channel is likely to be stronger for external trade oriented sectors [Gruen & Shuetrim (1994)]. By comparison, the balance sheet channel looks at demand for and supply of loans, and suggests that a change in interest rate is expected to produce a large effect for small firms, which are predictably more liquidity constrained. Conversely, firms with fairly large average profit margins or with high level of internal financing are expected not to be affected by this phenomenon.

An investigation into the impact of monetary policy at the disaggregated level may offer valuable insights into the aggregate transmission mechanism. In analyzing monetary policy's impact on industrial sector, Dedola & Lippi (2005) demonstrate that determinants of the effectiveness of monetary policy from both demand and supply side (such as interest rate elasticity of demand, capital intensity of the production process, firm size, firm's access to financial markets, etc) are likely to assume a wide range of values in disaggregated data. Consequently, a change in monetary policy is expected to produce asymmetric responses of the various sectors of the economy. While having major implications for policy effectiveness, these differential sectoral responses to monetary policy remain largely hidden at the aggregate level. For instance, Bernanke & Gertler (1995) found support for the heterogeneous industry effects of monetary policy. The information provided by this heterogeneity, which may be useful to understand the monetary transmission mechanism, is lost with aggregation.

2.2.1. Empirical evidence at sectoral level

Early investigations into the monetary transmission at the disaggregated level include Gertler & Gilchrist (1993) and Bernanke & Gertler (1995). In the context of credit market imperfections, Gertler & Gilchrist (1993) show that monetary tightening leads to a higher drop in credit disbursement to small firms compared with the large firms. Consequently, output of the smaller firms in the USA appears to be more responsive to monetary shocks relative to large-sized firms. Bernanke & Gertler (1995) also employed the credit view of the monetary transmission mechanism to show differing impact of monetary policy on constituents of final expenditures. Since that work, numerous studies have been undertaken to thoroughly explore the effect of monetary policy on different sectors of the economy. Thus, for instance, Ganley & Salmon (1997) studied for the UK the impact of monetary policy on the output of twenty four sectors and found important variation in the size and timing of responses of sectoral output to an exogenous interest rate shock. Specifically, construction sector is found to be most responsive to changes in interest rate. While they found evidence of uneven response across manufacturing industries, the results showed that small firms constituting a large proportion of industries found more sensitive to changes in monetary policy, thereby indicating the prevalence of credit market imperfections in the transmission mechanism of monetary policy. On the other hand, Hayo & Uhlenbrock (1999) examined Germany's manufacturing sector and found evidence supporting high sensitivity of heavy industries to changes in interest rate compared with the production of non-durables like clothing and food. Farès & Srour (2001) used Canadian disaggregated national income data from final expenditures and from production and, in each case, found evidence of sector-specific responses to exogenous shocks to monetary policy. For example, in the case of disaggregation at the level of production, they found that following a monetary tightening, construction reaches the trough of the cycle first even though manufacturing reacts twice as strongly. Furthermore, while the response of the service sector was significant, it lagged manufacturing. Similarly, using disaggregated US data from final expenditures, Raddatz & Rigobon (2003) documented evidence in support of disparities in the impact of monetary policy on the different spending components of the US economy. Specifically, most sensitive components to a change in monetary policy were found to be consumption of durables as well as of non-durables, and the residential investment. Equipment-and-software investment was observed to have just a mild response whereas investment in structures showed no response to a monetary policy shock.

Tena & Tremayne (2009) used system of threshold equations to capture for the UK industries asymmetries in the transmission of monetary policy and found support for cross-sectional variations across industries along with nonlinear impact of monetary policy for a few sectors. They showed that industries where degree of concentration is low are more likely to experience, depending on the business cycle, differential responses of a monetary policy change. Dedola & Lippi (2005) used industry data at the micro level for the 5 industrialized economies and found evidence in support of differences in the effects of monetary policy across various industries. Their study suggests a larger impact of monetary policy for industries that are small in size, manufacture durable goods and have high financing requirements. Sectoral heterogeneity in response to a monetary policy shock was reported by Ibrahim (2005) for Malaysia, by Pellényi (2012) for Hungary, and by Arnold & Vrugt (2002) for the Netherlands.

Evidence for Pakistan

In Pakistan, there is little empirical work regarding the transmission mechanism of monetary policy at the sectoral level, which is rather surprising given that monetary policy is a major policy tool used for economic management. At the disaggregated level, we could find only two studies undertaken so far in Pakistan. The first study on analysis of sectoral effects of monetary policy in Pakistan was done by Alam & Waheed (2006). Using standard vector autoregression (VAR) framework for the period 1973:1 to 2003:4, they examined the impact of monetary policy shock on seven major sectors of the economy and established sector-specific differences in the real effects of monetary policy. On the other hand, using disaggregated data on manufacturing studies, Faiz ur Rehman & Wasim Shahid Malik (2010) found evidence that cost channel dominates the traditional demand channel in industries such as textile, food and beverages, pharmaceuticals, automobiles, fertilizer, and paper and board.

A closer look at Alam & Waheed (2006) however reveals their model is misspecified. In particular, VAR for each sector is estimated using the sectoral output, price level, and the call money rate and therefore the structural shocks associated with the equation for call money rate are not representative of monetary policy shocks. Since it is the aggregate output, rather than sectoral outputs, that enters the reaction function of a typical central bank, a true representation of the model would customarily include the aggregate GDP. This paper improves on Alam & Waheed (2006) in a number of significant ways. Firstly, we develop a small scale five variable structural VAR model of Pakistan using Sims (1986) and Bernanke (1986) methodology to generate exogenous shocks to monetary policy with a view to examine the dynamic responses of sectoral outputs to these shocks. Secondly, and more importantly, this paper corrects for misspecification of their model so that shocks generated from the equation for call money rate are representative of the monetary policy shocks. Finally, we cover all the sectors of the economy in this paper in contrast to Alam & Waheed (2006) who estimated the effect of a monetary policy shock on seven sectors of the economy, which constitute roughly 70 percent of the economic activity.

2.3. Estimation Framework

Since our objective here is to capture the dynamics of interrelationships between monetary policy and sectoral outputs, and not to determine the relative strength of the many channels of the transmission mechanism, the appropriate framework to evaluate empirical evidence consists of vector autoregression (VAR). Sims (1980) pioneered the VAR approach to modeling monetary policy effectiveness, in stark contrast to traditional large-scale macro-econometric models built on categorization of variables into endogenous and exogenous. Sims argued that economic reasoning does not provide any significant *a priori* justification for classifying variables into endogenous and exogenous categories in the modeling process, and hence suggested to treat all variables as endogenous. Formulated this way, the dynamics of VAR systems is governed by exogenous shocks to various variables of the model.

VAR methodology has been quite popular among researchers of monetary policy transmission mechanism because it treats the economy like a black box whose working is veiled, and hence abstracts from spelling out the specific ways in which a monetary policy shock is transmitted to the economy. In essence, a VAR system contains a set of equations wherein every variable is treated symmetrically; i.e., each variable is explained by own lags as well as lags of all other variables in the model. Thus, this particular approach has the distinct advantage of allowing for the presence of feedback in the system. This particular framework to modeling monetary policy is intrinsically suitable for looking at sectoral comparisons because it allows a single reduced form system to estimate the responses of sectoral outputs to monetary policy shock. Additionally, the VAR methodology lets the data determine the shape of impulse response functions of various sectors when there are no clear priors about them.

Early VAR studies used the recursive structure suggested by Sims (1980) to recover shocks of the primitive or structural system from the estimated reduced-form system. Specifically, Sims (1980) proposed Choleski triangular decomposition, which mechanically imposes certain zero restrictions on the contemporaneous relationships between model variables. Once identified, we can conveniently evaluate the impact of these structural shocks on each variable by looking at impulse responses and forecast-error variance decomposition. Whereas impulse responses capture the time paths of the effects of structural shocks on model variables, the forecast error variance decomposition records relative contribution of these structural shocks in the variation in variables of the model.

While standard reduced-form VAR models are found helpful in explaining the stylized facts about the data, critics argue these lack any economic content. Cooley & Leroy (1985) contended that unless identifying restrictions are supported by economic theory, conclusions based on VAR methodology are not justified. In response to this critique on VAR, Sims (1986) and Bernanke (1986) proposed imposing non-recursive identification restrictions, based on economic theory[1], on the contemporaneous interrelations among variables. Models that use non-recursive structure based on economic theory have been termed structural vector autoregression (SVAR) models [Hamilton (1994)]. Since its

[1]Alternative identification schemes were later developed by Blanchard & Quah (1989), Shapiro & Watson (1988), and Gali (1992) who suggested using long run and/or cointegrating restrictions, like the money neutrality, to identify the VAR system. Indeed, standard recursive identification restrictions may also characterize a structural VAR provided it corresponds to a fair approximation of the hypothesized economic structure.

development, SVAR framework has been extensively employed to analyze the transmission of monetary policy under closed economy as well as open economy models [Sims (1986, 1992); Christiano, Eichenbaum & Evans (1996); Eichenbaum & Evans (1995); Bernanke & Mihov (1998); Cushman & Zha (1997); Gali (1992); and Sims & Zha (2006)].

2.3.1. Modeling Approach

For the purpose of this study, we adopt a small-scale five-variable SVAR.[2] The choice of variables broadly follows other studies on the transmission of monetary policy[3] and is intended to capture key macroeconomic interactions.

Data & Sources

For the purpose of this study, we use quarterly data spanning from 1973:1 to 2012:2. The five variables included in the model are world commodity prices, inflation, output, exchange rate, and an indicator of monetary policy. World commodity prices are used to capture influence of foreign sector on Pakistani economy. We include exchange rate in the model for two major reasons; (i) Malik (2007) finds that exchange rate is a statistically significant variable in the reaction function of the State Bank of Pakistan, and (ii) since exchange rate acts as a conduit for interactions between domestic and foreign sectors, its inclusion would not only help find out exchange rate channel of the transmission mechanism but would also capture effects of foreign sectors from channels other than the

[2] This excludes the sectoral variable.
[3] See, for example, Raddatz & Rigobon (2003).

commodity prices. Domestic economy is represented by the aggregate output, prices, a monetary policy indicator variable, and nine variables on sectoral outputs.

World commodity prices are proxied by international petroleum prices due to limited sample size available on the former.[4] The correlation coefficient between the two variables is found to be very close to 1, justifying the use of international oil prices for world commodity prices. The international oil prices used here corresponds to the average spot price of crude oil (in US$ per barrel) of Dubai Fateh, UK Brent and West Texas Intermediate, and is obtained from International Financial Statistics (IFS) published by the IMF.

The rupee-dollar parity or the exchange rate is represented by the nominal trade-weighted index (also known as the nominal effective exchange rate), taken again from IFS.[5] We prefer the trade-weighted index over the bilateral exchange rate between the US dollar and Pakistan rupee because of theoretical as well as computational advantages. Theoretically, trade weighted index more accurately reflects a country's linkages with rest of the world and the strength of its relationship with major trading partner. Moreover, computationally, the bilateral exchange rate between US dollar and the Pakistani rupee has remained a fixed or managed peg for quite some time and therefore its use would partially hide information on interactions between Pakistan and the world economy.

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[4] World commodity price index is available only from 1992 onwards.

[5] The construction of trade-weighted index is such that an increase would suggest appreciation of Pakistani rupee relative to currencies of its trading partners.

The constant price GDP denotes aggregate real economic activity in Pakistan. The aggregate GDP is taken from the websites of Pakistan Bureau of Statistics (PBS) and the State Bank of Pakistan (SBP). For the purpose of this study, we will use real output of nine sectors, which sum to the aggregate measure of economic activity in Pakistan. All output series are checked for seasonality and are adjusted accordingly.[6] We estimate nine SVAR models; a separate model for each of the nine sectors. The nine sectors are listed in the table below, which also provides sector abbreviations used throughout this study.

Table 2.1

Sector	Abbreviation
S1. Agriculture[7]	Agr
S2. Mining and quarrying	Mnq
S3. Manufacturing[8]	Man
S4. Electricity, gas and water supply	Egw
S5. Construction	Con
S6. Trade, and hotels and restaurants	Thr
S7. Transport, storage and communication	Tsc
S8. Finance and insurance	Fin
S9. Other services[9]	Ots

[6] We produce seasonally-adjusted output series using Census X-12 multiplicative procedure in the EViews.
[7] Consisting of crops, livestock, fishing and forestry subsectors.
[8] Comprising of large scale manufacturing, small scale manufacturing, and slaughtering subsectors.
[9] Consisting of ownership of dwelling, public administration and defense, and community, social and personal services subsectors.

The sectoral quarterly real outputs are taken from Arby (2008), which constructs such series for Pakistan for the period 1970: 3 to 2005:2. We extend these series up to 2012:2 using 8-quarter moving average of the quarterly shares in aggregate output. This approach is likely to produce reasonable estimates of the actual output given the fact that a quarter's share in total output of any given year has exhibited negligible variance over the period covered by Arby (2008). Following Raddatz & Rigobon (2003), GDP data is defined in terms of a ratio of the preceding 6-quarters average real GDP,[10] which then signifies the baseline. As a result, impulse response functions denote percent deviations from this baseline.

The consumer price index is used to calculate quarterly percentage changes in general price level.[11] Though using some measure of core inflation, like the trimmed mean or non-food-non-energy, might have been more suitable, time series on these measures in only available since the late 1990s and therefore restrict us to use the general headline inflation for the purpose of this study.

Regarding monetary policy indicator, we here use call money rate as the variable revealing the policy stance. [12,13] In the context of Pakistan, there is no general consensus among

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[10] A theoretically more relevant transformation would have been to construct output gaps through detrending the real GDP, for example using the HP filter, since monetary authority is expected to respond to deviation of output from the trend level rather than to the output level itself. However, this was avoided in favor of the transformation outlined above in light of Ashley & Verbrugge (2009), which shows modeling in HP-filtered levels yields poor results for both hypothesis testing and impulse response function confidence intervals with good coverage.

[11] Data is obtained from FBS and SBP.

[12] Interbank offer rate or the call money rate is Pakistan's equivalent to federal funds rate in the U.S.

policy makers or academia on whether some monetary aggregate or a short-term interest rate be used as an indicator of monetary policy stance. Many, however, now argue for using some short term interest rate as a monetary policy indicator because the financial sector reforms have, presumably, led to instability within the elements of reserve money, and the relationship between reserve money and broad money seems to have become inconsistent [Agha et al. (2005)]. Accordingly, and also due to being in conformity with numerous recent studies on the subject[14], this paper uses the call money rate as the indicator variable for the stance of monetary policy. Resultantly, a positive exogenous shock to the call money rate signals a contractionary monetary policy stance and vice versa.

Stationarity and differencing

An important issue relating to the estimation strategy consists of selecting the appropriate specification of the VARs. Specification entails deciding on whether to estimate the model in pure differences or in levels without imposing any restriction, or as a vector error correction model (VECM) taking into account the presence of cointegration. Thus far, the dominant view among researchers and econometricians has been that specification decision should primarily be based on the data temporal properties; i.e., on the stationarity and the cointegration properties of the variables under investigation. In particular, if the variables in a VAR are nonstationary and are found not to be cointegrated then the VAR should be specified in pure differences. Some [e.g., Sims (1980), and Sims, Stock & Watson (1990)]

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[13] Quarterly values for the CPI and the call money rate represent the averages of corresponding monthly data, expressed in percentage points.
[14] See, for example, Malik (2007) and Rehman (2010).

however oppose differencing even when the variables are found to be nonstationary. They argue that by way of differencing we trade loss of information for (statistical) efficiency. But given that our objective in using VAR analysis is to find out the interactions between model variables and not the parameter estimates, this trade-off is obviously unwarranted[15]. In contrast, if the variables are integrated of the same order and are cointegrated as well, then vector error correction is the preferred specification because it generates efficient estimates along with preserving information on the long run relationships present in the model. Similarly, Ashley & Verbrugge (2009) suggest that when the principal concern of the study is causality tests, the use of VAR in levels yields poorly sized test; however, if the primary task of the study is to obtain impulse response function confidence intervals with good coverage, VAR in levels perform adequately but the differenced estimation models are problematic. However, this is still a minority view and the pre-dominant methodology calls for looking at the data temporal properties. Consequently, we proceed by performing the unit root tests on all the transformed variables.

We first used the augmented Dickey Fuller (ADF) procedure to test the presence of unit root in the data. Test results rejected the null hypothesis of unit root, or of non-stationarity, for all variables of the model barring the call money rate, the oil price and the exchange rate. Since ADF is known to have power problems, we performed two alternative unit root tests on the three variables which confirmed the presence of unit root through ADF. These alternative tests are Phillips-Perron (PP), which tests the null of unit root and Kwiatkowski

[15] Ramaswamy & Sløk (1997) provide an economic justification against first differencing and for favoring to estimate the VAR in levels. Their argument goes like this: estimating the VAR in first differences tend to produce impulse response functions which entail that unanticipated monetary policy has long lasting effect on the level of output, whereas impulse responses from the VAR in levels let the data decide if the impact of unanticipated monetary policy is temporary or permanent.

et al. (KPSS, 1992), which tests the null of stationarity. While the results confirm the presence of unit root in the oil price and the exchange rate, the finding for the call money rate is mixed, with KPSS rejecting the null of stationarity and the PP rejecting the null of unit root.

Table 2.2. Result of the Augmented Dickey Fuller Test

H0: Unit Root

	Level		1st difference		
Variables	ct	ct, trend	ct	ct, trend	Conclusion
CMR	-1.9823	-1.9646	-11.2328*	-11.2022*	I(1)
Pi	-4.1366*	-4.027*			I(0)
Y	-8.225*	-8.335*			I(0)
S1	-8.0786*	-8.0533*			I(0)
S2	-5.1162*	-5.2615*			I(0)
S3	-3.481*	-3.8117*			I(0)
S4	-4.8432*	-4.9113*			I(0)
S5	-8.6213*	-8.781*			I(0)
S6	-5.5715*	-5.6843*			I(0)
S7	-3.5162*	-6.7869*			I(0)
S8	-14.566*	-14.5289*			I(0)
S9	-8.5597*	-8.6887*			I(0)
Oil	-0.0935	-1.1103	-10.9939*	-11.0639*	I(1)
ER	-0.3328	-2.5151	-8.5692*	-8.5472*	I(1)

* ADF: denotes significance at 5%

Since inflation and outputs (aggregate as well as sectoral) are stationary (a result of the way these are transformed), the best strategy is to include the remaining variables of the VAR in first differences. However, we leave call money rate in levels without any adjustment since nominal interest rates are generally considered mean-reverting in the economic literature, especially over a sufficiently long horizon. This is so because the zero rate forms a lower bound while the central bank works to ensure that inflation (and thereby the interest rate) does not overshoot at the upside. Moreover, an excessively high interest rate would dampen economic growth, causing a cyclical decline of the interest rate. Hence, nominal interest rate would revert to the mean if a sufficiently long horizon is considered. In structural macro models of the central bank, the short-term interest rate is commonly based on a Taylor rule, in which the policy rate is a function of the deviation from the inflation target and the output target (Taylor, 1993). Implicitly, this assumes that the interest rate is mean reverting. (Wu and Zhang, 1996) demonstrate that the empirical evidence against stationarity of interest rates is a result of lower power of unit root tests. They applied statistical procedures to enhance the power of the unit root test and found evidence of mean reversion in short term interest rates for a panel of OECD countries. Since we have mixed results on the presence of unit root in the call money rate, and also because it is being used as an indicator variable for measuring the stance of monetary policy, we opt to use call money rate (which is the same as federal funds rate in the case of USA) in levels as this treatment is consistent with most VAR studies.

Table 2.3 Results of Alternative Unit Root Test

(a) Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test

H0: Stationarity

	ct	ct, trend
Variables	test statistic	test statistic
CMR	0.0808*	0.0816*
Oil	0.8684*	0.2872*
ER	1.4515*	0.1626*

* denotes significance at 5%

(b) Phillips-Perron (PP) Test

H0: Unit Root

	ct	ct, trend
Variables	test statistic	test statistic
CMR	4.4875*	4.4767*
Oil	0.5804	0.9612
ER	1.8022	1.5465

* denotes significance at 5%

SVAR Model and Identification

The standard model in the literature is characterized as the following primitive VAR (ignoring intercept terms):

$$B_0 Z_t = \sum_{i=1}^{q} B_i Z_{t-i} + \upsilon_t , \qquad (1)$$

where $Z_t=(X_t , H_t)'$, H_t is the policy indicator of the monetary authority, X_t comprises of variables included in the information set of the monetary authority, and q is a non-negative integer. The above characterization implies that the monetary authority reacts symmetrically to changes in X_t and its lags. In addition, primitive disturbances are assumed to possess the following properties:

$E\upsilon_t\upsilon_t' = S$

$E\upsilon_t\upsilon'_{t+k} = 0, \forall k \neq 0$

B_0 is a non-singular (*nxn*) matrix normalized to have 1s on the diagonal, summarizing the contemporaneous interactions between the variables of the model. υ_t corresponds to a zero mean and serially uncorrelated (*nx1)* vector of structural disturbances, and S represents the variance-covariance matrix of υ_t.

To investigate the primitive model, we first estimate the corresponding reduced-form VAR given as:

$Z_t = \sum_{i=1}^{q} B_0^{-1} B_i Z_{t-i} + B_0^{-1}\upsilon_t = \sum_{i=1}^{q} A_i Z_{t-i} + \varepsilon_t$, such that

$E\varepsilon_t\varepsilon'_t = \zeta$

$E\varepsilon_t\varepsilon'_{t+k} = 0, \forall k \neq 0$ (2)

where ζ reflects the covariance matrix of the reduced-form model, and ε_t is a serially uncorrelated (*nx1*) vector of reduced form errors, and the relationship between the structural and the reduced form disturbances is given by

$$\varepsilon_t = B_0^{-1}\upsilon_t \quad (3)$$

Next, to retrieve structural parameters from the reduced form estimates, we need to impose a series of restrictions on the model to solve for under-identification. The approach used by Sims (1986) and Bernanke (1986) exploits the relationship in equation (3) above to ensure that adequate restrictions, supported by economic theory and empirical facts, are imposed on the matrix B_0 to enable the orthogonal structural disturbances to be identified from the reduced form errors. In this approach, B_0 can symbolize any structure so long it holds adequate number of identifying restrictions [Robert A Buckle, Kunhong Kim, Heather Kirkham, Nathan McLellan (2002)]. In this chapter, we follow Sims (1986) and Bernanke (1986) which suggested imposing specific restriction on the contemporaneous relationships of the model. Alternative approaches include identification through long run restrictions, mixing contemporaneous and long run restrictions, and sign restrictions.

2.4. A Small-scale Structural Model of Pakistan Economy

Before investigating the impact of a change in monetary policy on the outputs of various sectors of the Pakistani economy, we develop and examine a baseline SVAR model of the economy that incorporated only the standard aggregate variables. In this section, we outline the setup of a small SVAR model for Pakistan, estimate the system and provide an assessment of its adequacy for further applications.

Pakistan is a small, open economy with international factors (such as commodity prices, foreign investment, aid etc) producing major ripple effects on domestic economic outcomes. Given the size and contribution of Pakistan in the global economic developments, we can safely assume here that Pakistan's economic conditions are expected not to have a major economic influence on the rest of the world. Accordingly, we have imposed block exogeneity condition on the commodity price variable, which means that Pakistan is a price taker in world commodities market. Technically, block exogeneity implies that while commodity prices are allowed to enter the equations, both contemporaneously and as lags, of other variables in the system, no variable of the model could impact commodity prices.

Besides the block exogeniety restriction on commodity prices, we assume that the structural errors (υ_t) are orthogonal (S = I), reflecting that the structural shocks are not correlated. Additionally, to just-identify the structural system from the reduced form model, we impose six zero-restrictions on the contemporaneous relations among the variables, summarized in the matrix below.

$$B_0 Z_t = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & b_{23} & 0 & 0 \\ b_{31} & 0 & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 \end{pmatrix} \begin{pmatrix} woil_t \\ gdp_t \\ er_t \\ cpi_t \\ cmr_t \end{pmatrix}$$

Certainly, State Bank's policy reaction function is the major building block in the specification of the model because we would not be able to isolate the exogenous policy shock in case the reaction function is misspecified. Here we are assuming that the State Bank responds contemporaneously to any change in world oil prices, the inflation, the output and the exchange rate. Our assumptions on the contemporaneous response of SBP to changes in world oil prices, the inflation and the exchange rate is justified since these are observable almost immediately.[16] The assumption that SBP reacts contemporaneously to changes in domestic output would entail that SBP follows reliable leading indicators,

[16] Weekly inflation trends for a small set of items (SPI) are available with a lag of 1-2 days.

which does not appear to be factually incorrect. In summary, SBP is assumed to be able to adjust immediately to a change in any of the macroeconomic variables in the system. The other six assumptions used for the identification of the system are:

- Based on Malik (2006), monetary policy shocks are assumed to affect domestic macroeconomic variables (prices, output and the exchange rate) only with a lag.
- A price shock is assumed not to affect aggregate GDP and the exchange rate contemporaneously.
- Finally, an output shock is assumed not to affect exchange rate contemporaneously.

2.4.1. Estimation and Results

Based on Akaike Information Criterion (AIC), we fix the lag length at four for estimation of the reduced form model. Later, the same lag length is being used for estimating sectoral SVARs.[17]

Figures 2.3 and 2.4 exhibit impulse responses of major interest to us. The first set of impulse response shown in Fig 2.3 presents impact of 1 standard deviation rise in call money rate on the macroeconomic variables. A look at these impulse responses establishes that our model is indeed a reasonable framework for the analysis of monetary policy. Panel (a) demonstrates that output contracts relative to its long-run trend level following a monetary policy tightening. The largest reduction in output is recorded in the 4th quarter while most of the decline is recorded up to 6th quarter, indicating monetary policy in

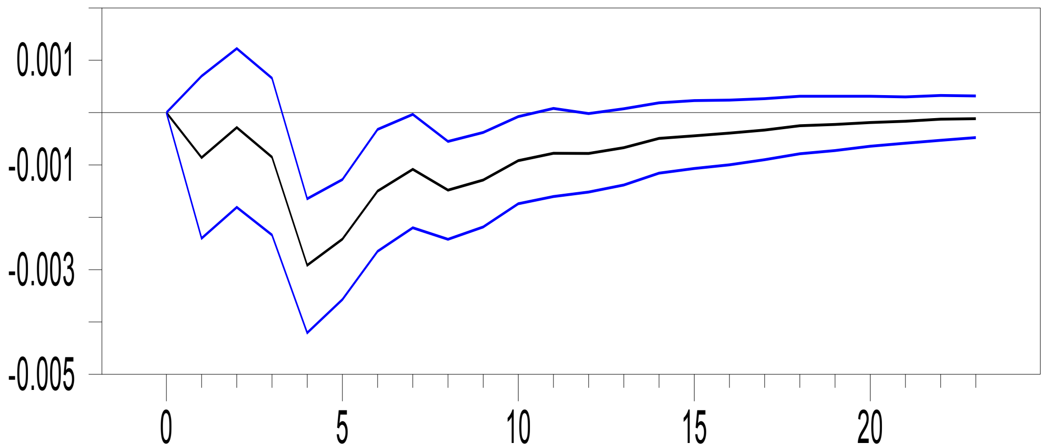
[17] Alternatively, we could have chosen to select lag lengths for sectoral SVARs based on AIC criterion for each VAR. However, this is avoided in order to separate the responses of sectoral outputs to a change in monetary policy from any variations in sectoral responses generated by differences in lag structure.

Pakistan has 18-month lagged effect. Furthermore it is worth noting that the fall in output is transitory, a result that points to long-run neutrality of money for the case of Pakistan. Panel (b) depicts response of inflation to monetary tightening. While inflation first rises up to the second quarter in response to an increase in interest rates (thus providing evidence of a price puzzle), it ultimately drops relative to its baseline level. Also note that the two impulse response functions hint towards a possible stronger impact of monetary policy shock on prices than on output.

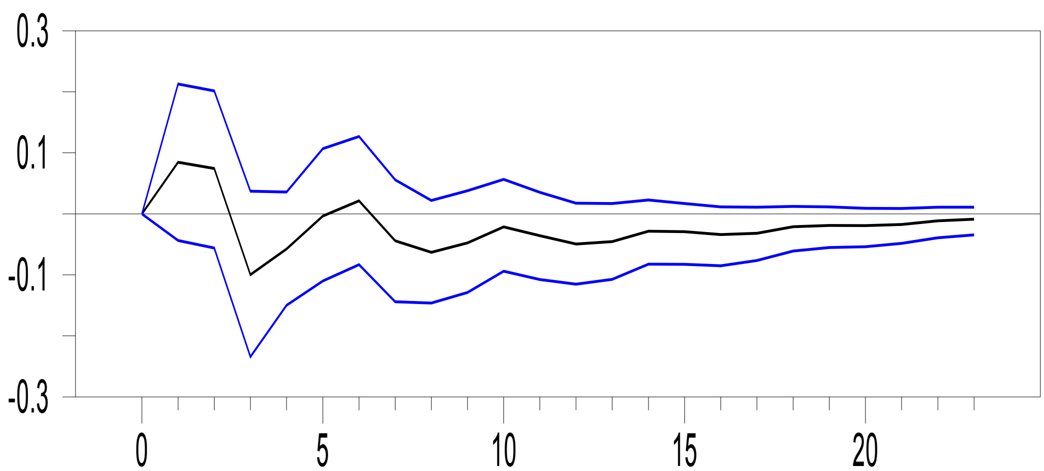
The next set of impulse responses in Fig 2.4 demonstrate how the monetary authority reacts to exogenous shocks to inflation and output. As illustrated in panel (b), a positive shock to inflation results in quick monetary tightening and that tight stance is maintained consistently for many quarters. In case of an exchange rate appreciation, panel (a), interest rates are lowered. This reaction of monetary policy is plausible: exchange rate appreciation is associated with loss of competitiveness and therefore a policy of monetary easing might be adopted to halt country's loss of competitive position. Panel (c), which shows reaction of monetary authority to a positive output shock, is quite interesting. It demonstrates that not only the monetary authority refrains from tightening its policy stance when output rises above the baseline, but it actually attempts to accommodate output expansion by lowering the interest rates for a brief period.

Figure 2.3: Impulse responses to a positive interest rate shock

(a) Real GDP

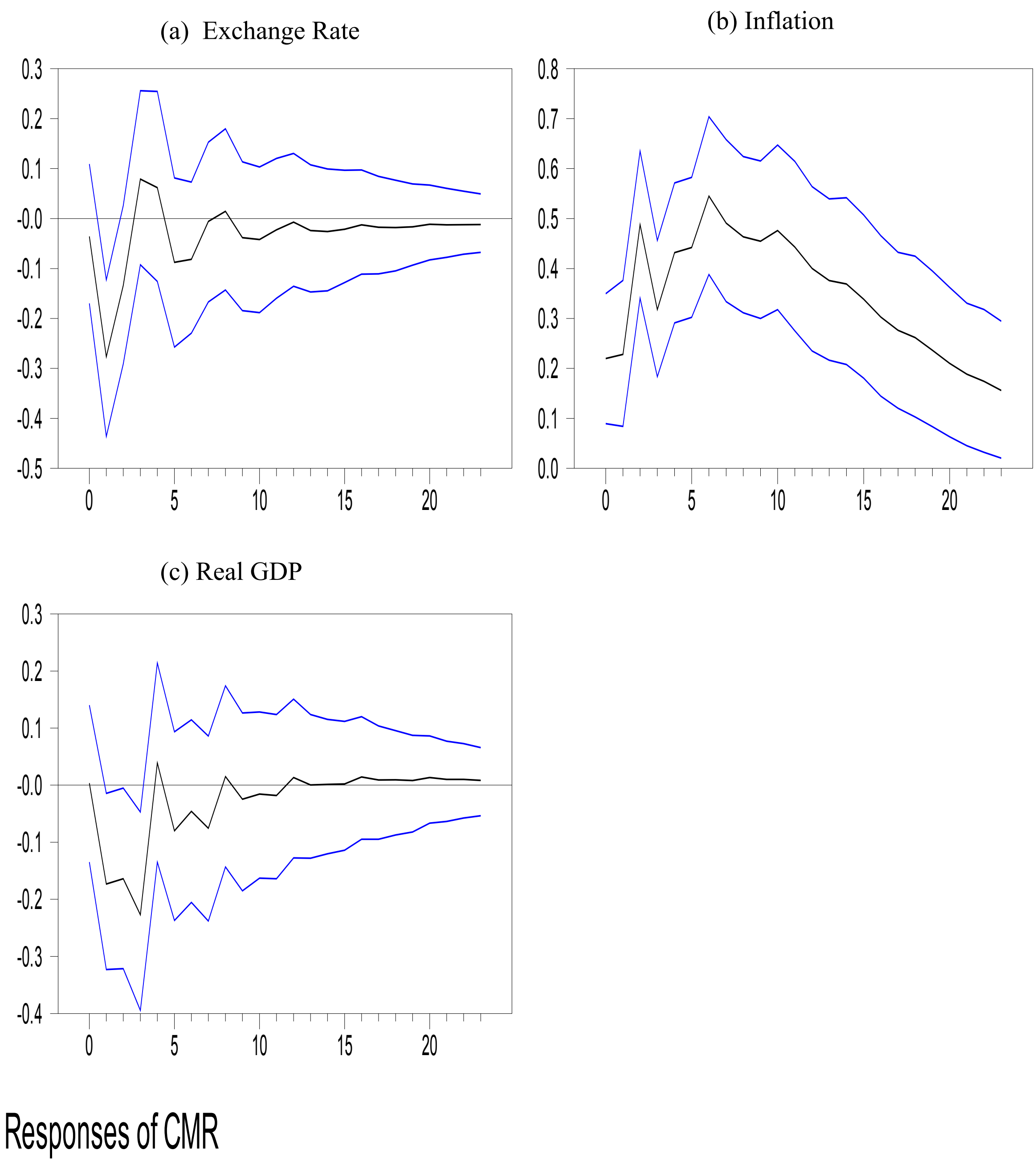


(b) Inflation



Responses to CMR

Figure 2.4: Monetary Policy Reaction to a positive shock in aggregate variables



2.5. Sectoral Models

After laying down the basic SVAR framework to analyze the impact of monetary policy, we are now ready to extend our model to sectoral outputs and examine how these react to a monetary policy shock. As depicted in the extended model below, the sectoral variable is appended at the end of the basic SVAR model developed in Section 2.4. We are here assuming that the sectoral output would have the least influence over other variables of the model. Thus, taken as the most endogenous variable, sectoral output reacts contemporaneously to all other variables of the model. Though it is possible that this assumption holds for some and not for others, we nevertheless apply it to all sectors for the sake of consistency. Raddatz & Rigobon (2003) have contended that this identification scheme is internally inconsistent because it assumes that sectoral output responds contemporaneously to monetary policy even though aggregate output does not respond contemporaneously to it. We however believe that such a possibility is not unexpected since any movement in interest rates is likely to cause extremely interest-elastic sectors to respond instantly but is unlikely to be translated into a meaningful immediate impact at the aggregate level.

We estimate a separate SVAR for each of the nine sectors. Theoretically, this would suggest that the structural parameters underlying the monetary authority's reaction function might change across sectors, and therefore, could alter the monetary policy shock across various sectors. However, as Table 2.4 shows, the magnitude of the interest rate shock is nearly identical across all sectoral models. The contemporaneous interactions among variables of the model are shown in the matrix below. This is same as developed in

Table 2.4 Exogenous Shock to Monetary Policy Variable
(1 standard deviation of the structural disturbances)

	Size
Aggregate GDP	0.686
Agriculture	0.702
Mining and Quarrying	0.695
Manufacturing	0.695
Electricity, gas and water supply	0.702
Construction	0.688
Trade and hotels and restaurants	0.699
Transport, storage and communication	0.693
Finance and insurance	0.692
Other services	0.704

$$B_0 x_t = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & a_{23} & 0 & 0 & 0 \\ a_{31} & 0 & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{pmatrix} \begin{pmatrix} woil_t \\ gdp_t \\ er_t \\ cpi_t \\ cmr_t \\ s_t \end{pmatrix}$$

Section 2.4, with the exception of s_t which is added to the model to represent output of individual sector. From the SVAR, we generate impulse response functions and forecast-error variance decompositions. Impulse response functions trace through time the response of a variable to an unanticipated change in itself or other interrelated variables. Since our focus in this paper is on reactions of sectoral outputs to a monetary policy shock, we only derive the impulse-response functions which trace the reaction of sectoral output to a 1 standard deviation shock to the call money rate. The forecast error variance decomposition provides the proportion of variation in a variable that is explained by unanticipated change in itself and other variables of the model. Two variables are termed interdependent or jointly determined when the unanticipated change in one variable is able to explain at least some proportion of the forecast error variance of the other variable.

2.5.1 Estimation Results[18]

We first present summary results on the responses of sectoral output to an unanticipated increase in call money rate. For this purpose, we construct a numbers of measures to describe the size, timing and persistence of responses exhibited by sectoral outputs to a change in monetary policy (see Tables 2.5 and 2.6 below). The first of these two tables provides information on the sign and magnitude of the largest absolute deviation of output from its trend level and the period which experienced this largest output deviation. Moreover, it also gives a statistics on the persistence of the response calculated in terms of how long this largest decline in sectoral output prevailed. The final column provides average output contraction up to twelfth quarter, roughly the period expected to experience the most effect of monetary policy on real activity. This is also confirmed from impulse responses of sectoral outputs to a monetary policy shock which indicate that most of the monetary impact on output occurs up to quarter 12 (3 years). Table 2.6 gives the point estimate of responses of sectoral outputs at selected time intervals following the

[18] We note here that we can construct a number of plausible sets of identifying restrictions. One possibility suggested to us is that sectoral output, if large, could possibly have a significant contemporaneous impact on aggregate output. We re-estimated SVAR incorporating this particular assumption. The results show that while the size of the differential impact of monetary policy slightly changes, the ranking of the sectors remains the same. We therefore continue with our chosen economic system.

contractionary monetary policy shock. For each time interval, we rank the sectors in terms of their responses to a monetary policy contraction, starting from those that react most

Table 2.5 Characteristics of Responses to a Contractionary Monetary Policy

Sector	Relative output effect	Size of Max effect (in any one quarter)	Timing of Max effect (quarter)	Length of Largest Decline in Output (Quarters)	Average output change (1-12 quarters)
Agriculture	(-)	-0.00233	5	8	-0.0002
Mining and quarrying	(-)	-0.00547	6	9	-0.0021
Manufacturing	(-)	-0.00554	3	12	-0.0031
Electricity, gas and water supply	(-)	-0.01667	3	7	-0.0045
Construction	(-)	-0.00756	5	8	-0.0015
Trade and hotels and restaurants	(-)	-0.0034	3	12	-0.0017
Transport, storage & communicatic	(+)	0.00139	8	2	0.0006
Finance and insurance	(-)	-0.03125	6	6	-0.0056
Other services	(-)	-0.00123	1	4	-0.0002

(+)/(-) shows overall positive/negative output impact. Size of maximum effect provides the largest deviation over the 6-year horizon following the monetary policy contraction calculated in standard deviations of the structural disturbances. Timing of maximum impact refers to the quarter which experienced this largest output deviation.

Table 2.6 Ranking in terms of Strongest Response to a Tight Monetary Policy

	End 2nd Quarter		End 4th Quarter		End 8th Quarter		End 12th Quarter	
Rank	Sector	Output change	Sector	Output change	Sector	Output change	Sector	Output change
1	Fin	-0.0164	Egw	-0.0099	Mnq	-0.0049	Fin	-0.0028
2	Egw	-0.0071	Mnq	-0.0039	Fin	-0.0042	Con	-0.002
3	Man	-0.0029	Man	-0.0037	Man	-0.0031	Man	-0.0014
4	Thr	-0.0016	Thr	-0.0011	Con	-0.0028	Mnq	-0.0012
5	Tsc	-0.0012	Ots	-0.0004	Thr	-0.0013	Thr	-0.0006
6	Ots	-0.0002	Agr	0.0003	Agr	-0.0009	Agr	-0.0005
7	Mnq	0.0004	Tsc	0.0006	Egw	0.0003	Ots	-0.0004
8	Con	0.0013	Fin	0.0016	Ots	0.0004	Egw	0.0007
9	Agr	0.0027	Con	0.0099	Tsc	0.0014	Tsc	0.0013

strongly to the shock. This is helpful in analyzing the relative persistence of the output change.

Impulse responses for the nine sectors confirm that all the nine sectors undergo a reduction in output at some point in time following the contractionary monetary policy. The first column of Table 2.5 demonstrate that for eight of the total nine sectors, the overall output response over the 6-year horizon is negative – a finding consistent with results from the real effect of monetary policy on aggregate output. It further reveals that the greatest output deviations from baseline level are observed within the first 18 months following the monetary policy shock, with the exclusion of Transport, storage and communication sector, which recorded the largest (positive) effect at 24-month lag. Relatively short delays are experienced by Manufacturing sector, Electricity, gas and water supply sector, and Trade and hotels & restaurants sector (within the 3rd quarter). The second last column of Table 2.5 presents a measure of the persistence of output effects following the unanticipated change in interest rate. Sectoral outputs that experienced the longest contraction following a tight monetary policy shock are found to be Manufacturing sector (12 quarters), Trade and hotels & restaurants sector (12 quarters), Mining and quarrying sector (9 quarters), Agriculture sector (8 quarters) and Construction sector (8 quarters).

Defining interest rate sensitivity as the highest output deviation from long-run level, we find that Finance and Insurance is the most interest rate sensitive sector, since it faces the largest output contraction from the baseline relative to other sectors (-0.03125). The next three interest rate sensitive sectors are Electricity, gas and water supply sector (-0.01667), Construction sector (-0.00756), and Manufacturing sector (-0.00554), followed by Mining and quarrying sector (-0.00547)), Trade and hotels & restaurants sector (-0.00340), Agriculture sector (-0.00233), Other services sector (-0.00123). Transport, storage and communication was the only sector that exhibited a positive output response (0.00139) after a monetary contraction. Nevertheless, Transport, storage and communication does experience period of mild contraction during 2nd and 3rd quarters following a tight monetary policy shock. The final column of Table 2.5 gives a composite indicator of both persistence and the size. Using this indicator, and starting with the most sensitive sector, the nine sectors are ranked as follows: Finance and Insurance sector, Electricity, gas and water supply sector, Manufacturing sector, Mining and quarrying sector, Trade and hotel & restaurants sector, Construction sector, Agriculture sector, Other services sector, and Transport, storage and communication sector.

Impulse Responses and Variance Decompositions

The shapes of impulse response functions generated by the disaggregated models disclose major variation in the reactions of sectoral outputs to an exogenous shock to monetary policy. In line with general expectations, majority of sectors displayed a lagged output reduction after the contractionary monetary policy shock. One sector (transport, storage and communication), however, exhibited periods in which output increased, contrary to expectations. Regarding the persistence of output effects, the results depicted that output responses for all the nine sectors sooner or later go back to the baseline. This phenomenon is observed around approximately 12-15 quarters for almost all sectors, a feature consistent with the behavior of the aggregate output. This shows that the real effects of monetary policy for the case of Pakistan are fairly long, and can persist for roughly 3 years.

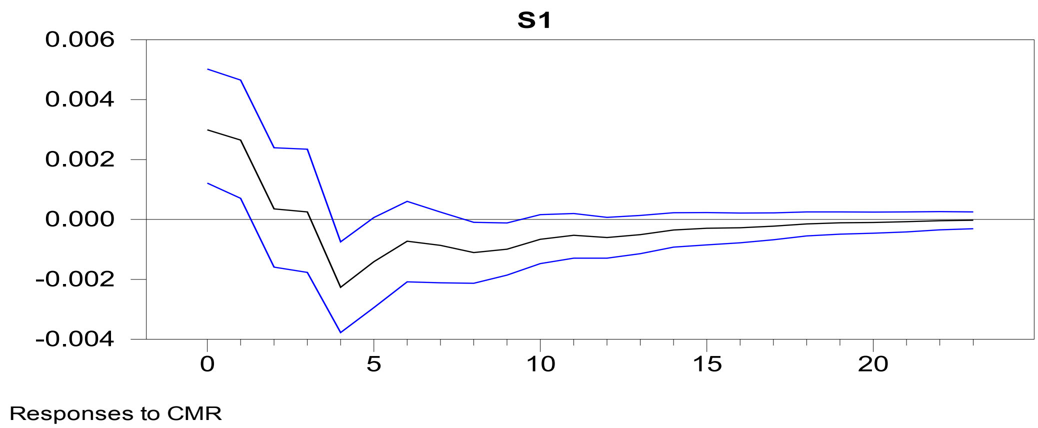
We now turn to sector-wise results. The summary results of forecast error variance decomposition (FEVD), showing the contribution of interest rate shock in the forecast error variance of each sector for forecast horizons 1, 2, 4, 8, 12, 18 and 24 quarters ahead, are reported in Table 2.7.[19]

Table 2.7 Variance Decomposition of Sectoral Outputs to an Interest Rate Shock

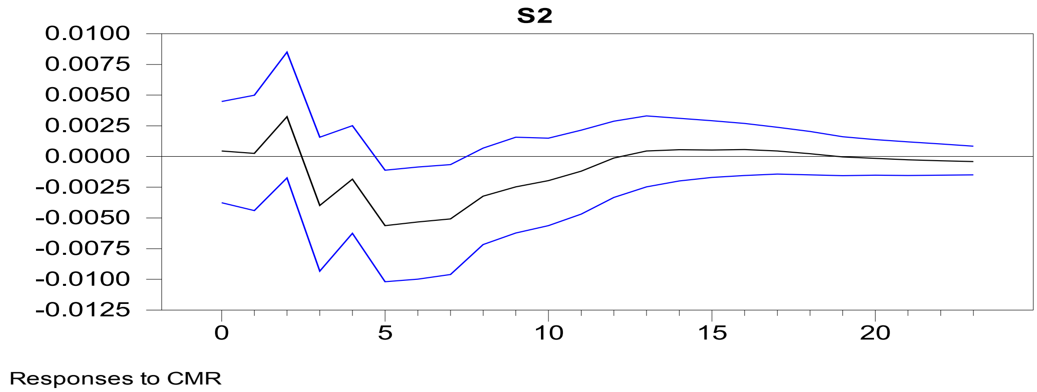
Horizon	*Agr*	*Mnq*	*Man*	*Egw*	*Con*	*Thr*	*Tsc*	*Fin*	*Ots*
1	1.552	0.012	0.201	3.086	0.174	0.440	0.012	0.004	0.270
2	2.456	0.012	1.364	2.391	0.183	0.803	0.088	0.463	0.249
4	2.211	0.570	4.937	3.976	1.552	2.240	0.265	2.613	0.246
8	3.295	1.862	8.304	3.825	3.244	4.272	0.472	5.182	0.411
12	3.661	2.079	8.615	3.793	3.684	4.683	0.752	5.220	0.591
18	3.742	2.114	8.528	3.801	3.974	4.713	0.971	5.306	0.686
24	3.737	2.122	8.529	3.806	4.029	4.702	1.022	5.303	0.702

S1: Agriculture (Agr): Agriculture sector experiences decline in output starting from the 5th quarter following an interest rate shock suggesting significant lags in the transmission of monetary policy. Output returns to the baseline approximately after fifteen quarters. Over 3-year horizon, output falls by 0.2% from its long-run trend. However the FEVD for agriculture sector suggests that unanticipated shock to interest rate only contributed around 4% of variation in the output of this sector. Instead, nearly all of variation (around 75%) in agricultural output is explained by the sector itself, not an unexpected finding given the absence of the main driver of fluctuations in Agr, ie climatic changes, from the model.

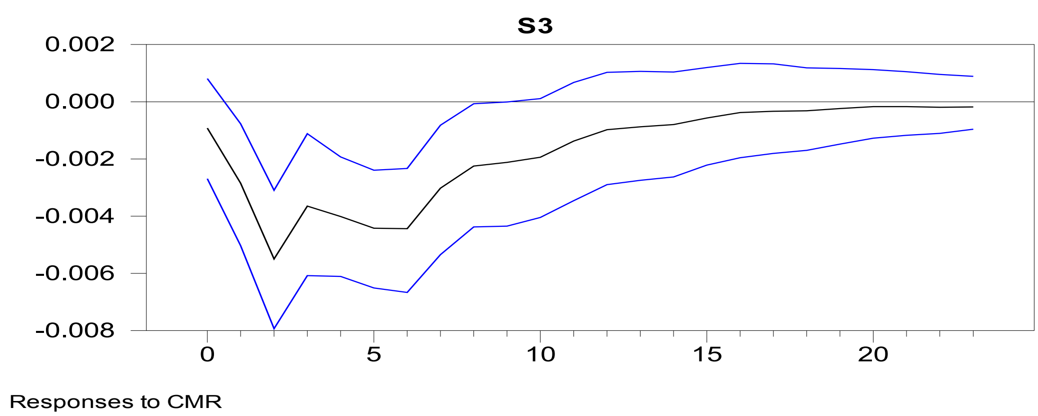
[19] Complete set of FEVD are appended at the end.



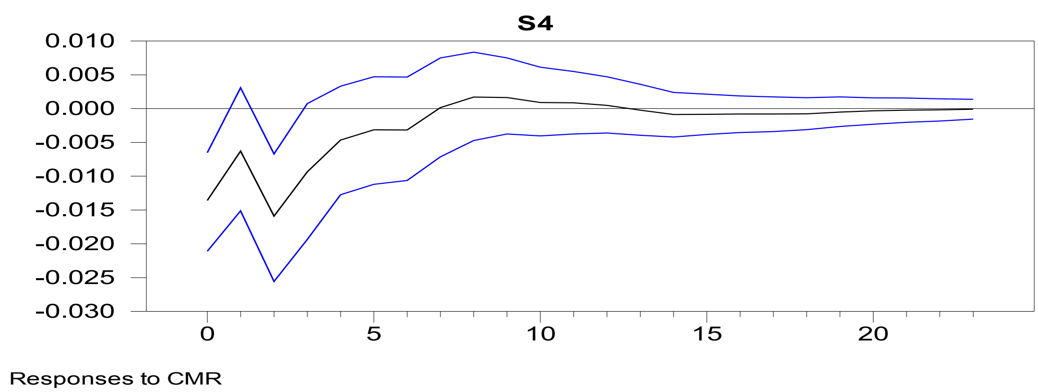
S2: Mining and Quarrying (Mnq): In response to a tight monetary policy shock, the output of Mnq experiences a more rapid and a larger decline than was the case for Agr. Output falls roughly 2.5% from the long-run trend over the three-year horizon in response to monetary tightening. However, it is noteworthy that interest rate shocks only explain approximately 2% of the variation in Mnq's forecast error. The very low explanatory power of interest rate shock to this sector's forecast error coupled with the comparatively large interest elasticity exhibited by the impulse response function indicates that either the sector's output characterizes the presence of high intrinsic volatility (and not driven by changes in interest rates) or is simply working through feedback from a strong exchange rate channel of transmission mechanism. This later argument is substantiated by the fact that exchange rate shocks make up a significant part of the variation in this sector's forecast error – up to 14% between 8-24 quarters.



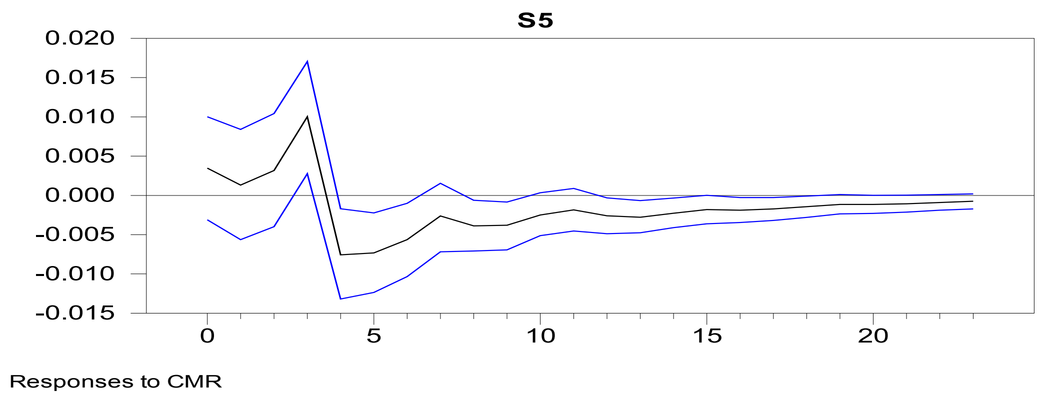
S3: Manufacturing (Man): Manufacturing sector experiences a relatively large and quick response to a change in monetary policy, a finding consistent with other studies on the effectiveness of monetary policy (see Ganley and Salmon, 1997). Manufacturing output falls 3.7% from the baseline over 3-year horizon; moreover, nearly half of this decline is completed within 5 quarters. Also, FEVD shows that the interest rate shock explains over 8% of the forecast error variation in manufacturing sector's output, the largest among all sectors. All of this suggests manufacturing is among the high interest rate sensitive sectors. Importantly, manufacturing represents the second largest sector (after agriculture) of the aggregate economy, and hence any variation in the sector's output will produce significant effects at the aggregate level.



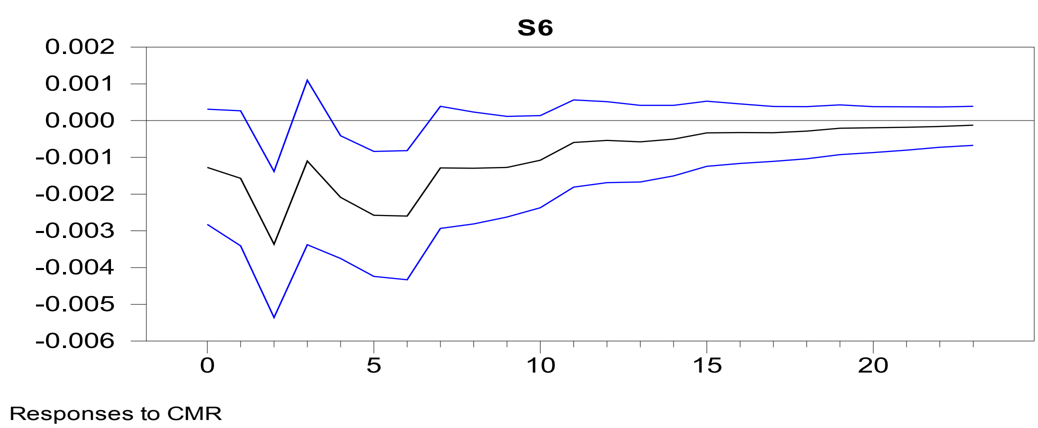
S4: Electricity, gas and water (Egw): Similar to mining and quarrying, the dynamic response of Egw sector indicates large interest elasticity, as displayed by the impulse response, coupled with low explanatory power of interest rate shock to this sector's forecast error, as exhibited by FEVD. On the other hand, exchange rate shocks explain 10-12 percent of 3-5 quarter forecast error variance of real output in Egw sector. As before, we conclude that the relatively high interest rate sensitivity exhibited by the sector might reflect the volatile nature of the sector or the work of exchange rate channel of monetary transmission mechanism.



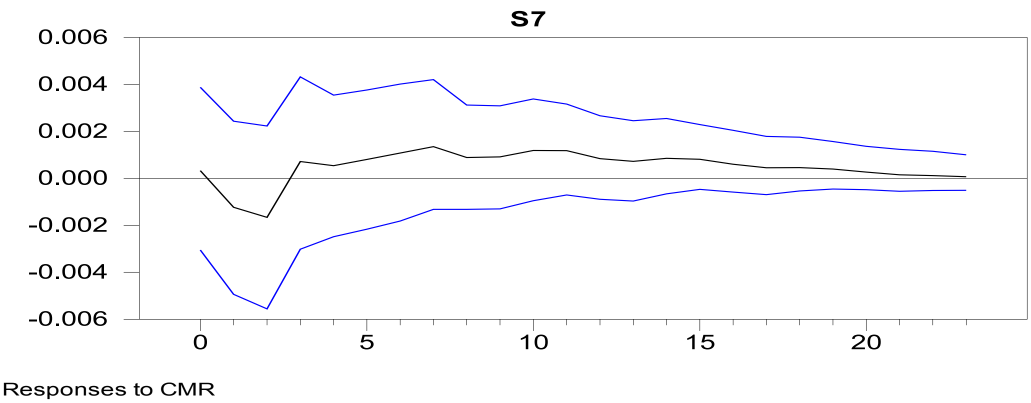
S5: Construction: While public investment in physical infrastructure might have slowed over years due to financial constraints, residential investment has generally remained buoyant and has seen a plethora of housing societies entering the market. Thus, one would expect a sizeable reaction of the construction sector to changes in interest rate. The results show that construction output falls by 1.8% from its long-run trend over 3-year horizon in response to an increase in interest rate while monetary policy shock explains roughly 4% of the forecast error variance of construction sector output.



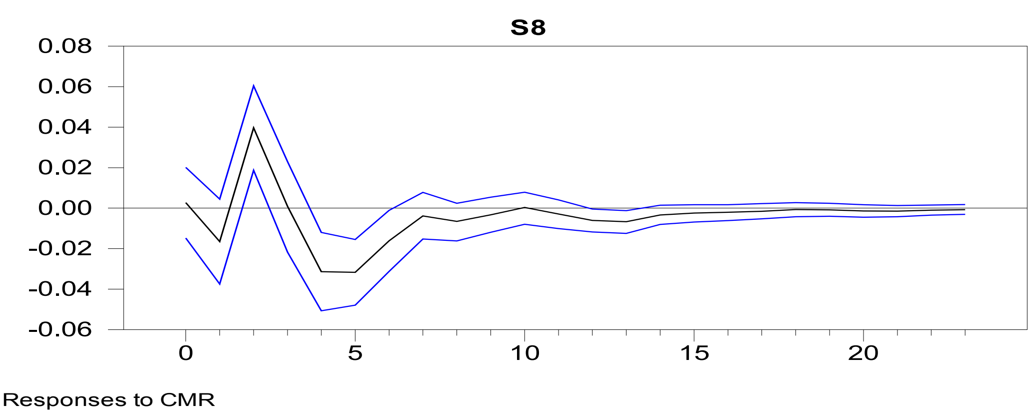
S6: Trade and Hotels and Restaurants (Thr): This is yet another sector which exhibits a respectable response to changes in interest rate. Specifically, over the 3-year horizon, output of the sector falls about 2 percent from the baseline in response to an unanticipated shock to monetary policy. Furthermore, the interest rate shock is found to make up 4-5% of forecast error variation over 8-24 quarter horizon. Again, Thr is the third largest sector of the economy, and hence any movement in the output of this sector is likely to exert substantial effect at the aggregate level.



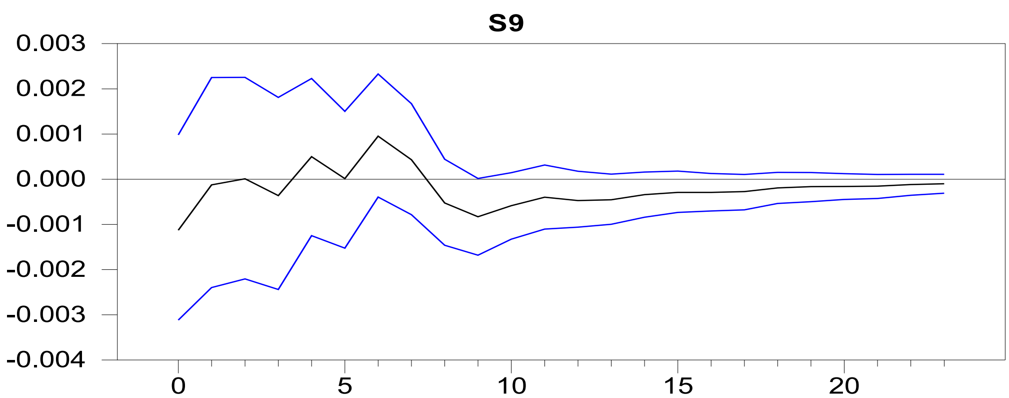
S7: Transport, storage and communication (Tsc): Typically, this sector is characterized by high concentration of large firms with the sectoral output facing low price elasticity of demand. Hence, monetary policy is expected to have little impact on the output of this sector. The results show that while Tsc output did fall 0.2 percent during 2nd and 3rd quarter, it actually went up, albeit only slightly, in response to an increase in interest rate over the 3-year horizon. FEVD show that Tsc is among the two sectors with the lowest contribution from monetary policy shock (only 1 percent).



S8: Finance and Insurance (Fin): As expected, finance and insurance sector experiences the quickest and the largest reduction in output in response to an unanticipated increase in interest rate. As the central bank resorts to tightening of monetary policy, output of finance and insurance sector falls by 6.8% from the baseline over the three year horizon. FEVD indicates that monetary policy shocks contribute over 5 percent to the sectoral forecast error variance over 6-24 quarter horizons.



S9: Other services (Ots): The other services sector comprise of three subsectors: Ownership of dwellings, Public administration and defense, Social, personal and community services. Since this sector is dominated by the public entities and industries facing inelastic demand like health and education, one would expect the sector to be relatively less interest rate sensitive. The shape of impulse response function confirms our prior expectation. The monetary policy shock contributes less than 1 percent of forecast error variance in the output of these subsectors. While the finding of low interest sensitivity of these subsectors is not unexpected, it nevertheless has significant implications for the effectiveness of monetary policy at the aggregate level as these subsectors have a combined share of 22 percent, more than the share of agriculture in overall GDP.



Responses to CMR

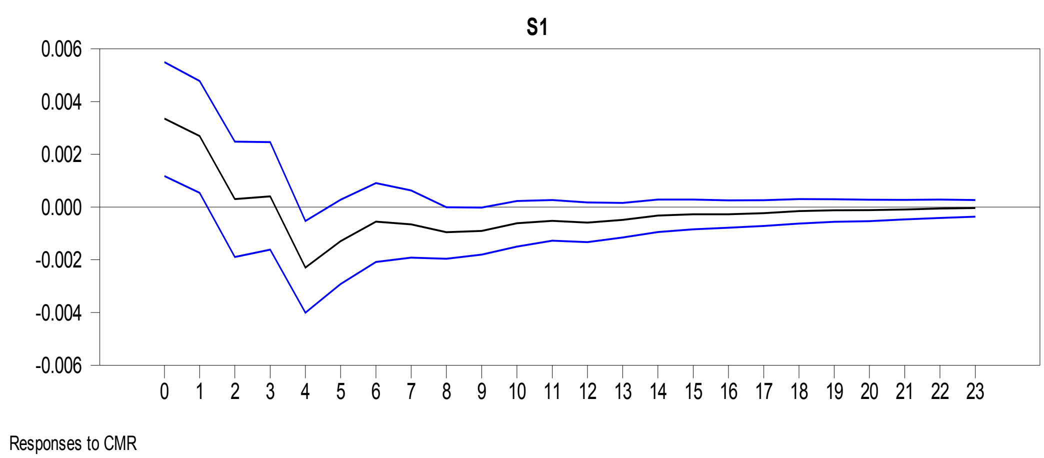
2.5.2. Interdependence of aggregate and sectoral outputs

Here, we note that since aggregate output is the sum of outputs of all sectors, equations for aggregate and sectoral outputs could be highly interdependent for large sectors.[20] For this

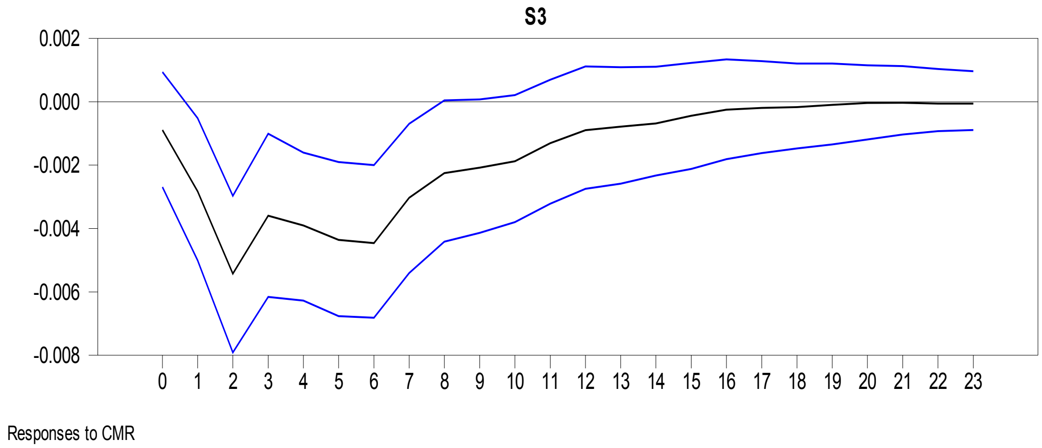
[20] This possibility was suggested by one of the external referees and this sub-section added on his advice.

reason, we redo SVAR estimations for the largest three sectors of the economy while construction aggregate GDP sans that particular sector's output. These sectors are agriculture (agr.), manufacturing (man.) and trade & hotels and restaurants (thr.).

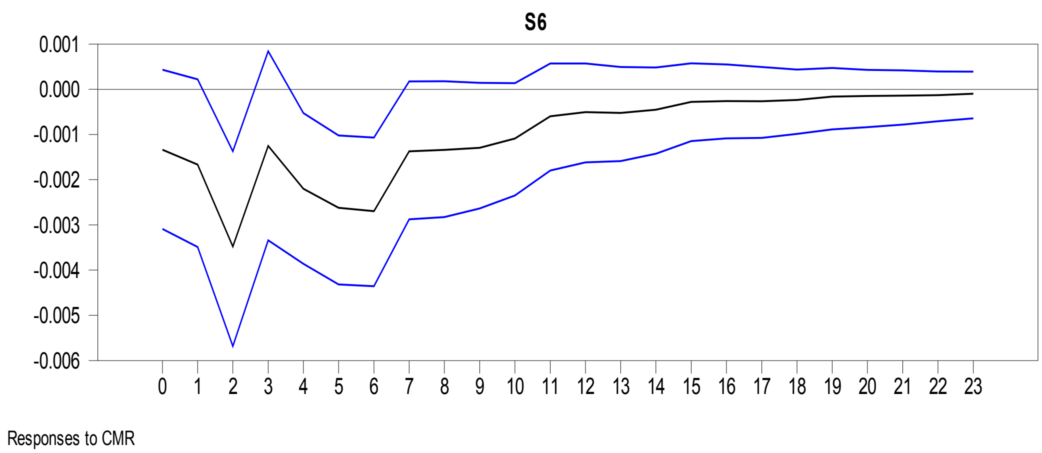
S1: Agriculture (Agr): The new Impulse Response Function shows that while initial impact of interest rate rise on agricultural output is marginally higher, all other characteristics remain the same as before. Therefore, the output of agriculture sector experiences decline from the 5th quarter, again suggesting significant lags in the transmission of monetary policy. Like before, output returns to the baseline approximately after fifteen quarters and the decline in output from its long-run trends remains about 0.2% over the 3-year horizon.



S3: Manufacturing (Man): The impulse response function for new manufacturing SVAR does not exhibit any meaningful difference from the one estimated before. The output of the sector experiences a relatively large and quick response to a change in monetary policy, declining by 3.7% from the baseline over 3-year horizon. Again, nearly half of this decline is completed within 5 quarters.



S6: Trade and Hotels and Restaurant (Thr): Like manufacturing, the new impulse response function for trade & hotels and restaurants SVAR is the same as before. Output of the sector falls about 2 percent from the baseline in response to an unanticipated shock to monetary policy over the 3-year horizon.



2.6. Sensitivity Analysis

The financial sector of Pakistan underwent a drastic reform process starting from early 1990. This included various measures to switch from a highly regulated to a liberalized and market-based monetary and financial system. In all likelihood, these reform measures have fundamental implications for the monetary transmission mechanism in Pakistan.[21] This section performs further analysis on a sub-sample of the data set containing observation over the period 1991 to 2012 in order to check whether the variation in sectoral responses witnessed in full-sample have undergone any changes with the monetary and financial system reforms.

Several observations are notable from dynamic responses of aggregate and sectoral outputs to a monetary policy shock in the period after the financial sector reforms, as shown in Figure 2.5 below. First, at the aggregate level, the effects of monetary policy seem much stronger thereby indicating improvements in the transmission mechanism of monetary policy as a result of financial sector reforms. Second, at the sectoral level, impulse responses generated for the sub-sample period exhibits dynamics similar to the full-sample model in terms of macroeconomic relationships but varies in terms of the size of sectoral responses. Specifically, sub-sample results demonstrate a much weaker impact of monetary shock on the outputs of agriculture, mining and quarrying, trade and hotels and restaurants, and other services sectors. In contrast, monetary policy's effectiveness in relation to outputs of finance and insurance, manufacturing, and construction sectors improves considerably. Last, but not the least, Figure 2.5 also reveals that though the effects of monetary policy are still realized with some lags, the time required for the reaction of real activity to bottom out in response to interest rate shock is now significantly reduced.

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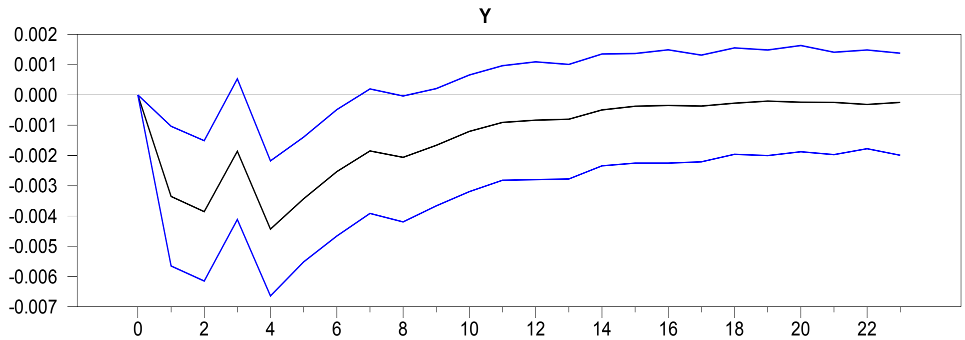
[21] For detailed description of the reform process and its implications, see Financial Sector Assessment (various issues), State Bank of Pakistan. http://sbp.org.pk/publications/fsa.htm

Figure 2.5: Robustness Test –

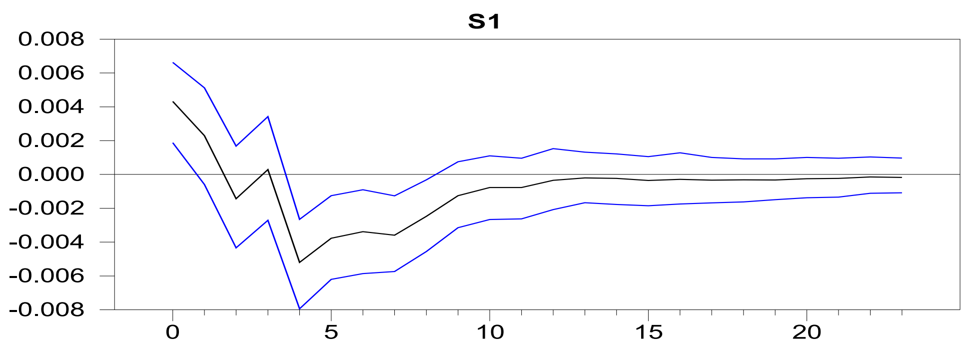
1991-2012

Real GDP



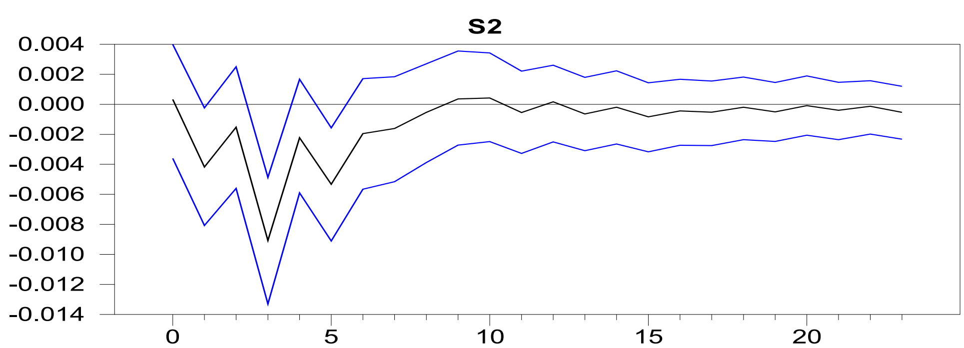
Responses to CMR

Agriculture



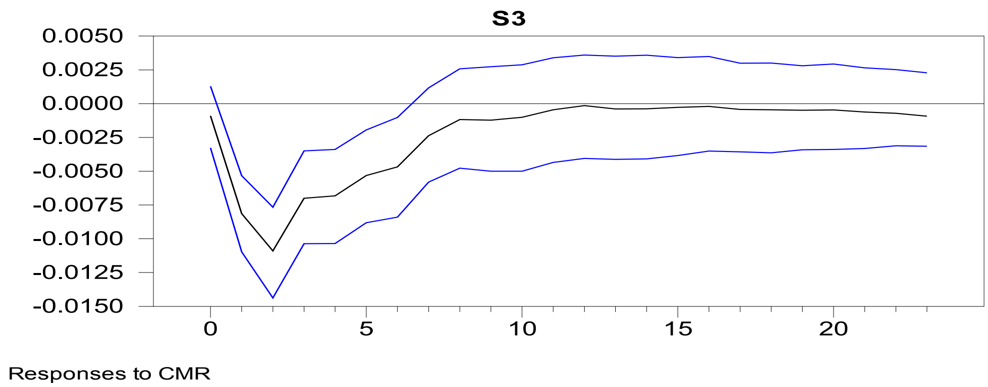
Responses to CMR

Mining and Quarrying

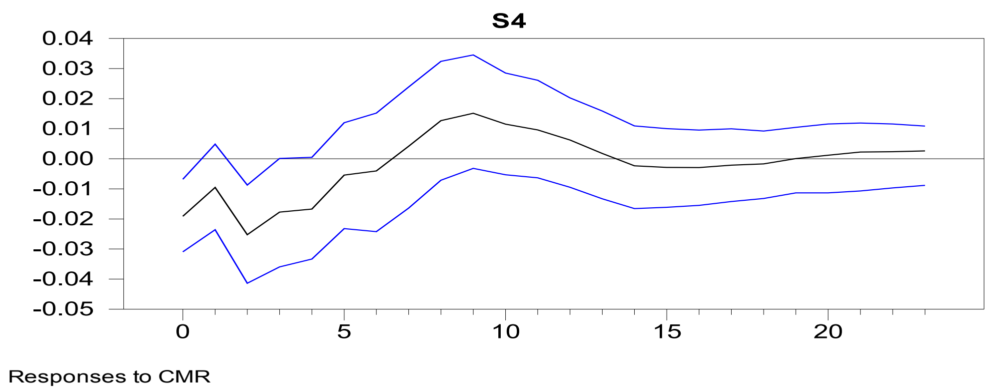


Responses to CMR

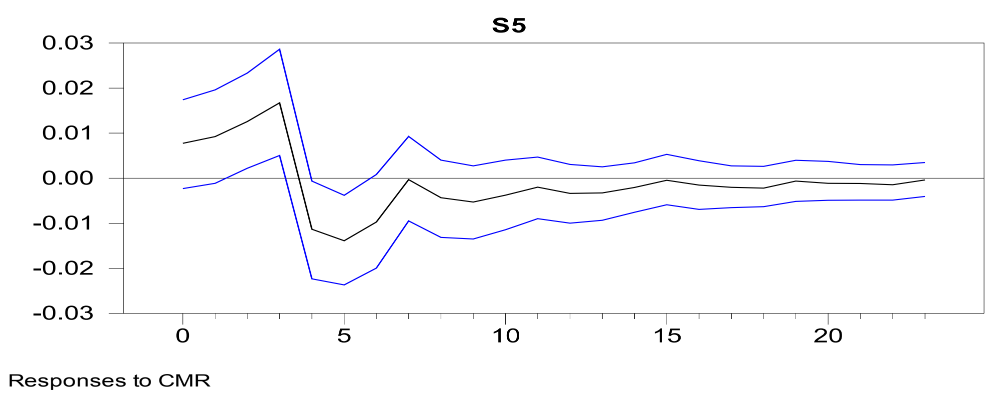
Manufacturing



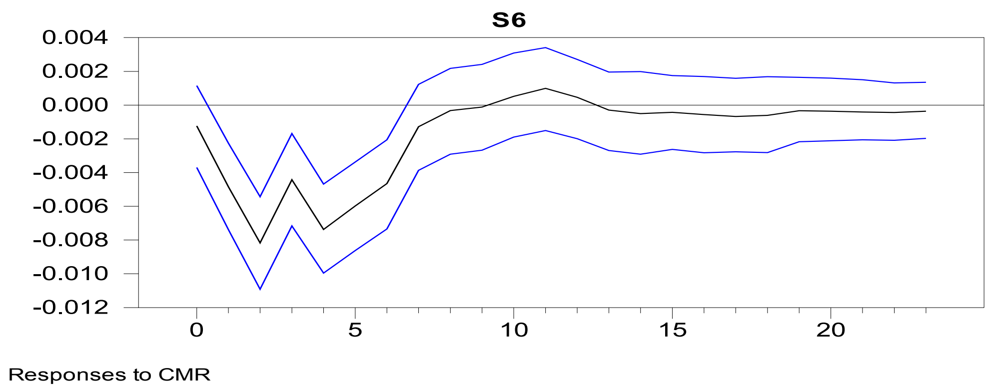
Electricity, Gas and Water Supply



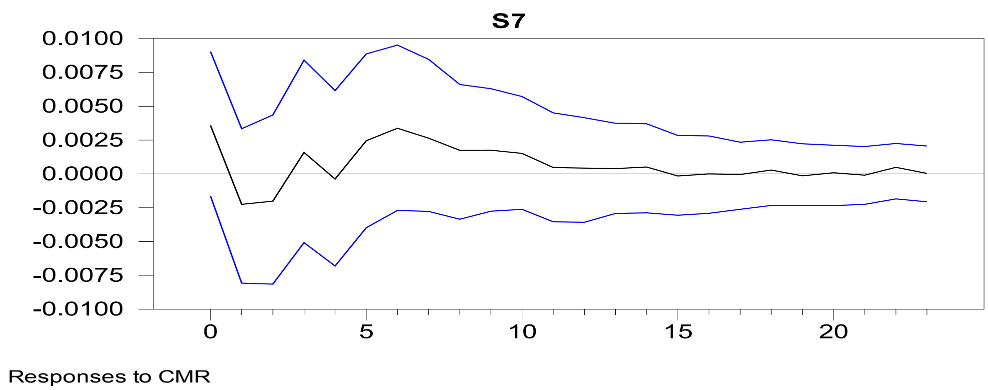
Construction



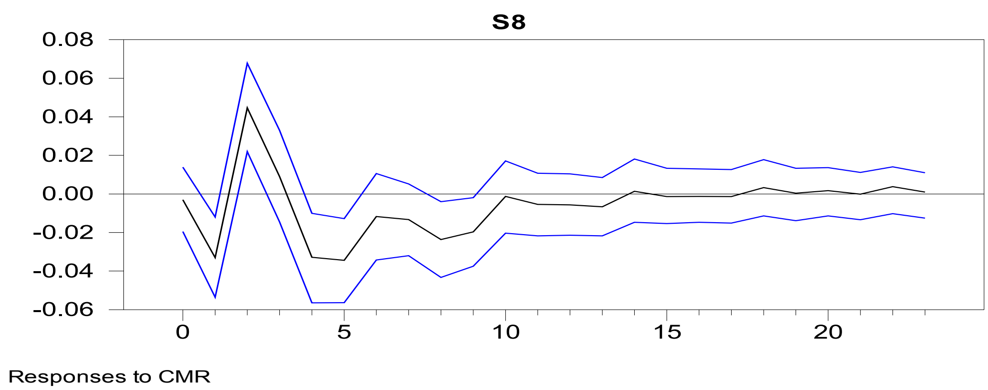
Trade and Hotels and Restaurants



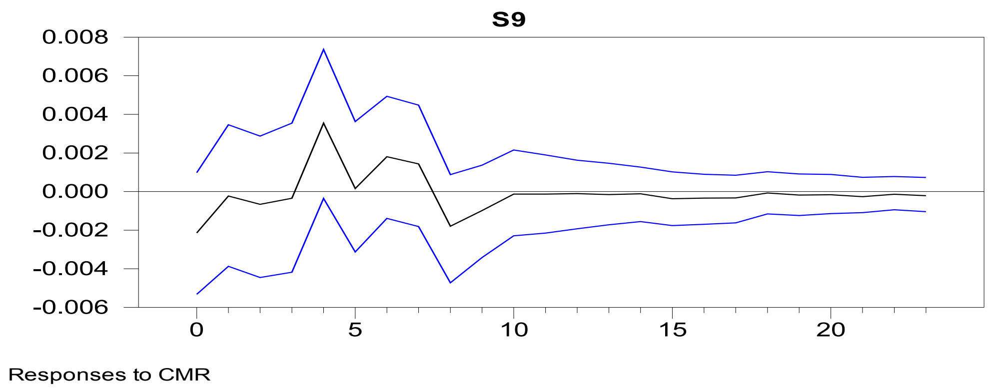
Transport, Storage and Communication



Finance and Insurance



Other Services



2.7. Conclusion

The present paper forms a small-scale, open economy structural VAR model of Pakistan to study the response of sectoral outputs to an unanticipated change in the call money rate. We disaggregate the national economy into nine subsectors and estimate a separate structural VAR model for each of the nine sectors, in addition to estimating SVAR for the aggregate output. Then, from the estimated VAR, we generate impulse response functions to measure the effect of monetary policy shock on real activity. Moreover, we undertake a sub-sample analysis to check the robustness of the results with respect to financial and monetary sector reforms initiated in 1990.

In line with many other studies on the subject, we find evidence that a tight monetary policy is likely to produce varying responses across various sectors. Results on the dynamic responses of sectoral outputs establish that some sectors are highly sensitive to a policy changes in interest rate. As one would expect, finance and insurance sector and the manufacturing sector demonstrate a large and fast reduction in their outputs. On the other hand, sectors like services and utilities display a relatively mild response to changes in monetary policy.

The differences in the responses of various sectors of the Pakistan economy to a change in monetary policy have significant implications for the design of monetary policy. Traditionally, monetary policy in Pakistan has been geared towards supporting economic growth while also ensuring stability in prices. Thus, SBP has often followed an accommodative policy stance as long as rate of inflation is not high enough to threaten macroeconomic stability. However, given our findings of substantial variation in the impact of monetary policy at the disaggregated level, State Bank must fully assess the potential impact of its policy action on the distribution of income across various sectors. At the broader level, the economic policy makers need to recognize the distributional consequences of changes in monetary policy and therefore calibrate all policy tools available to them, such as tax and expenditure policies, for an equitable economic growth outcome.

Finally, a word on the limitations of this work. As the next essay demonstrates, SBP's reaction function exhibits some elements of non-linearity. Unfortunately, SVAR is not suited to handle non-linearity in the model. However, there is need to look differential impacts of monetary policy on sectoral outputs under a non-linear reaction function for SBP.

References

Agha, A, Ahmed, N, Mubarik, Y & Shah, H (2005), "Transmission mechanism of monetary policy in Pakistan," *SBP-Research Bulletin*, vol. 1, no. 1.

Alam, T & Waheed, M (2006), "Sectoral Effects of Monetary Policy: Evidence from Pakistan," *The Pakistan Development Review*, vol. 45, no. 4, pp. 1103–1115.

Arby, F (2008), *Some Issues in the National Income Accounts of Pakistan (Rebasing, Quarterly and Provincial Accounts and Growth Accounting) PhD Dissertation*, Pakistan Institute of Development Economics, Islamabad.

Arnold, IJM & Vrugt, EB (2002), "Regional Effects of Monetary Policy in the Netherlands," *International Journal of Business and Economics*, vol. 1, no. 2, pp. 123–134.

Ashley, RA & Verbrugge, RJ (2009), "To difference or not to difference: a Monte Carlo investigation of inference in vector autoregression models," *International Journal of Data Analysis Techniques and Strategies*, vol. 1, no. 3, pp. 242–274.

Bernanke, BS (1986), "Alternative explanations of the money-income correlation," *Carnegie-Rochester Conference Series on Public Policy*, vol. 25, no. 1, pp. 49–99.

Bernanke, BS & Gertler, M (1995), "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *Journal of Economic Perspectives*, vol. 9, no. 4, pp. 27–48.

Bernanke, BS & Mihov, I (1998), "Measuring Monetary Policy," *The Quarterly Journal of Economics*, vol. 113, no. 3, pp. 869–902.

Blanchard, OJ & Quah, D (1989), "The Dynamic Effects of Aggregate Demand and Supply Disturbances," *American Economic Review*, vol. 79, no. 4, pp. 655–73.

Christiano, LJ, Eichenbaum, M & Evans, C (1996), "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," *The Review of Economics and Statistics*, vol. 78, no. 1, pp. 16–34.

Cushman, DO & Zha, T (1997), "Identifying monetary policy in a small open economy under flexible exchange rates," *Journal of Monetary Economics*, vol. 39, no. 3, pp. 433–448.

Dedola, L & Lippi, F (2005), "The monetary transmission mechanism: Evidence from the industries of five OECD countries," *European Economic Review*, vol. 49, no. 6, pp. 1543–1569.

Eichenbaum, M & Evans, CL (1995), “Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates,” *The Quarterly Journal of Economics*, vol. 110, no. 4, pp. 975–1009.

Farès, J & Srour, G (2001), “The Monetary Transmission Mechanism at the Sectoral Level,” viewed 23 February, 2013, <http://boc-en.ets.net/wp-content/uploads/2010/02/wp01-27.pdf>.

Gali, J (1992), “How Well Does the IS-LM Model Fit Postwar U.S. Data,” *The Quarterly Journal of Economics*, vol. 107, no. 2, pp. 709–38.

Ganley, J & Salmon, C (1997), *The Industrial Impact of Monetary Policy Shocks: Some Stylised Facts*, Bank of England.

Gertler, M & Gilchrist, S (1993), “The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence,” *Scandinavian Journal of Economics*, vol. 95, no. 1, pp. 43–64.

Gordon, DB & Leeper, EM (1994), "The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification," *Journal of Political Economy*, vol.102, no.6, pp.1228-47 .

Gruen, D & Shuetrim, G (1994), “Internationalisation and the Macroeconomy,” *RBA Annual Conference Volume*.

Hamilton, JD (1994), *Time Series Analysis*, Princeton University Press.

Hayo, B & Uhlenbrock, B (1999), “Industry Effects of Monetary Policy in Germany,” *SSRN Electronic Journal*.

Ibrahim, MH (2005), “Sectoral Effects of Monetary Policy: Evidence from Malaysia,” *Asian Economic Journal*, vol. 19, no. 1, pp. 83–102.

Kwiatkowski, D, Phillips, PCB, Schmidt, P & Shin, Y (1992), “Testing the null hypothesis of stationarity against the alternative of a unit root,” *Journal of Econometrics*, vol. 54, no. 1-3, pp. 159–178.

Lack, C & Lenz, C (2000), "A Program for the Identification of Structural," *Manuscript*..

Malik, WS (2006), “Money, output and inflation: Evidence from Pakistan," *The Pakistan Development Review*, vol. 45, no.4 (part II), pp. 1277-1286

Malik, WS (2007), “Monetary Policy Objectives in Pakistan : An Empirical Investigation,” *Macroeconomics Working Papers*.

Pellényi, G (2012), “The Sectoral Effects of Monetary Policy in Hungary: A Structural Factor Analysis,” *MNB Working Papers*.

Raddatz, C & Rigobon, R (2003), “Monetary policy and sectoral shocks : did the Federal Reserve react properly to the high-tech crisis?,” *Policy Research Working Paper Series*.

Ramaswamy, R & Sløk, T (1997), “The Real Effects of Monetary Policy in the European Union: What Are the Differences?,” *IMF Working Papers*.

Rehamn, F ur & Malik, WS (2010), "A Structural VAR (SVAR) Approach to Cost Channel of Monetary Policy," *MPRA Working Paper No.32349*.

Robert A Buckle, Kunhong Kim, Heather Kirkham, Nathan McLellan, JS (2002), “A structural VAR model of the New Zealand business cycle,” *New Zealand Treasury, Treasury Working Paper Series*, no. 02/26.

Shapiro, M & Watson, M (1988), “Sources of Business Cycles Fluctuations,” *NBER Chapters*, pp. 111–156.

Sims, CA (1980), “Macroeconomics and Reality,” *Econometrica*, vol. 48, no. 1, pp. 1–48.

Sims, CA (1986), “Are forecasting models usable for policy analysis?,” *Quarterly Review*, no. Win, pp. 2–16.

Sims, CA (1992), “Interpreting the Macroeconomics Time Series Facts: The Effects of Monetary Policy,” *European Economic Review*, vol. 36, no. 5, pp. 975–1000.

Sims, CA, Stock, JH & Watson, MW (1990), “Inference in Linear Time Series Models with Some Unit Roots,” *Econometrica*, vol. 58, no. 1, pp. 113–44.

Sims, CA & Zha, T (2006), “Does Monetary Policy Generate Recessions?,” *Macroeconomic Dynamics*, vol. 10, no. 02, pp. 231–272.

Taylor, JB (2000), “Alternative Views of the Monetary Transmission Mechanism: What Difference Do They Make for Monetary Policy?,” *Oxford Review of Economic Policy*, vol. 16, no. 4, pp. 60–73.

Tena, J de D & Tremayne, AR (2009), “Modelling monetary transmission in UK manufacturing industry,” *Economic Modelling*, vol. 26, no. 5, pp. 1053–1066.

Wu, Yangru & Zhang, Hua (1996), " Mean reversion in interest rates: New evidence from a panel of OECD countries," *Journal of Money, Credit and Banking*, vol. 28, issue 4 (Part 1), pp. 604-621

Appendix A: Parameter estimates for sectoral SVAR[22]

SVAR (Agriculture)

	Dependent Variables				
	gdp_t	er_t	cpi_t	cmr_t	agr_t
gdp_t	1	-0.016	0	0	0
		(0.004)			
er_t	0	1	0	0	0
cpi_t	-0.337	0.143	1	0	0
	(0.201)	(0.016)			
cmr_t	-0.0126	-0.0561	-0.178	1	0
	(0.121)	(0.031)	(0.053)		
agr_t	-2.039	0.071	-2.184	0.08254	1
	(0.521)	(0.112)	(0.085)	(0.001)	

Test for Over-identification Restrictions X2(2) 1.484 (0.476)

Standard errors from the MLE estimates are reported in parentheses.

SVAR (Manufacturing)

	Dependent Variables				
	gdp_t	er_t	cpi_t	cmr_t	man_t
gdp_t	1	0.0314	0	0	0
		(0.029)			
er_t	0	1	0	0	0
cpi_t	-0.104	0.187	1	0	0
	(0.128)	(0.011)			
cmr_t	-0.413	0.0826	-0.1823	1	0
	(0.213)	(0.135)	(0.074)		
man_t	-0.393	0.4721	0.1688	-0.952	1
	(0.020)	(0.152)	(0.066)	(0.167)	

Test for Over-identification Restrictions X2(2) 0.354 (0.837)

Standard errors from the MLE estimates are reported in parentheses.

[22] Estimates for *woil* are not produced as it is block exogenous in the system.

SVAR (Trade & Hotels and Restaurants)

	Dependent Variables				
	gdp_t	er_t	cpi_t	cmr_t	thr_t
gdp_t	1	0.014	0	0	0
		(0.010)			
er_t	0	1	0	0	0
cpi_t	-0.308	0.042	1	0	0
	(0.156)	(0.013)			
cmr_t	-0.258	0.0263	-0.227	1	0
	(0.142)	(0.118)	(0.035)		
thr_t	-0.037	0.005	0.0431	-0.094	1
	(0.074)	(0.012)	(0.078)	(0.052)	

Test for Over-identification Restrictions X2(2) 1.938 (0.550)

Standard errors from the MLE estimates are reported in parentheses.

Appendix B: Forecast error variance decompositions for sectors

S1: Agriculture

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	0.3775	22.0262	0.1933	1.5520	75.8511	100
2	0.3437	19.8619	0.1803	2.4558	77.1583	100
3	0.3421	18.5560	0.4486	2.2810	78.3723	100
4	0.3493	19.3157	0.9536	2.2105	77.1709	100
5	0.3732	18.9581	1.1537	2.9079	76.6071	100
6	0.3677	19.2739	1.1497	3.1545	76.0543	100
7	0.3840	19.3008	1.1477	3.2030	75.9645	100
8	0.4596	19.2801	1.2673	3.2954	75.6977	100
9	0.5656	19.2085	1.4859	3.4542	75.2858	100
10	0.6519	19.1340	1.6503	3.5842	74.9797	100
11	0.6914	19.0744	1.8527	3.6350	74.7466	100
12	0.7023	19.0213	2.0829	3.6609	74.5327	100
13	0.7047	18.9754	2.2701	3.6965	74.3532	100
14	0.7057	18.9429	2.4018	3.7204	74.2293	100
15	0.7064	18.9161	2.5134	3.7305	74.1336	100
16	0.7073	18.8922	2.6187	3.7356	74.0462	100
17	0.7082	18.8734	2.7037	3.7400	73.9747	100
18	0.7093	18.8594	2.7699	3.7422	73.9194	100
19	0.7101	18.8478	2.8273	3.7417	73.8731	100
20	0.7104	18.8382	2.8769	3.7406	73.8340	100
21	0.7105	18.8311	2.9145	3.7395	73.8044	100
22	0.7104	18.8261	2.9418	3.7386	73.7831	100
23	0.7104	18.8222	2.9628	3.7378	73.7668	100
24	0.7103	18.8193	2.9788	3.7372	73.7544	100

S2: Mining and Quarrying

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	0.2217	1.6963	0.1009	0.0122	97.9688	100
2	0.1919	1.3489	4.0030	0.0122	94.4441	100
3	1.0142	1.0607	3.9059	0.2909	93.7283	100
4	2.9073	1.0366	5.1532	0.5703	90.3327	100
5	7.4505	1.0600	6.2013	0.5814	84.7068	100
6	10.4715	0.9900	7.7254	1.0793	79.7337	100
7	12.5741	1.0196	8.3212	1.5001	76.5849	100
8	13.6524	0.9972	8.5826	1.8618	74.9059	100
9	14.1142	1.0154	8.8060	1.9850	74.0793	100
10	14.1872	1.0085	8.9329	2.0387	73.8328	100
11	14.1005	1.0021	8.9775	2.0749	73.8450	100
12	14.0374	0.9973	8.9719	2.0795	73.9139	100
13	14.0378	0.9951	8.9853	2.0742	73.9076	100
14	14.0789	0.9955	8.9994	2.0784	73.8479	100
15	14.1309	0.9994	9.0072	2.0862	73.7763	100
16	14.1688	1.0043	9.0100	2.0948	73.7221	100
17	14.1786	1.0081	9.0161	2.1050	73.6922	100
18	14.1722	1.0105	9.0240	2.1139	73.6794	100
19	14.1626	1.0122	9.0301	2.1186	73.6765	100
20	14.1568	1.0131	9.0350	2.1204	73.6747	100
21	14.1567	1.0133	9.0402	2.1212	73.6686	100
22	14.1610	1.0132	9.0446	2.1216	73.6596	100
23	14.1662	1.0131	9.0470	2.1217	73.6520	100
24	14.1702	1.0131	9.0479	2.1217	73.6471	100

S3: Manufacturing

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	0.0807	18.5869	0.0038	0.2007	81.1279	100
2	1.2046	20.6325	0.0108	1.3636	76.7885	100
3	2.2792	20.3215	0.0218	4.4466	72.9309	100
4	5.2354	18.8561	0.0906	4.9370	70.8809	100
5	6.8136	17.3180	0.5241	5.8424	69.5018	100
6	7.2380	16.0546	0.8362	6.9116	68.9597	100
7	7.4071	15.3676	1.2019	7.9624	68.0610	100
8	7.4666	14.9510	1.5122	8.3044	67.7658	100
9	7.3834	14.7113	1.8090	8.4085	67.6878	100
10	7.2676	14.5917	2.0452	8.5135	67.5821	100
11	7.1721	14.5653	2.2046	8.6066	67.4515	100
12	7.1110	14.5591	2.3391	8.6152	67.3756	100
13	7.0630	14.5787	2.4500	8.5932	67.3152	100
14	7.0245	14.6145	2.5271	8.5768	67.2572	100
15	6.9983	14.6633	2.5728	8.5652	67.2004	100
16	6.9814	14.7057	2.6052	8.5502	67.1575	100
17	6.9701	14.7404	2.6276	8.5368	67.1250	100
18	6.9628	14.7707	2.6395	8.5278	67.0991	100
19	6.9587	14.7955	2.6440	8.5225	67.0793	100
20	6.9563	14.8132	2.6456	8.5204	67.0644	100
21	6.9549	14.8251	2.6459	8.5212	67.0528	100
22	6.9542	14.8334	2.6456	8.5232	67.0437	100
23	6.9538	14.8386	2.6455	8.5255	67.0366	100
24	6.9535	14.8413	2.6460	8.5286	67.0307	100

S4: Electricity, Gas and Water Supply

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	3.5356	0.9590	0.8159	3.0858	91.6037	100
2	8.6353	1.1559	2.4583	2.3910	85.3596	100
3	10.0561	3.0446	3.3775	3.7353	79.7865	100
4	11.3938	2.8572	4.0440	3.9762	77.7290	100
5	12.3324	3.2565	4.1158	4.0233	76.2719	100
6	12.9712	4.1749	4.0845	3.9936	74.7758	100
7	12.9913	5.6740	3.9984	3.9203	73.4159	100
8	12.8171	6.6138	3.9839	3.8250	72.7602	100
9	12.6965	7.0325	3.9950	3.7940	72.4821	100
10	12.6743	7.1265	4.0079	3.7898	72.4015	100
11	12.6690	7.1314	4.0223	3.7903	72.3870	100
12	12.6655	7.1358	4.0307	3.7932	72.3748	100
13	12.6613	7.1615	4.0318	3.7939	72.3515	100
14	12.6550	7.1931	4.0305	3.7922	72.3292	100
15	12.6490	7.2161	4.0288	3.7932	72.3130	100
16	12.6449	7.2295	4.0280	3.7954	72.3022	100
17	12.6425	7.2349	4.0282	3.7976	72.2968	100
18	12.6411	7.2356	4.0293	3.8007	72.2932	100
19	12.6403	7.2352	4.0310	3.8037	72.2897	100
20	12.6397	7.2350	4.0337	3.8053	72.2863	100
21	12.6392	7.2351	4.0366	3.8059	72.2832	100
22	12.6386	7.2353	4.0394	3.8062	72.2804	100
23	12.6381	7.2354	4.0419	3.8064	72.2781	100
24	12.6377	7.2355	4.0442	3.8063	72.2763	100

S5: Construction

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	0.2114	9.1203	1.7935	0.1744	88.7005	100
2	0.5387	8.4139	1.6660	0.1827	89.1986	100
3	1.9917	7.8685	1.6353	0.2965	88.2080	100
4	2.9409	7.5876	2.8071	1.5518	85.1125	100
5	3.1110	7.4734	3.1464	2.2218	84.0473	100
6	3.2905	7.3931	3.7827	2.8635	82.6703	100
7	3.4419	7.4119	3.9894	3.1848	81.9719	100
8	3.4166	7.6648	4.2827	3.2436	81.3923	100
9	3.4103	7.6766	4.2758	3.4081	81.2293	100
10	3.4034	7.6827	4.2676	3.5800	81.0664	100
11	3.4086	7.6765	4.2637	3.6459	81.0053	100
12	3.4076	7.6816	4.2640	3.6844	80.9623	100
13	3.4047	7.6763	4.2727	3.7539	80.8924	100
14	3.4020	7.6702	4.2833	3.8351	80.8094	100
15	3.4004	7.6671	4.2977	3.8839	80.7509	100
16	3.3983	7.6649	4.3258	3.9145	80.6966	100
17	3.3958	7.6605	4.3598	3.9465	80.6374	100
18	3.3935	7.6557	4.3942	3.9744	80.5822	100
19	3.3918	7.6517	4.4289	3.9919	80.5358	100
20	3.3901	7.6479	4.4664	4.0028	80.4928	100
21	3.3885	7.6442	4.5018	4.0128	80.4527	100
22	3.3872	7.6409	4.5327	4.0210	80.4182	100
23	3.3860	7.6381	4.5610	4.0261	80.3888	100
24	3.3850	7.6357	4.5875	4.0290	80.3628	100

S6: Trade and Hotels and Restaurants

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	0.7736	13.7991	0.0068	0.4396	84.9808	100
2	0.7259	18.8314	0.3345	0.8033	79.3050	100
3	0.7929	24.3815	0.6077	2.3633	71.8545	100
4	2.8592	26.4194	0.5644	2.2405	67.9166	100
5	3.3461	27.5244	1.1653	2.6910	65.2732	100
6	3.6953	27.7199	1.6834	3.4156	63.4860	100
7	4.1691	27.0607	2.5464	4.1270	62.0967	100
8	4.3301	26.6941	3.0527	4.2716	61.6515	100
9	4.3398	26.3888	3.7132	4.4119	61.1464	100
10	4.3063	26.1291	4.3035	4.5611	60.6999	100
11	4.2802	25.9554	4.7676	4.6632	60.3337	100
12	4.2628	25.8337	5.1312	4.6825	60.0898	100
13	4.2462	25.7344	5.4513	4.6922	59.8758	100
14	4.2326	25.6512	5.7162	4.7088	59.6912	100
15	4.2227	25.5897	5.9132	4.7179	59.5565	100
16	4.2152	25.5421	6.0747	4.7162	59.4518	100
17	4.2087	25.5029	6.2102	4.7136	59.3646	100
18	4.2035	25.4701	6.3194	4.7130	59.2940	100
19	4.1999	25.4450	6.4012	4.7117	59.2422	100
20	4.1972	25.4250	6.4675	4.7090	59.2014	100
21	4.1948	25.4090	6.5211	4.7066	59.1685	100
22	4.1930	25.3967	6.5621	4.7049	59.1433	100
23	4.1918	25.3876	6.5922	4.7034	59.1250	100
24	4.1909	25.3807	6.6155	4.7021	59.1108	100

S7: Transport, Storage and Communication

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	0.3451	12.8089	0.0003	0.0117	86.8340	100
2	0.9290	11.8926	0.2429	0.0885	86.8470	100
3	3.2335	11.5288	0.5162	0.2371	84.4844	100
4	3.3566	11.5466	0.5615	0.2653	84.2700	100
5	3.1328	11.5318	0.5398	0.2675	84.5281	100
6	3.1005	11.4272	0.7398	0.3003	84.4323	100
7	3.4832	11.3412	0.7465	0.3654	84.0637	100
8	3.5668	11.3213	0.7494	0.4718	83.8907	100
9	3.5651	11.3026	0.7625	0.5219	83.8480	100
10	3.5527	11.2672	0.9387	0.5736	83.6679	100
11	3.5955	11.2359	1.0482	0.6622	83.4582	100
12	3.6133	11.2160	1.1091	0.7518	83.3097	100
13	3.6134	11.2010	1.1818	0.8008	83.2031	100
14	3.6066	11.1792	1.3303	0.8373	83.0465	100
15	3.6047	11.1594	1.4591	0.8844	82.8924	100
16	3.6033	11.1438	1.5474	0.9283	82.7773	100
17	3.5999	11.1311	1.6314	0.9541	82.6834	100
18	3.5955	11.1175	1.7356	0.9707	82.5808	100
19	3.5916	11.1054	1.8280	0.9873	82.4878	100
20	3.5887	11.0957	1.8967	1.0018	82.4170	100
21	3.5861	11.0879	1.9560	1.0104	82.3597	100
22	3.5838	11.0806	2.0147	1.0151	82.3059	100
23	3.5818	11.0745	2.0647	1.0188	82.2601	100
24	3.5803	11.0698	2.1026	1.0218	82.2255	100

S8: Finance and Insurance

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	0.0004	30.5794	0.5100	0.0044	68.9058	100
2	0.0067	30.2488	0.6215	0.4625	68.6605	100
3	2.0347	29.4792	1.2885	2.7649	64.4326	100
4	2.4625	27.8194	1.6536	2.6131	65.4514	100
5	2.8320	26.0145	3.3499	3.7657	64.0380	100
6	2.8878	25.5059	3.4614	4.9414	63.2035	100
7	3.0978	25.2330	3.7629	5.2043	62.7020	100
8	3.0743	25.3658	3.7525	5.1817	62.6257	100
9	3.0648	25.3105	3.9038	5.2229	62.4980	100
10	3.0832	25.2544	3.9721	5.2206	62.4697	100
11	3.0898	25.2459	3.9967	5.2177	62.4500	100
12	3.0892	25.2162	4.0829	5.2202	62.3914	100
13	3.0851	25.1724	4.1852	5.2564	62.3009	100
14	3.0857	25.1309	4.2848	5.2958	62.2029	100
15	3.0869	25.1103	4.3468	5.3040	62.1520	100
16	3.0849	25.0938	4.4014	5.3056	62.1143	100
17	3.0830	25.0782	4.4488	5.3067	62.0832	100
18	3.0821	25.0674	4.4805	5.3064	62.0638	100
19	3.0816	25.0597	4.5064	5.3050	62.0473	100
20	3.0809	25.0532	4.5304	5.3040	62.0316	100
21	3.0802	25.0472	4.5523	5.3038	62.0164	100
22	3.0798	25.0427	4.5690	5.3038	62.0047	100
23	3.0795	25.0392	4.5817	5.3033	61.9963	100
24	3.0792	25.0364	4.5918	5.3027	61.9899	100

S9: Other Services

Horizon	%age Variation in Sectoral Output on Account of					
	ER_t	GDP_t	CPI_t	CMR_t	S_t	Total
1	0.0051	13.5676	0.2658	0.2698	85.8917	100
2	0.0467	13.1868	1.0521	0.2490	85.4654	100
3	0.9633	14.5789	1.0405	0.2305	83.1868	100
4	1.1806	15.3324	1.0631	0.2455	82.1784	100
5	1.3269	15.5454	1.7937	0.2749	81.0591	100
6	1.3191	15.5902	2.0633	0.2725	80.7549	100
7	1.3034	16.8937	2.6118	0.3893	78.8018	100
8	1.3211	17.3111	3.0325	0.4106	77.9246	100
9	1.4507	17.3574	3.0517	0.4466	77.6936	100
10	1.5426	17.3336	3.0710	0.5309	77.5219	100
11	1.6007	17.3155	3.0707	0.5734	77.4397	100
12	1.6079	17.3149	3.0721	0.5908	77.4143	100
13	1.6096	17.3120	3.0717	0.6175	77.3893	100
14	1.6108	17.3100	3.0710	0.6411	77.3670	100
15	1.6126	17.3051	3.0720	0.6554	77.3549	100
16	1.6129	17.3013	3.0762	0.6655	77.3441	100
17	1.6126	17.2975	3.0825	0.6766	77.3308	100
18	1.6124	17.2944	3.0890	0.6857	77.3185	100
19	1.6122	17.2928	3.0945	0.6904	77.3101	100
20	1.6120	17.2915	3.1009	0.6934	77.3022	100
21	1.6118	17.2901	3.1076	0.6964	77.2941	100
22	1.6117	17.2886	3.1138	0.6992	77.2868	100
23	1.6116	17.2873	3.1198	0.7009	77.2804	100
24	1.6115	17.2861	3.1256	0.7022	77.2747	100

CHAPTER 3

ASYMMETRIC MONETARY POLICY REACTION FUNCTION: EVIDENCE FOR PAKISTAN

3.1. Introduction

The preceding Essay outlined how State Bank of Pakistan responds to an unanticipated increase in aggregate output and the inflation. The SVAR methodology used there implicitly assumes linearity of relationship among the variables and constancy of interest rate responses over time. Therefore, by implication, the response of SBP to an unanticipated decrease in output and inflation would be the same, only with the opposite sign. In other words, it presupposes that the reaction function of the SBP is neutral to the state of the economy as represented by the direction of change in macroeconomic variables; that is, SBP treats a 1 percent decline in GDP growth from the long-run trend and a 1 percent expansion in GDP growth from the long-run trend equally. Similarly, the SVAR methodology also implies that SBP treats a 1 percent appreciation and a 1 percent depreciation of rupee relative to baseline exchange rate in the same way, and so on. Obviously, this is a very strong assumption and needs to be checked empirically. Additionally, time-invariant reaction function implies that the parameters of the system remain constant over time.

This linearity or 'symmetric preferences' assumption has been challenged by many economists, leading to development of non-linear reaction functions of the central banks. Subsequently, many monetary researchers tested for asymmetric preferences and found evidence in support of nonlinearities in the reaction functions of many central banks.

Besides, a few studies have found evidence in support of change in the coefficients of central banks' reaction functions over time.

There has been only a little empirical work on the reaction function of Pakistan. Malik (2007) estimated linear policy reaction function using SVAR methodology and found that SBP responds to output gap, inflation, exchange rate, central bank lending to the government, trade deficit, foreign exchange reserves and foreign interest rates. Using a dummy variable to test for the significance of inflation threshold, Ahmed & Malik (2011) found that the response of State Bank was more aggressive for inflation rates above 6.4% than for inflation rates below it, thereby suggesting nonlinearity in the reaction function. They used regime switching framework which assumes that the threshold is sharp and therefore the transition from one regime to the other is abrupt. However, most macroeconomic processes are believed to undergo smooth transition between regimes. The present paper contributes to this literature by examining the possibility of nonlinear preferences of the policy-makers over inflation, output gap and lagged interest rate for the case of Pakistan while also checking for the change in coefficients of the reaction function since early 1970s. Contrary to the regime switching framework adopted by Ahmed & Malik (2011) that presupposes abrupt change from one regime to the other, this paper assumes that the transition from one state of the economy to the other is smooth, and therefore, our estimation framework comprises of the smooth transition regression (STR) model, which, as the name suggests, allows for smooth transition between regimes.

The structure of this essay is the following. In next two sections, we offer a review of the relevant literature and discuss the estimation framework consisting of the smooth transition regression model. We then discuss data and the theoretical specification of interest rate reaction function. Our findings from model estimation are explained in the followimg section. Finally, we conclude the paper with main findings and limitations.

3.2. Review of Literature

Discussion on interest rate reaction function of the monetary authority has largely been based on the standard linear-quadratic framework; consisting of a quadratic loss function describing the behavior of the monetary authority, and a linear dynamic system describing the economy [Taylor (1993), Svensson (1997), Clarida & Gertler (1997), Clark, Goodhart & Huang (1999) and Clarida, Gali & Gertler (1998); Clarida, Galí & Gertler (2000)]. The monetary authority seeks to minimize this loss function defined over macroeconomic variables representing its policy objectives. Initially, inflation and output were the only two policy objectives considered in the quadratic loss function. Later studies however extended the loss function of the monetary authority to include other variables like the exchange rate and the lagged interest rate. By incorporating lags of interest rate, the model accounts for interest rate smoothing, a phenomenon that has been observed for many central banks.

The quadratic loss function used for standard monetary policy analysis has a major drawback: it assumes that the central bank has symmetric preferences over the macroeconomic variables included in its loss function. Symmetric preferences, for example, over output imply that the central bank is equally averse to negative and positive output gaps of the same size. However, the symmetry assumption has been challenged by a growing body of empirical work that demonstrates the possibility of nonlinear preferences of the central bank in regard to inflation, output and other variables of the loss function. Cukierman (1999), for instance, suggests that the central bank is "more sensitive to policy errors that lead to below normal economic activity than to policy errors that lead to the opposite". This asymmetric employment objective is believed to come from political pressures. Thus Blinder (1999, pp19-20) indicated:

> *"In most situations the central bank will take far more political heat when it tightens pre-emptively to avoid higher inflation than when it eases pre-emptively to avoid higher unemployment".*

Another source of asymmetric preferences is rooted in the psychology of decision-making under uncertainty. It has been pointed out that most individuals will likely derive less utility from the gains of a given size compared to the disutility from the losses of the same size, resulting in nonlinear behavior in choices under uncertainty. Thus, for example, in times of high inflation a central bank will likely react more aggressively to rates of inflation above the desired level than to rates of inflation below it. While most researchers have focused on nonlinearities in the reaction function with respect to output and inflation, asymmetry of preferences could also be associated with other macroeconomic variables like the exchange rate and the lagged interest rate.

Parameters of the model are presumed time-invariant in all the studies discussed above. However, there is wide recognition among monetary economists that the behavior of a central bank, as explained by the interest rate reaction function, might change over time. Judd & Rudebusch (1998) explicitly tested the variability of coefficients of the Fed's reaction function over time, linking change in parameters with the change of the Chairman of the Federal Reserve. Clarida, Gali & Gertler (1998) assumed a shift in UK monetary policy parameters in early 1990s but treated these as essentially constant for Germany and the US from 1979. Nelson (2001) considered structural breaks for the UK given that the UK monetary policy framework had gone through many changes since 1970, and with formal adoption of inflation targeting in 1992. He estimated Taylor rule for the UK data and found evidence of considerable change in parameters over the sample period.

Empirical work on asymmetric responses of the central banks has been growing rapidly recently. Clarida & Gertler (1997) found that Germany's central bank seems to react nonlinearly to the inflation gap, while Gerlach (2000) demonstrated that the Federal Reserve acted nonlinearly with respect to output before 1980. For central banks of the US, Germany, Spain and France, Dolado, María-Dolores & Naveira (2000) tested for possible nonlinearities in their responses to inflation and output gaps through the estimation of a generalized Taylor rule and an ordered probit model. They found evidence in support of nonlinear behavior of these central banks related to inflation but could not found asymmetries related to output, except for the US. Another contribution in this context came from Bec, Ben Salem & Collard (2002) who concluded that while Federal Reserve's response to output gap is symmetric, the German central bank reacts asymmetrically to changes in both inflation and output gap. Ruge-Murcia (2004) introduced asymmetry with respect to unemployment and empirically tested the monetary policy response of some selected countries namely, Canada, France, Italy, UK and the US. The results showed that deviation of unemployment rate above the target level are treated more severely in the central banks' reaction functions than the deviation of unemployment rate below the target level. Cukierman & Muscatelli (2002) documented evidence in favour of nonlinearities in the reaction functions of all the selected central banks except Germany. Furthermore, combining nonlinear Phillips curve with asymmetric objective function to formulate central bank preferences, Dolado, Pedrero & Ruge-Murcia (2004) reported that Federal Reserve has asymmetric response towards inflation deviations from the target rate. Nobay & Peel (2003) also challenges the notion of a quadratic loss function. There is large body of empirical studies that records evidence in support of asymmetry in central banks' reaction functions with respect to output and/or inflation include Osborn, Kim & Sensier (2005), Martin & Milas (2004), Bruinshoofd & Candelon (2005), Surico (2004), Hayat & Mishra (2010), Klose (2011), and Vítor (2011).

Florio (2006), on the other hand, extended the work on asymmetric reaction function by also including lagged interest rate variable. This allowed Florio (2006) to test whether the Fed adjusts short term interest rate towards the desired interest rate at the same pace during a monetary policy easing and a monetary tightening. Results from her paper show evidence of nonlinearities in the reaction function of Federal Reserve not only with respect to inflation and output but also to lagged interest rate. Similarly, Kesriyeli & Osborn (2006) went a step further and tested for both structural breaks and nonlinearities in the reaction function for the US, UK and Germany. They found evidence that structural breaks and nonlinearities are important features of the reaction functions for these countries. In the case of Pakistan, the only study undertaken so far is Ahmed & Malik (2011), which tested for the significance of inflation threshold using a switching regime model. Their results show that the response of State Bank was more aggressive for inflation rates above 6.4% than for inflation rates below it, thereby suggesting nonlinearity in the interest rate reaction function of the State Bank.

3.3. Estimation Framework

Nonlinear models have become increasingly popular in both macroeconomic and financial modeling. While linear approximations to nonlinear economic phenomena have generally been useful, in many cases nonlinear specifications have proved to add significant insights to the economic analysis. Nonlinear models can be broadly classified into two categories: the first one comprises of economic models that do not nest a linear model as a special case like the disequilibrium models; the second category includes models that do nest a linear model. The switching regression model, Markov-switching models, and the smooth transition regression models are examples of models that belong to this later class. In these models, the starting building block is a linear model, which is then extended to consider nonlinear dimensions in the model should they appear significant. In this paper, we will employ the smooth transition regression framework to test and estimate asymmetries in the reaction function of the State Bank of Pakistan.

The smooth transition regression (STR) framework can be considered as an extension of the regime switching model introduced by Quandt (1958). In a regime switching model, the dynamics of the system are allowed to change with a change in the state of the system.

For instance, the behavior of unemployment rate is believed to be associated with the state of the economy. Thus, while in recessions, unemployment rate is found to initially increase sharply and then slowly return to its long-run trend, it does not decrease equally sharply in booms. Therefore, the dynamic adjustment of the unemployment rate is believed to change with the change in the state of the economy from, say, boom to recession or vice versa.

To better understand the working of regime switching model, we consider its univariate version known as the threshold autoregressive (TAR) model. A simple TAR process is given by the following:

$$x_t = \begin{cases} a_1 x_{t-1} + \varepsilon_{1t} & \text{if } x_{t-1} > 0 \\ a_2 x_{t-1} + \varepsilon_{2t} & \text{if } x_{t-1} \leq 0 \end{cases} \qquad (1)$$

where $x_{t-1} = 0$ represents the threshold. As depicted by equation (1), the $\{x_t\}$ sequence follows two different autoregressive processes on each side of the threshold. While linear on each side of the threshold, the possibility of regime switching implies that the full $\{x_t\}$ sequence is nonlinear. Shocks to $\{\varepsilon_{1t}\}$ or $\{\varepsilon_{2t}\}$ are responsible for regime switching. If, for example, $x_{t-1}>0$, that means subsequent values of the series tend to decay towards zero at the rate a_1. However, a negative realization of ε_{1t} can cause x_t to fall by such an extent that it lies below the threshold. In the other regime where $x_{t-1} \leq 0$, the behavior of the process is governed by $x_t = a_2 x_{t-1} + \varepsilon_{2t}$. A more general TAR model allows for non-zero threshold, and the possibility of more than two different regimes, with each regime following separate higher order autoregressive processes. The following gives a two-regime general TAR model:

$$x_t = \begin{cases} \alpha_{10} + \alpha_{11} x_{t-1} + ...+ \alpha_{1p} x_{t-p} + \varepsilon_{1t} & if\ x_{t-1} > \tau \\ \alpha_{20} + \alpha_{21} x_{t-1} + ...+ \alpha_{2r} x_{t-r} + \varepsilon_{2t} & if\ x_{t-1} \le \tau \end{cases} \quad (2)$$

where τ is the value of threshold and can differ from zero.

The threshold autoregressive models (TAR) of equations (1) and (2) imply that the threshold is sharp, ie, the change from one state to another is abrupt. However, for many processes it seems reasonable to assume that the adjustment from one state to another state is smooth, giving rise to smooth transition models. Most economic processes are likely to exhibit characteristics of smooth transition. Therefore smooth transition model is being adopted in this paper for estimating asymmetries in the reaction function of the State Bank of Pakistan.

3.3.1. Smooth Transition Regression

The smooth transition regression (STR) model originated as a generalization of a particular switching regression model in the work of Bacon & Watts (1971). These authors considered two regression lines and devised a model in which the shift from one line to the other was smooth. In the context of time series literature, Chan & Tong (1986) suggested univariate smooth transition autoregressive (STAR) model. The earliest references in the econometrics literature are S.M. Goldfeld and R.E. Quandt (1972) and Maddala (1977). Recent accounts include Granger & Teräsvirta (1993), Terasvirta (1994); Teräsvirta (1996), Franses & Dijk (2000) van Dijk, Terasvirta & Franses (2002).

The standard STR model is specified as below:

$$x_t = \eta' y_t + \pi' y_t F(\gamma, c, s_t) + u_t$$

$$= \{\eta + \pi F(\gamma, d, \lambda_t)\}' y_t + u_t, \qquad t = 1, 2, \ldots\ldots, T, \qquad (3)$$

where $y_t = (h_t^{'}, z_t^{'})^{'}$ defines a vector of explanatory variables, $h_t^{'} = (1, x_{t-1}, \ldots\ldots, x_{t-p})^{'}$, and $z_t^{'} = (z_{1t}, z_{2t}, \ldots\ldots, z_{wt})^{'}$ represents a vector of exogenous variables. Furthermore, $\eta = (\eta_0, \eta_1, \ldots., \eta_j)^{'}$ and $\pi = (\pi_0, \pi_1, \ldots.., \pi_j)^{'}$ are [(j+1) x 1] parameter vectors and $u_t \sim iid(0, \sigma^2)$. $F(\gamma, d, \lambda_t)$ is defined as a bounded function over the continuous transition variable λ_t, γ corresponds to the slope coefficient, and $d = (d_1, \ldots.., d_W)^{'}$ represents the vector of location parameters such that $d_1 \leq \ldots\ldots \leq d_{W.}$ Equation (3) indicates that the system can be viewed as a linear model with stochastic time-varying parameters $\eta + \pi F(\gamma, d, \lambda_t)$. It is being assumed that the transition function is a general logistic function

$$F(\gamma, d, \lambda_t) = (1 + \exp\{-\gamma \prod_{w=1}^{W} (\lambda_t - d_w)\})^{-1}, \gamma > 0 \qquad (4)$$

where γ > 0 characterizes an identifying restriction. Equations (3) and (4) jointly define the logistic STR (LSTR) model. The two most frequently discussed options for W are W=1 and W=2. When W is taken 1, the coefficients $\eta + \pi F(\gamma, d, \lambda_t)$ change monotonically as a function of λ_t from η to $\eta + \pi$. When W=2, these coefficients change symmetrically around the midpoint $(d_1 + d_2)/2,$ which is the point of minimum value of the logistic function.

The logistic smooth transition regression model with W=1 (LSTR1) is helpful in explaining nonlinear behavior around the baseline. As an example, suppose that λ_t

measures the phases of the business cycle. In this case, the LSTR1 model portrays a system which has different dynamic characteristics in expansions and in recessions, and the move from one phase of business cycle to the other is smooth. In contrast, the logistic smooth transition regression model with W=2 (LSTR2) is capable of describing a system which has identical dynamic characteristics at both large and small values of λ_t but has different characteristics in the middle. In practice, the transition variable λ_t is a stochastic variable and very often an element of x_t. It can also be a linear combination of several variables. In some cases, it can be a difference of an element of x_t. A special case, $\lambda_t = t$, yields a linear model with deterministically changing parameters.

3.4. Methodology and Choice of Variables

The typical linear interest rate reaction function is specified as

$$r_t = \alpha' g_t + \mu_t \tag{5}$$

with r_t representing the short-term interest rate, and g_t being a (k × 1) vector of variables, typically included in monetary authority's reaction function. α defines a (k × 1) vector of coefficients, whereas μ_t corresponds to a zero mean and serially uncorrelated vector of disturbances. Taylor (1993) and subsequent literature on the reaction function hypothesizes that the central bank changes the nominal short-term interest rate in response to inflation and output gaps. Later, researchers also included the lagged interest rate in equation (5) to illustrate features of interest rate smoothing, supposedly one of the objectives pursued by the monetary authority [Clarida, Galí & Gertler (2000)].

Given that the present study is not primarily concerned with the source of asymmetry in the interest rate reaction function and also to circumvent simultaneity issues, we work with the reduced form system and therefore only the lagged values of output gap and inflation are included in equation (5). Our primary interest is in the specification and estimation of nonlinear interest rate reaction function using the STR methodology summarized by equations (3) and (4). We also make an attempt to analyze variability in the parameters of SBP's reaction function by testing time as one of the transition variables in equation (4). Lundbergh, Teräsvirta & Dijk (2003) discusses in detail this methodology to capture asymmetry and structural change using STR models.

3.4.1 Modeling Steps

We start with the reduced-form specification of linear reaction function. In line with standard monetary policy objectives examined in the literature, we confine our set of policy objectives to price stability, employment and financial stability (reflected by inclusion of interest rates lags as explanatory variables). Starting with four lags of each variable, individual lags are successively excluded from the model with the lowest t-value with the objective to formulate a linear specification which has the minimum value for the Akaike Information Criterion (AIC). The selected model gives out g_t, the (kx1) vector of explanatory variables from equation (5). This specification is then tested for nonlinearity considering a set of possible transition variables. We test for the presence of structural change by allowing time as a potential transition variable. For test results that lend statistically significant support for either hypotheses of asymmetry or structural change, we estimate appropriate LSTR model, depending on the identification results of the tests.

LSTR model estimation comprises of finding appropriate initial values for the parameters of the system and then estimating the model using non-linear least squares.

3.4.2 Data and sources

We use quarterly data with sample spanning from 1973:2 to 2012:2. Except for aggregate output, all data has been obtained from International Financial Statistics, published by the IMF. Estimates of quarterly real GDP come from Arby (2008), which constructs it for Pakistan for the period 1970: 3 to 2005:2. We extend these quarterly estimates up to 2012:2 using 8-quarter moving average of the quarterly shares in aggregate output. This approach is likely to produce reasonable estimates of the actual output given the fact that a quarter's share in total output of any given year has exhibited negligible variance over the period covered by Arby (2008). The use of Hodrick-Prescott filter is standard for calculating output gap (ie deviation from potential output) and we use the same method to construct output gap series for Pakistan. The consumer price index is used to calculate y-o-y percentage changes in general price level for each quarter whereas the call money rate reflects the short term interest rate used to reflect monetary policy stance.

3.5. Estimation Results

3.5.1. Linear Reaction Function

The selected reduced form dynamic linear interest rate equation has the form:

$$cmr_t = \alpha_0 + \alpha_1 cmr_{t-1} + \alpha_2 cmr_{t-4} + \alpha_3 \inf_{t-1} + \alpha_4 y_{t-4} + \varepsilon_t \tag{6}$$

where *cmr* is the call money rate, *inf* the inflation rate and *y* the output gap. The linear reaction function in equation (6) is estimated using the OLS technique and results reported in Table A-1 at the appendix. A quick look at the results shows interest rate is stationary, as the sum of the coefficients for lags of interest rates is significantly less than unity. The estimated linear model illustrates both inflation and output gap have important and positive impact on setting of interest rates. The model also confirms that interest rate smoothing is one of the objectives pursued by the State Bank of Pakistan as interest rate lags included in the model are found to be significant. The errors do not seem autocorrelated when the null hypothesis of no autocorrelation is checked with the usual LM test (see Table 3.1). Also, there is no sign of autoregressive conditional heteroscedasticity (ARCH) either.

Table 3.1: Diagnostic Tests

p-values of LM test of no autocorrelation				
Lags	2	4	6	8
	0.94	0.92	0.96	0.92
p-values of LM test of no ARCH				
Lags	2	4	6	8
	0.11	0.27	0.23	0.22
p-values of tests of linearity against STR				
	Cmr_{t-1}	Cmr_{t-4}	Inf_{t-1}	Y_{t-2}
	0.1687	0.15793	0.02314	0.10203
p-values of tests of parameter constancy[23]				
	time			
	0.02382			

Next, we test for the null of linearity against the alternative of STR model with the residual based test discussed in Teräsvirta (1996). Using the fitted residuals from equation (6), we estimate the following auxiliary equation:

$$\hat{\varepsilon}_t = \upsilon_0' g_t + \upsilon_1' g_t \lambda_t + \upsilon_2' g_t (\lambda_t)^2 + \upsilon_3' g_t (\lambda_t)^3$$

[23] This tests the null of no change in parameters against smooth continuous change in parameters and is checked through F-statistics for a nonlinear auxiliary regression.

where, as explained before, g_t represents the vector of explanatory variables in the linear model and λ_t reflects a transition variable.[24] The null hypothesis of linearity is H$_{0:}$ $\upsilon_1 = \upsilon_2 = \upsilon_3 = 0$. Results from the nonlinearity tests, presented in Table 3.1, show strong support for nonlinearity in the model. Furthermore, these results suggest inflation and time are the only two potential transition variables. Based on results of these diagnostic tests, we restrict our analysis in the following section to test nonlinearity in the reaction function with respect to each of these two transition variables.

3.5.2. Nonlinear Models

For each candidate of transition variable, we first estimate a full LSTR model using least squares and a two-dimensional grid search for γ and *d* as suggested in Teräsvirta (1996) to obtain reasonable starting values and then re-estimate the system using non-linear least squares.

Time Transition (Structural Change)

Table 3.1 above provided evidence of parameter inconstancy over time implying nonlinearity with respect to trend. Parameter inconstancy is also confirmed by the recursive estimates of the coefficients from the linear specification, which tests stability of the parameters over the sample period. As is evident from Figure 3.1, there is considerable parameter instability over the sample period.

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[24] As explained earlier, in a model where the value of a random variable depends on the state of the economy or 'the regime', a transition variable determines the regime that generates the next observation. Though Terasvirta (1994) assumes the transition variable to be a lagged endogenous variable, more recent literature allows exogenous variables as well as the time trend to act as transition variables.

The step shape of the time transition function (Figure 3.2) reveals the rather abrupt shift in the parameters of State Bank's reaction function in the year 1991, providing evidence for the presence of structural change at that point. This gives credence to the view that the monetary and financial sector reforms starting in late 80s and continuing in 1990s had a significant impact on how monetary policy is conducted.

Figure 3.1:Linear recursive estimates of coefficients

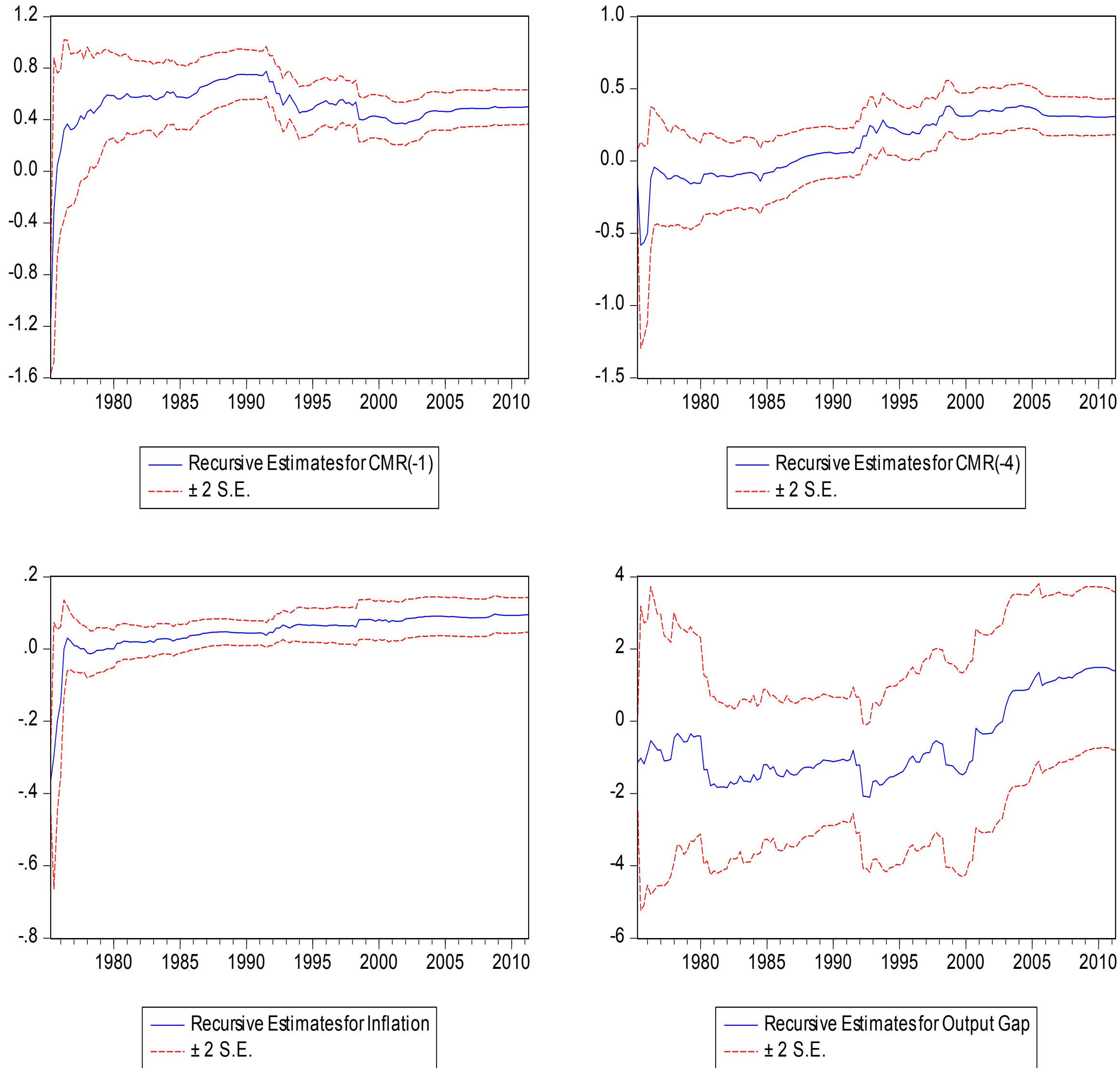
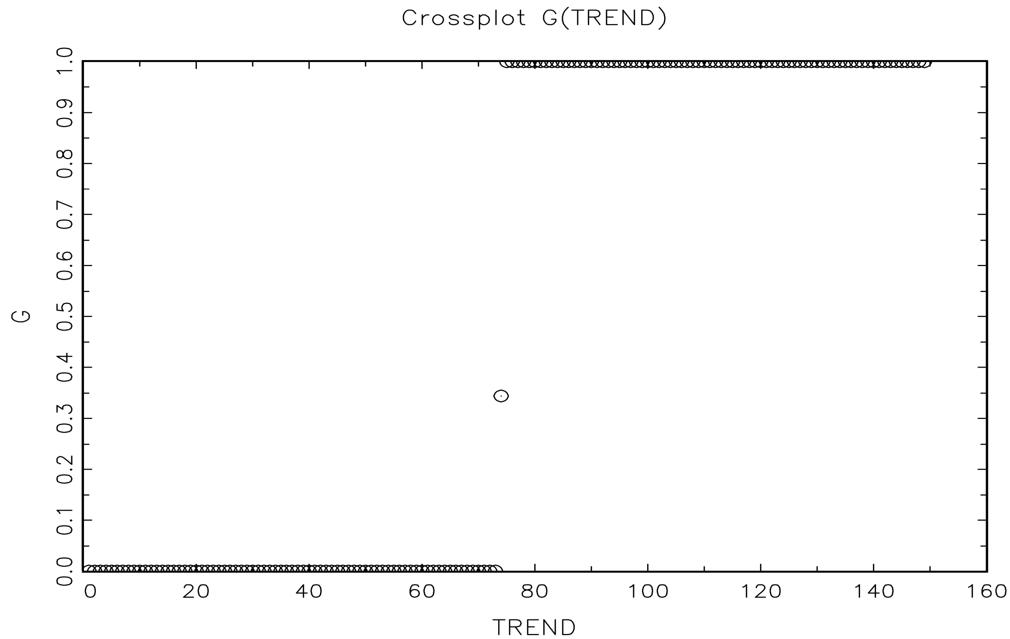


Figure 3.2: Time Transition Function

(a) Plot against time



(b) Plot against variable

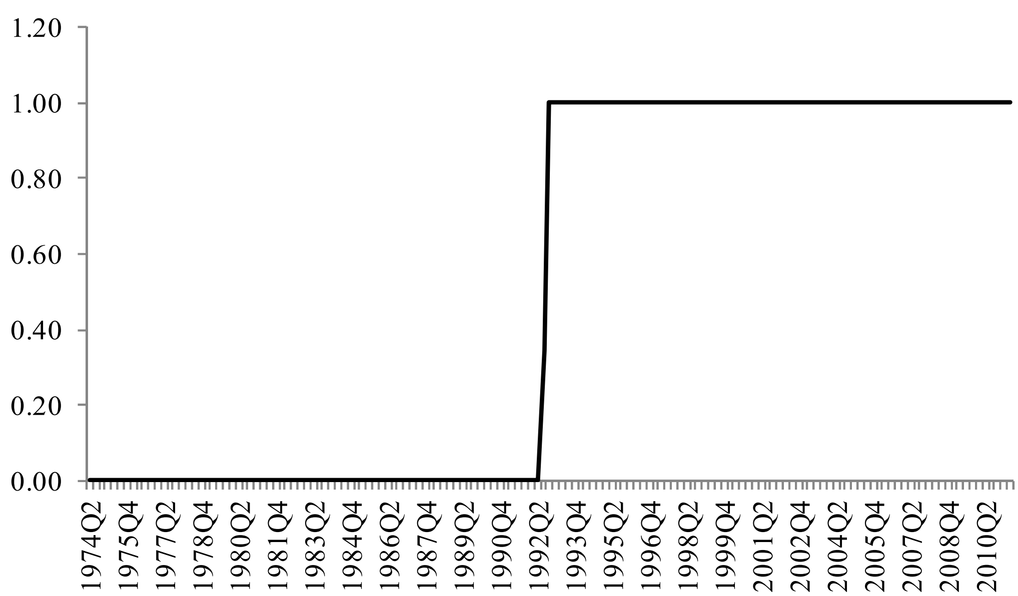


Table 3.2. Nonlinear Interest Rate Model

Transition variable: Time

Variables	start	estimate	t-stat	p-value
CONST	1.277	1.235	1.227	0.222
CMR(t-1)	0.688	0.621	3.941	0.000
CMR(t-4)	0.111	0.171	1.189	0.237
Inf(t-1)	0.041	0.049	1.495	0.137
y(t-2)	-1.523	-2.121	-1.450	0.150
F*CONST	-0.512	-0.359	-0.314	0.754
F*CMR(t-1)	-0.367	-0.279	-1.602	0.112
F*CMR(t-4)	0.273	0.187	1.190	0.236
F*Inf(t-1)	0.182	0.171	3.132	0.002
F*y(t-2)	6.477	7.413	3.574	0.001
AIC:		0.835		
SC:		1.077		
HQ:		0.933		
adjusted R2:		0.730		
variance of residuals		2.134		
SD of residuals		1.461		

Next we estimate single transition nonlinear interest rate reaction function using time as the transition variable and present the estimation results in Table 3.2. The coefficients in the lower part of the table (denoted by F*) are defined by the interaction of the explanatory variables and a bounded function over the continuous transition variable, and therefore represents the nonlinear part of the STR equation. From Table 3.2, we can see that both inflation and output gap are significant in the nonlinear part of the interest rate reaction function, implying different dynamics of inflation and output gap in the objective function of the State Bank before and after the break-point.

We also checked the quality of the estimated nonlinear model and the results from these diagnostic tests (presented in Table 3.3) give further important insights. There are no traces of errors being serially correlated, although LM test for ARCH shows some ARCH issue after the estimation.[25] The tests confirms that once the structural change in early 1990s is accounted for in the model, the null of constant parameters against smooth continuous change in parameters cannot be rejected. The test also checks whether there is remaining nonlinearity in the model and results show that additional nonlinearity with respect to interest rate could not be rejected. The presence of additional nonlinearity indicate the structural change identified here does not completely account for the nonlinearity originally exhibited by the interest rate reaction function and we need to explore other potential sources of nonlinearity of the model .

Table 3.3: Diagnostic Tests

	p-value
LM test for autocorrelation	0.400
LM test for ARCH	0.005
Parameter Constancy*	0.430
<u>No additional nonlinearity with respect to:</u>	
Cmr_{t-1}	0.007
Inf_{t-1}	0.214

* H0: No change in parameters

Inflation as Transition Variable

Next, we estimate LSTR1 model with inflation rate as the new transition variable. Table 3.4 reports estimation results while Figure 3.3 gives the corresponding transition function. These results convey several findings of major significance. First, these confirm that

[25] Blake and Kapetanios (2003) show that neglected nonlinearity can lead to spurious rejection of the null of no ARCH. In our case, while we have incorporated the structural break, there are still unaccounted for traces of nonlinearity with respect to interest rate.

inflation exhibits characteristics of smooth transition rather than a sudden threshold assumed in Ahmed & Malik (2011). Furthermore, the transition from low-inflation regime to high-inflation regime is built roughly around 10-11 percent inflation rates. Second, the coefficient of inflation in the high-inflation regime is smaller than the coefficient in the low-inflation regime, suggesting that the amount of inflation required to induce SBP for a 1 percent increase in interest rates is lower in the high-inflation regime compared to the low-inflation regime. In other words, SBP adopts a more aggressive tight monetary policy under conditions of high inflation than when inflation rate is low. Third, output gap turns insignificant thereby implying that SBP does not give any weight to changes in output gap

Table 3.4. Nonlinear Interest Rate Model

Transition variable: Inflation Rate

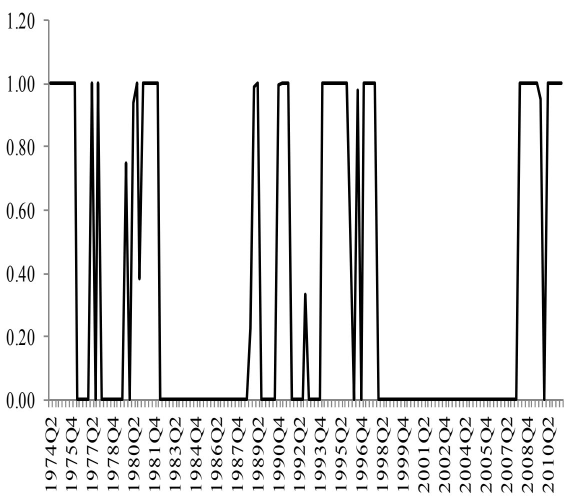
Variables	start	estimate	t-stat	p-value
CONST	-0.187	-0.551	-0.845	0.400
CMR(t-1)	0.371	0.357	4.445	0.000
CMR(t-4)	0.393	0.414	5.742	0.000
Inf(t-1)	0.306	0.364	4.974	0.000
y(t-2)	0.717	0.562	0.421	0.674
F*CONST	1.873	1.977	1.341	0.182
F*CMR(t-1)	0.351	0.340	2.363	0.020
F*CMR(t-4)	-0.305	-0.286	-2.030	0.044
F*Inf(t-1)	-0.287	-0.336	-3.965	0.000
F*y(t-2)	1.545	0.807	0.348	0.728
AIC:		0.890		
SC:		1.132		
HQ:		0.988		
adjusted R2:		0.715		
variance of residuals		2.254		
SD of residuals		1.501		

while setting interest rates. Finally, the plot of transition function against time, panel (a) of Figure 3.3, highlights two most prominent periods of low inflation, which comprise of the first half decade of1980s and the period from late 1990s to roughly 2007.

Diagnostic tests (Table 3.5) indicate the model adequately takes care of autocorrelation and the ARCH effects. However, inflation alone cannot fully capture the nonlinearity present in the interest rate reaction function.

Figure 3.3: Inflation Transition Function

(a) Plot against time



(b) Plot against variable

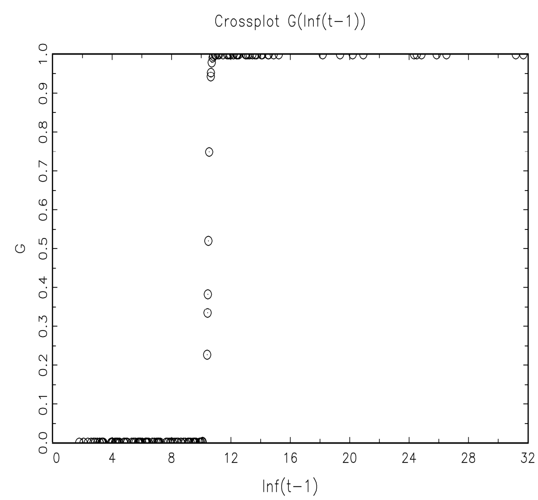


Table 3.5: Diagnostic Tests

	p-value
LM test for autocorrelation	0.9967
LM test for ARCH	0.1441
Parameter Constancy*	0.1172
<u>No additional nonlinearity with respect to:</u>	
Cmr_{t-1}	0.002

* H0: No change in parameters

3.6. Conclusion

Estimation results from smooth transition regression model show considerable evidence in support of asymmetry as well as parameter variability in the reaction function of the State Bank of Pakistan over 1973 onward. Our findings further demonstrate that the asymmetry in the reaction function of SBP is mainly related to time and the inflation rate. We however do not find support for non-linearity in SBP's reaction function with respect to output gap or the interest rate. Thus, our model does not confirm asymmetry in the response of the State Bank with respect to phases of business cycle.

With respect to parameter variability over the sample period, our model finds substantial evidence of shift in the parameters of SBP's reaction function around the year 1991. The presence of structural break in the reaction function of SBP has major implications for modeling the dynamics of monetary policy in Pakistan. Furthermore, our model finds support for asymmetry in the response of State Bank of Pakistan relating to inflationary regimes. Specifically, in response to a rise in inflation relative to target, SBP is found to raises interest rates more aggressively when economy is in a high inflation regime than under conditions of low-inflation. Moreover, our results reveal that the transition between these two regimes is smooth around inflation rates of 10-11 percent per annum.

While we were able to document evidence in support of asymmetries with respect to potential transition variable individually, it would be interesting to see how the interest rate reaction function behaves if these two transition functions are estimated jointly. A 2-variable smooth transition regression model would also allow us to check whether there are still traces of additional nonlinearity in SBP's reaction function and to examine role of other variables (such as exchange rate) believed to be included in the objective function of the central bank in asymmetries of the interest rate reaction function.

References

Ahmed, AM & Malik, WS (2011), "The Economics of Inflation, Issues in the Design of Monetary Policy Rule, and Monetary Policy Reaction Function in Pakistan," *Lahore Journal of Economics*, vol. 16, no. Special Edition, pp. 213–232.

Arby, F (2008), *Some Issues in the National Income Accounts of Pakistan (Rebasing, Quarterly and Provincial Accounts and Growth Accounting) PhD Dissertation*, Pakistan Institute of Development Economics, Islamabad.

Bacon, DW & Watts, DG (1971), "Estimating the Transition between Two Intersecting Straight Lines," *Biometrika*, vol. 58, no. 3, Biometrika Trust, pp. 525–534.

Bec, F, Ben Salem, M & Collard, F (2002), "Asymmetries in Monetary Policy Reaction Function: Evidence for U.S. French and German Central Banks," *Studies in Nonlinear Dynamics & Econometrics*, vol. 6, no. 2, Berkeley Electronic Press.

Blake, PA & Kapetanios, G (2003), "Testing for ARCH in the Presence of Nonlinearity of Unknown Form in the Conditional Mean," Working Paper no. 496, Department of Econoics, Queen Marry, University of London.

Blinder, AS (1999), *Central Banking in Theory and Practice (Lionel Robbins Lectures)*, The MIT Press.

Bruinshoofd, A & Candelon, B (2005), "Nonlinear monetary policy in Europe: fact or myth?," *Economics Letters*, vol. 86, no. 3, pp. 399–403.

Chan, KS & Tong, H (1986), "ON ESTIMATING THRESHOLDS IN AUTOREGRESSIVE MODELS," *Journal of Time Series Analysis*, vol. 7, no. 3, pp. 179–190.

Clarida, R, Gali, J & Gertler, M (1998), "Monetary policy rules in practice Some international evidence," *European Economic Review*, vol. 42, no. 6, pp. 1033–1067.

Clarida, R, Galí, J & Gertler, M (2000), "Monetary Policy Rules And Macroeconomic Stability: Evidence And Some Theory," *The Quarterly Journal of Economics*, vol. 115, no. 1, pp. 147–180.

Clarida, RH & Gertler, M (1997), "How the Bundesbank Conducts Monetary Policy," *NBER Chapters*, pp. 363–412.

Clark, PB, Goodhart, CAE & Huang, H (1999), "Optimal monetary policy rules in a rational expectations model of the Phillips curve," *Journal of Monetary Economics*, vol. 43, no. 2, pp. 497–520.

Cukierman, A (1999), “The Inflation Bias Result Revisited,” *Papers*.

Cukierman, A & Muscatelli, V (2002), “Do central banks have precautionary demands for expansions and for price stability?: theory and evidence.”

Van Dijk, D, Terasvirta, T & Franses, PH (2002), “Smooth Transition Autoregressive Models — A Survey Of Recent Developments,” *Econometric Reviews*, vol. 21, no. 1, pp. 1–47.

Dolado, J, Pedrero, RM-D & Ruge-Murcia, FJ (2004), “Nonlinear Monetary Policy Rules: Some New Evidence for the U.S,” *Studies in Nonlinear Dynamics & Econometrics*, vol. 8, no. 3.

Dolado, JJ, María-Dolores, R & Naveira, M (2000), *Asymmetries in monetary policy : evidence for four central banks*, London : Centre for Economic Policy Research.

Florio, A (2006), “Asymmetric interest rate smoothing: The Fed approach,” *Economics Letters*, vol. 93, no. 2, pp. 190–195.

Franses, PH & Dijk, D van (2000), “Non-Linear Time Series Models in Empirical Finance,” *Cambridge Books*.

Gerlach, S (2000), “Asymmetric Policy Reactions And Inflation,” *Bank for International Settlements*, vol. Mimeo.

Granger, CWJ & Teräsvirta, T (1993), *Modelling Nonlinear Economic Relationships (Advanced Texts in Econometrics)*, Oxford University Press, USA, p. 198.

Hayat, A & Mishra, S (2010), “Federal reserve monetary policy and the non-linearity of the Taylor rule,” *Economic Modelling*, vol. 27, no. 5, pp. 1292–1301.

Judd, JP & Rudebusch, GD (1998), “Taylor’s rule and the Fed, 1970-1997,” *Economic Review*, pp. 3–16.

Kesriyeli, M & Osborn, D (2006), “Nonlinearity and structural change in interest rate reaction functions for the US, UK and Germany,” *Contributions to Economic Analysis*, no. November.

Klose, J (2011), “Asymmetric Taylor reaction functions of the ECB: An approach depending on the state of the economy,” *The North American Journal of Economics and Finance*, vol. 22, no. 2, pp. 149–163.

Lundbergh, S, Teräsvirta, T & Dijk, D van (2003), “Time-Varying Smooth Transition Autoregressive Models,” *Journal of Business & Economic Statistics*, vol. 21, no. 1, American Statistical Association, pp. 104–121.

Maddala, GS (1977), *Econometrics*, McGraw-Hill.

Malik, WS (2006), "Money, output and inflation: Evidence from Pakistan," The Pakistan Development Review, vol. 45, no. 4, (part II), pp. 1277-1286

Malik, WS (2007), "Monetary Policy Objectives in Pakistan : An Empirical Investigation," *Macroeconomics Working Papers*.

Martin, C & Milas, C (2004), "Modelling Monetary Policy: Inflation Targeting in Practice," *Economica*, vol. 71, no. 282, Wiley on behalf of The London School of Economics and Political Science and The Suntory and Toyota International Centres for Economics and Related Disciplines, pp. 209–221.

Nelson, E (2001), "UK Monetary Policy 1972-97: A Guide Using Taylor Rules," *CEPR Discussion Papers*.

Nobay, AR & Peel, DA (2003), "Optimal Discretionary Monetary Policy in a Model of Asymmetric Central Bank Preferences," *Economic Journal*, vol. 113, no. 489, pp. 657–665.

Osborn, DR, Kim, DH & Sensier, M (2005), "Nonlinearity in the Fed's monetary policy rule," *Journal of Applied Econometrics*, vol. 20, no. 5, pp. 621–639.

Quandt, RE (1958), "The Estimation of the Parameters of a Linear Regression System Obeying Two Separate Regimes," *Journal of the American Statistical Association*, vol. 53, no. 284, American Statistical Association, pp. 873–880.

Ruge-Murcia, FJ (2004), "The inflation bias when the central bank targets the natural rate of unemployment," *European Economic Review*, vol. 48, no. 1, pp. 91–107.

S.M. Goldfeld and R.E. Quandt (1972), *Nonlinear methods in econometrics*, North-Holland Publ. Co., Amsterdam and London.

Surico, P (2004), "Inflation Targeting and Nonlinear Policy Rules: The Case of Asymmetric Preferences (new title: The Fed's monetary policy rule and U.S. inflation: The case of asymmetric preferences)," *CESifo Working Paper Series*.

Svensson, LEO (1997), "Inflation forecast targeting: Implementing and monitoring inflation targets," *European Economic Review*, vol. 41, no. 6, pp. 1111–1146.

Taylor, JB (2000), "Alternative Views of the Monetary Transmission Mechanism: What Difference Do They Make for Monetary Policy?," *Oxford Review of Economic Policy*, vol. 16, no. 4, pp. 60–73.

Terasvirta, T (1994), “Specification, Estimation, and Evaluation of Smooth Transition Autoregressive Models,” *Journal of the American Statistical Association*, vol. 89, no. 425, American Statistical Association, pp. 208–218.

Teräsvirta, T (1996), “Modelling Economic Relationships with Smooth Transition Regressions,” *Working Paper Series in Economics and Finance*.

Vítor, C (2011), “Can central banks' monetary policy be described by a linear (augmented) Taylor rule or by a nonlinear rule?,” *Journal of Financial Stability*, vol. 7, no. 4, pp. 228–246.

Table 3A.1. Linear Interest Rate Reaction Function

Dependent Variable: CMR

Method: Least Squares

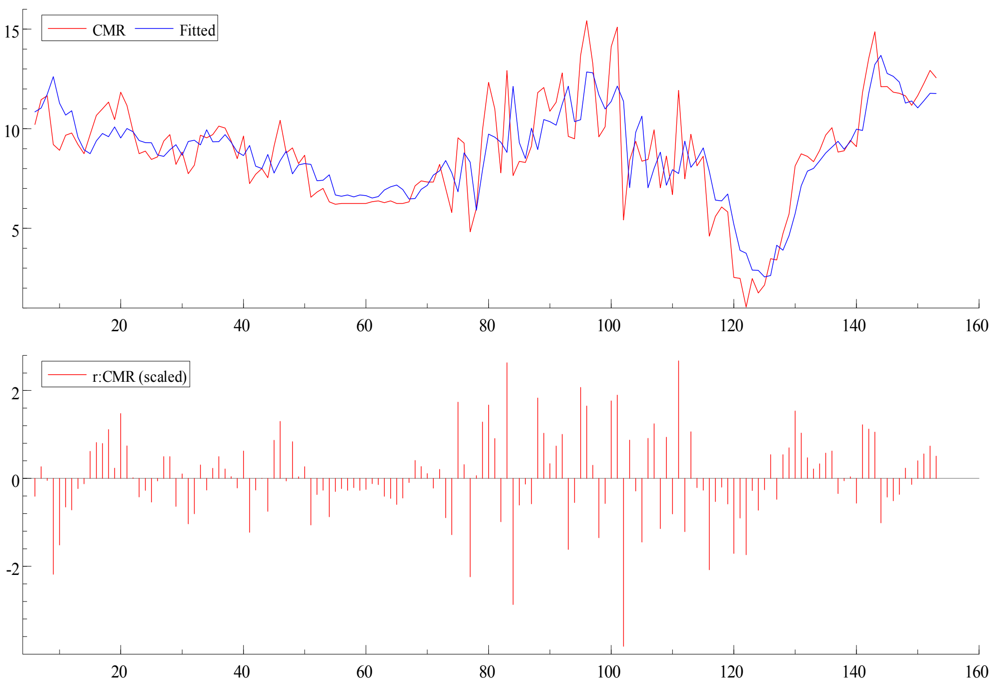
Date: 06/14/12 Time: 11:59

Sample (adjusted): 1974Q1 2011Q2

Included observations: 150 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.845061	0.491179	1.720476	0.0875
CMR(-1)	0.500708	0.066415	7.539024	0.0000
CMR(-4)	0.307517	0.061987	4.961037	0.0000
INF(-1)	0.094680	0.024139	3.922248	0.0001
Y(-2)	1.392006	1.093436	1.273056	0.2050

R-squared	0.671278	Mean dependent var	8.779133
Adjusted R-squared	0.662210	S.D. dependent var	2.687761
S.E. of regression	1.562119	Akaike info criterion	3.762729
Sum squared resid	353.8313	Schwarz criterion	3.863083
Log likelihood	-277.2047	Hannan-Quinn criter.	3.803500
F-statistic	74.02556	Durbin-Watson stat	1.963094
Prob(F-statistic)	0.000000		



CMR
Fitted
15
10
5
20
40
60
80
100
120
140
160
r:CMR (scaled)
2
0
-2
20
40
60
80
100
120
140
160

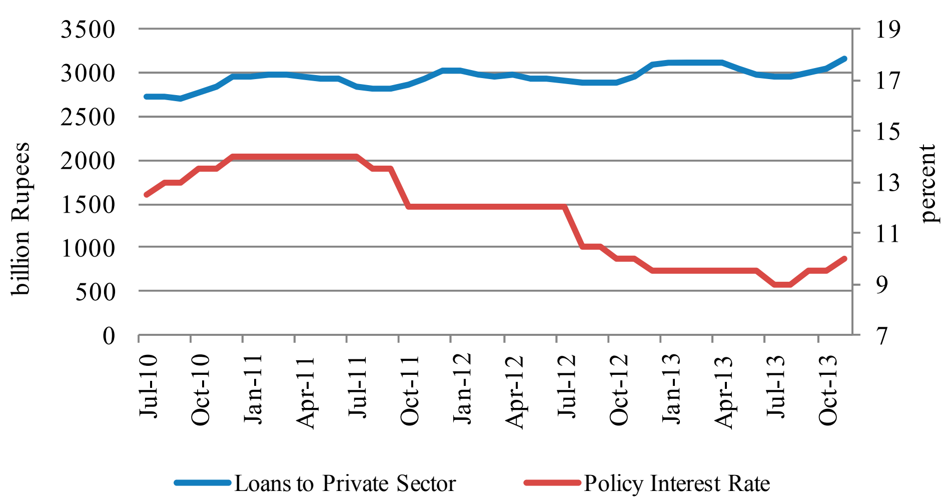
CAPTER 4

An Empirical Study on the Asymmetric Effects of Monetary Policy in Pakistan

4.1. Introduction

Private sector activity, as demonstrated by loans availed by the private sector from the commercial banks, subsided towards the end of 2008 as Pakistan hit a balance of payments crisis and inflation soured to historic highs. Compelled by these circumstances, and as a pre-condition for IMF's stand-by arrangement, State Bank of Pakistan increased its policy interest rate by 2 percentage points in November 2008. However, as Pakistan emerged from the 2008 BOP crisis and inflation set on the declining trend, SBP started to ease off interest rates to stimulate private sector activity. However, unabated government borrowing from the State Bank kept inflation persistently in double digits and SBP was forced to partially reverse the decline in interest rates afterwards. Finally, starting from August 2011 through September 2013, the State Bank aggressively reduced the interest rates in a bid to end the long slump in private sector credit. Over these two years SBP

Figure 4.1: Loans to Private Sector & Policy Interest Rate



reduced its policy interest rates by 500 basis points. Surprisingly, despite such large reduction in interest rates spread over two long years, private sector loans from the commercial banks have not responded equally strongly (see figure 4.1).

There have been two explanations from SBP on non-responsiveness of private sector credit to reductions in interest rates. First, reduction in interest rate alone cannot make a difference to private sector activity unless accompanied with supporting environment such as low government borrowing requirements and availability of energy:

> *"While there is some seasonal pick up (in private sector credit) since mid-October onwards, the outlook for the year is not encouraging. The reason, as highlighted by the SBP earlier as well, is that the expected support to the SBP's initiative in the shape of improvement in the availability of energy and reduction in fiscal borrowing needs has not come through yet. Thus, both the demand for and supply of credit to the private sector remain sub-optimal." SBP (2012b)*

The second argument put forward by the State Bank is the counterfactual theory: had SBP not reduced interest rates, private sector credit would have plummeted further.

> *"A declining interest rate environment has put pressure on banks to increase their exposure to the private sector as opposed to just placing their funds in the risk free high-yielding government securities. ..... Thus, there may be an incremental improvement in the supply of credit to the private sector." SBP (2012a)*

While the two arguments sound appealing, economic theory presents models that predict muted response of private economic agents to a reduction in interest rates. Specifically, these models suggest asymmetric response of output to a monetary policy shock in a way that a contractionary monetary shock of a known size is assumed to produce a larger and meaningful impact on real economic activity relative to the effect of an easy monetary shock of the same magnitude.

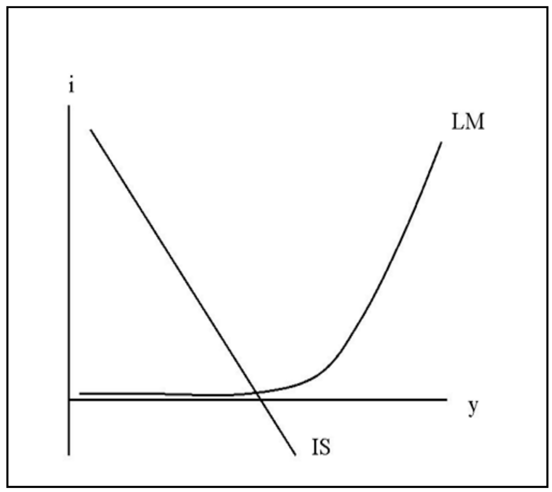
A number of studies have documented validity of asymmetric response models for many developed and developing economies. Using M1 as the monetary policy indicator, Zakir & Malik (2013) find support for asymmetry related to the direction of monetary policy.[26] We extend the work on empirics of asymmetric response models for Pakistan in three significant ways. First, we believe short term interest rate is the more appropriate measure of the stance of monetary policy (see Chapter 2 for detailed discussion on this), and therefore we use the call money rate as our preferred indicator of monetary policy stance. Secondly, we find that Zakir & Malik (2013) use government borrowing from central bank as one of the explanatory variables in the equation for M1 growth. Computationally, government borrowing from SBP is a constituent unit of M1 and therefore using it as an explanatory variable in the equation for M1 growth is likely to produce unreliable results. Lastly, Mishkin (1982) demonstrated that system estimation of these types of non-linear models produce more efficient estimates. Therefore, in contrast to Zakir & Malik (2013) who use the two step procedure, we employ non-linear least squares (NLLS) methodology to estimate our model.

[26] Incidentally, no empirical study was available on this topic at the time we started work on the dissertation. Our attention was drawn to Zakir & Malik (2013) when an initial draft of this work was under review and hence the discussion was accordingly amended.

The organization of this paper is as follows. The next section presents a review of relevant literature. Section 3 describes the estimation framework and the modeling approach. Section 4 discusses the results. Section 5 concludes the paper with a summary of the main findings.

4.2. Literature Review

4.2.1. Theoretical Framework



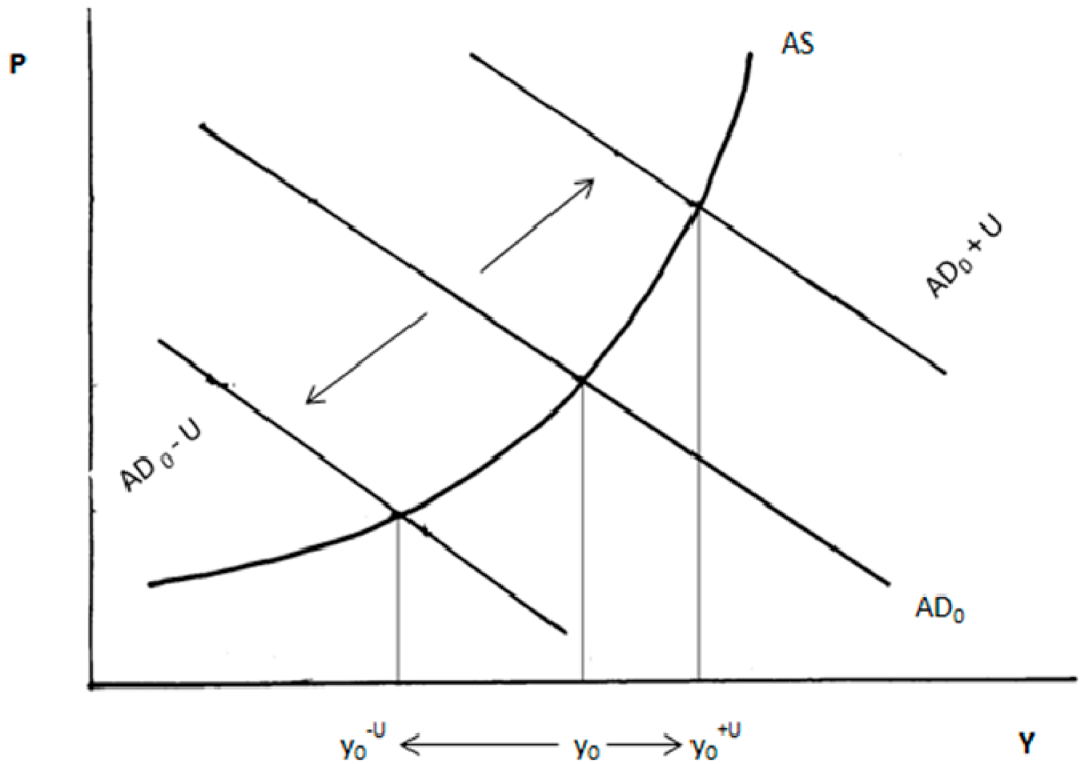
Discussions on asymmetric effects of monetary policy are generally rooted in the grand debate on policy (in)effectiveness. Keynes was the first one who noted that expansionary monetary policy might turn ineffective in times of depression, when interest rates fall very low. The phenomenon was termed liquidity trap and was formalized by Hicks (1937) using the famous IS-LM framework. The underlying reason behind the existence of a liquidity trap is that nominal interest rates cannot be negative, or otherwise, economic agents would always prefer holding money over bonds. Therefore, at near zero interest rates, the demand for money is perfectly elastic implying a flat LM curve to the left of the IS curve as depicted in figure below. Resultantly, monetary expansion would only move upward sloping part of the LM curve to the right and have no effect in lowering interest rates which is required to stimulate aggregate demand and restore full employment. To sum up, expansionary monetary policy would become ineffective in deep recessions.

This particular asymmetry relates to dissimilar state-contingent effects of monetary policy. In this regard, Garcia & Schaller (1995) examined whether monetary policy affects economic activity differently between recessions and expansions while Ravn & Solà (1999) studied the transitional dynamics of asymmetries in the relationship between monetary policy indicator variable and aggregate output over different phases of the business cycle. We are however not concerned with this source of asymmetry in this paper and will only examine the likely asymmetric impact of monetary policy shocks of different signs on the aggregate output.

The proposition that monetary policy shocks of different signs may impact the aggregate economic activity differently is based on two alternative theoretical frameworks, namely a convex aggregate supply curve and the nonlinear response of aggregate demand curve.

4.2.1.1 Convexity of Aggregate Supply Curve

We can see from figure below that monetary policy produces nonlinear impact on real output when the aggregate supply curve has a convex shape. In such circumstances, tight and expansionary monetary policy of the same size shifts the aggregate demand to the left or right respectively, producing different-sized impact on prices and the output. Specifically, a contractionary monetary policy causes a larger reduction in output than the increase in output produced by same-sized expansionary monetary policy.



The convex aggregate supply curve can be considered as generating from smoothing an inverted L-shaped aggregate supply curve that is horizontal up to full employment (as in the Keynesian case) and vertical at the full employment (as in the neoclassical case). Capacity constraint and several models of price and wage setting behavior result into a convex aggregate supply. We briefly describe some of these models below.

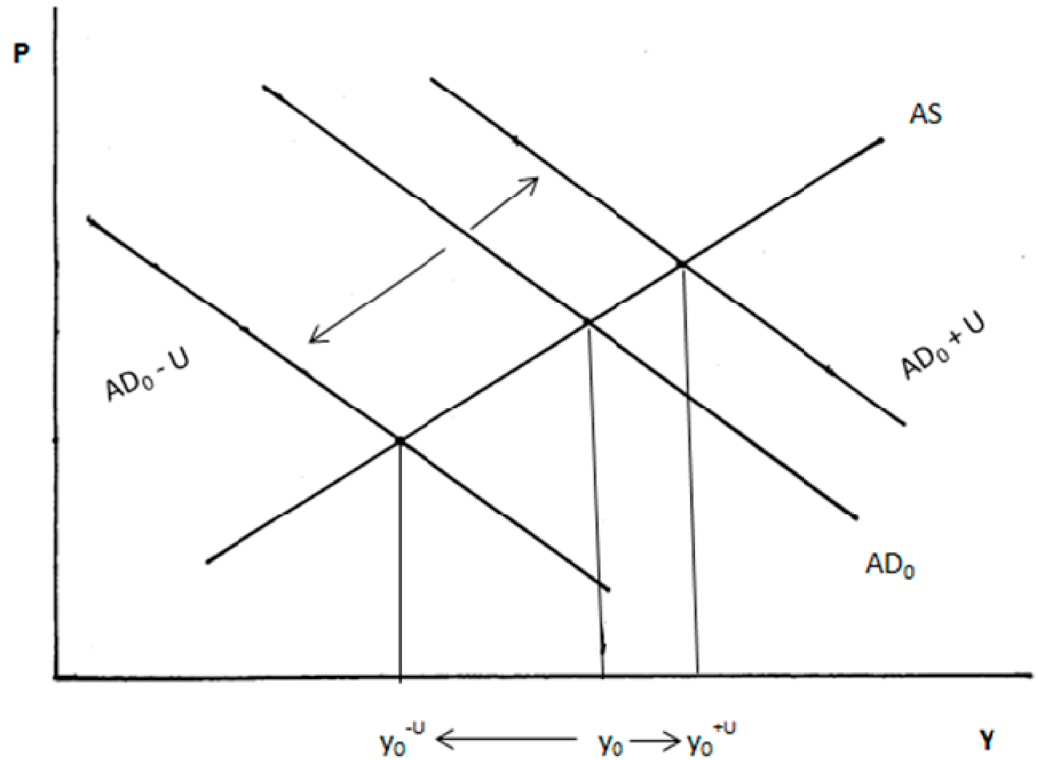
The *capacity constraint model* postulates that it is difficult for many firms to enhance their production capacity in the short run. Consequently, the impact of an easy monetary policy on aggregate economic activity will be limited in the short run as more and more firms run up against capacity constraints. However, a contractionary monetary policy will be more effective since firms do not face any constraints to restrict their output. Thus, in the presence of capacity constraints, the short-run aggregate supply curve will have a convex shape.

Next, we consider the traditional *Keynesian model of downwardly rigid nominal wages*. While early Keynesian models assumed nominal wage rigidity, various theoretical models were later developed to explain this kind of nominal rigidity. Stiglitz (1984) provides an overview of theoretical frameworks that produce downward nominal wage rigidity. In particular, nominal wages are hypothesized to adjust downward slowly because of either money illusion or institutional or behavioral factors. Under conditions of downwardly rigid and upwardly flexible nominal wages, a positive monetary shock would largely translate into higher prices - instead of increased employment and output- since wages are flexible upward. However, a negative monetary shock would initially reflect into reduced employment and output because nominal wages would not adjust quickly to clear the labor market.

Similarly, *asymmetric price adjustment models* are also consistent with a convex aggregate supply curve. The theoretical models that provide micro foundations to this explanation of asymmetry in the response of output to monetary shocks of different signs depend on the assumptions of trend inflation and costly price adjustment. The costly adjustment models suggest that firms would decide to adjust prices following a nominal demand shock only if the benefit from changing prices exceeds the costs associated with price adjustment. These costs have been labeled menu costs in the economic literature. The presence of menu costs makes it difficult for firms to continuously adjust prices to the level otherwise dictated by the competitive economy. Using a menu cost model with trend inflation, Ball & Mankiw (1994) demonstrate that prices are more flexible upwards than downwards thereby implying asymmetric real effects of monetary policy. They explain that positive trend inflation makes price reductions less likely than price increases since some firms will attain relative price declines from trend inflation, without having to reduce their own prices and thereby sustaining real costs. Hence, after a monetary contraction, such firms are expected not to cut their prices and therefore the monetary shock is more likely to produce somewhat larger real effects; on the other hand, firms are more likely to raise their prices following a monetary expansion. The model thus implies a convex aggregate supply curve.

4.2.1.2 Asymmetric Response of Aggregate Demand Curve

Unlike models that relate nonlinear effects of monetary policy to the shape of aggregate supply curve, theoretical explanations in the second category suggest that these asymmetries are a result of disparities in the effect of easy and tight monetary policy shocks on the aggregate demand. Specifically, these theories predict that negative monetary policy shocks are expected to have far greater impact on the aggregate demand than positive shocks of the same size. This is illustrated in the figure below. We can see that the shift in aggregate demand schedule is larger for a tight monetary policy than for an expansionary monetary policy, thus resulting in asymmetric real effects such that a tight monetary policy has larger output effect than a corresponding expansionary monetary policy.



Main explanations cited in the literature for the nonlinear response of aggregate demand to positive and negative monetary policy shocks are term structure of interest rates, credit market imperfections and the progressive tax system. We briefly describe each of these explanations below.

Term Structure of Interest Rates

In the context of transmission mechanism, policy announcement by the central bank aims at adjusting short-term interest rate to some desired level. On the other hand, decisions of households and firms on their level of spending are affected by changes in the long-term interest rates. Resultantly, the effectiveness of monetary policy is directly related to the degree to which long-term interest rates follow short-term interest rates. The relationship between interest rates of different maturities has been labeled in the economic literature as term structure of interest rates and therefore theories of term structure of interest rates are likely to help explain the dynamics of monetary policy effectiveness.

The expectations theory of the term structure of interest rates is accepted by most monetary economists to represent the true relationship between interest rates of different maturities. The mathematical representation of the expectations theory is as follows:

$$i_{k,t} = \frac{1}{k+1} i_t + \frac{1}{k+1} \sum_{i=1}^{k} E_t i_{t+i} = \frac{1}{k+1} \sum_{i=0}^{k} E_t i_{t+i} \qquad (1)$$

that is, the k-period nominal interest rate at time t ($i_{k,t}$) amounts to the average of the current short-term nominal interest rate and the future short term nominal interest rates likely to prevail over the k-period horizon. Based on Fisher's relationship between nominal and real interest rates, equation (1) can be transformed as:

$$i_{k,t} = \frac{1}{k+1} \sum_{i=0}^{k} E_t r_{t+i} + \frac{1}{k+1} \sum_{i=0}^{k} E_t \pi_{t+i} \qquad (2)$$

where $E_t r_{t+i}$ reflects expectation, formed in period t, of interest rate in period $t+i$ whereas the latter term gives the expected inflation from t to $t+k$. Thus, any change in the long-term interest rate will result from fluctuation in the above two components, namely short maturity interest rates and inflation expectations.

Under this framework, the asymmetric real effects of tight and easy monetary policy are produced from the dissimilar effects of inflation expectations on long term interest rates and consequently on the spending behavior of households and the firms. An expansionary monetary policy might fail to stimulate aggregate demand as expectations of higher inflation following the monetary expansion may not allow long term interest rates to decline sufficiently. On the contrary, a contractionary monetary policy, aimed at reduction in inflation rate, will be able to raise long term interest rates rather swiftly through policy induced expectations of lower inflation and thus reduce aggregate demand.

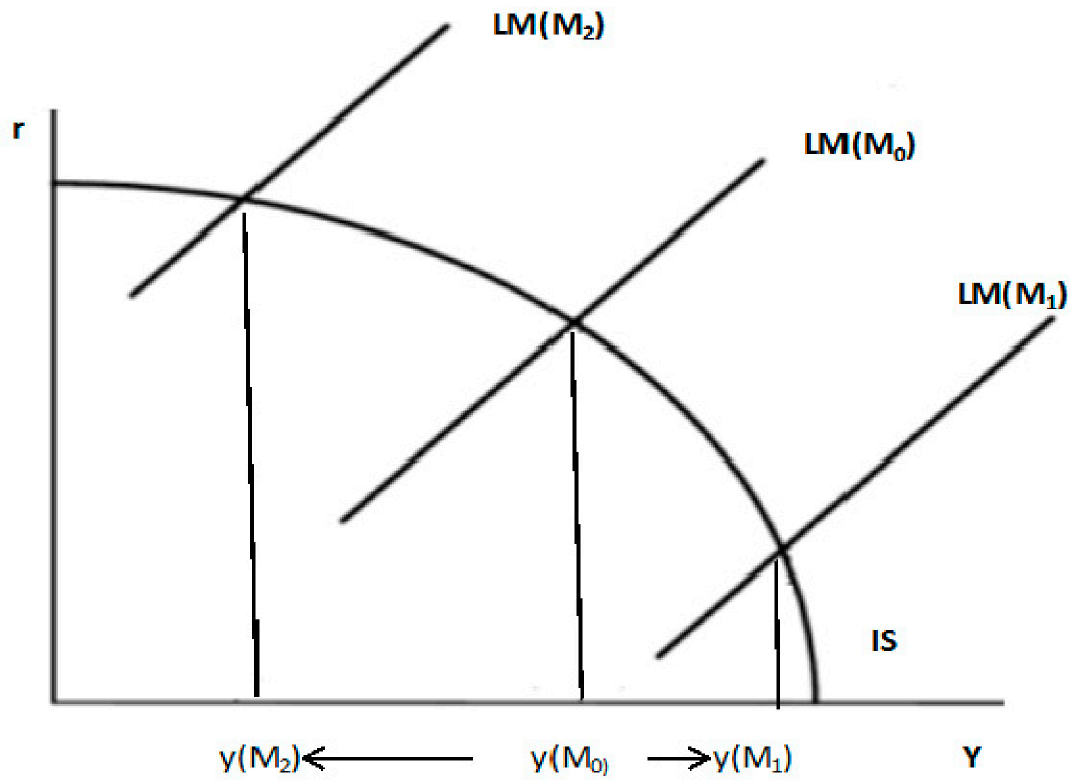
Credit Market Imperfections

Some models examine the role of banks in the effectiveness of monetary transmission mechanism. Under these models, the presence of credit market imperfections explains the nonlinear impact of monetary policy. For example, Morgan (1993) suggests tight monetary policy is likely to discourage banks from making loans to some borrowers resulting into binding credit constraints thereby augmenting the impact of contractionary monetary policy and leading to a larger decline in borrowing and spending than would result from higher market interest rates alone. What causes banks to resort to credit rationing instead of raising lending rates? Morgan (1993) suggests higher loan rates can increase the risk of bankruptcy by increasing the borrower's obligation to the bank. Therefore, in circumstances where banks feel higher loan rates threaten to increase bankruptcy risk too much, they will ration the quantity of credit available to riskier borrowers, leaving them credit constrained.

Contrary to rationing of credit supply, Bernanke & Gertler (1989) suggest constrains on the demand for credit arising out of low collateral. They indicate that when loans are fully collateralized, sharp reductions in investment outlays are more likely than sharp increases. In contrast, Dell'Ariccia & Garibaldi (1998) develop a matching model with characteristics of asymmetric reaction of bank credit to monetary policy shocks. Non-linearity in this model is generated from the assumption that while banks are able to swiftly recall existing loans, they cannot extend credit equally fast (because finding a good investment is not easy, the screening process takes time etc.). In a related model of credit constraints for the household, Jackman & Sutton (1982) show asymmetric effects arising through permanent income effects.

Progressive Tax System

Sweidan & Al-Rabbaie (2007) linked asymmetric response of aggregate demand to the presence of a progressive income tax system. Under a progressive income tax regime, the tax rate rises as incomes increase thereby constraining the ability of the economy to expand and also creating pessimistic sentiments among entrepreneurs. The former effect of a progressive tax system translates into a concave IS curve. A cut in interest rates



(expansionary monetary policy) generates optimism that works against the pessimism from the progressive income tax system being in effect. These two forces work against each other and therefore an expansionary monetary policy has only little effect on aggregate demand. In contrast, an increase in interest rates (tight monetary policy) reinforces the pessimistic view and therefore results in a much larger impact on aggregate demand. Thus we have non-linear effect of monetary policy shocks on the aggregate demand.

4.2.2. Empirical Evidence

Cover (1992) was the first to document empirical evidence that supported the assertion that tight monetary policy has a larger and more important impact on output compared to real effects of an expansionary monetary policy. Using quarterly data for the years 1951-1987, Cover (1992) estimated the impact of exogenous shocks in money supply (M1) on output growth in the US. Employing a number of specifications for the money supply and output processes, he established that negative exogenous shocks to money growth (reflecting tight monetary policy) produced a large and statistically significant impact on output growth. On the contrary, positive exogenous shocks to money growth (reflecting easy monetary policy) only had a minor and statistically insignificant impact on output growth. In reaction to an initial version of Cover (1992), DeLong & Summers (1988) tested whether asymmetric responses of output to monetary shocks holds for annual data too. Their results confirmed the findings of Cover (1992) for a number of sample periods over annual US data.

Since then, a number of studies have come out to check validity of these findings for different economies of the world and for extended empirical models. A few have also attempted to simultaneously identify the sources of these asymmetries. Thus, using federal funds rate and a narrative index of monetary policy as two alternative measures of the monetary stance of Fed, Morgan (1993) concluded that "tight monetary policy, however measured, substantially and significantly reduced output ……, while easy monetary policy usually had an insignificant effect on output." Using annual data for the period 1953-1990, Karras (1996a) found evidence supporting asymmetric response of output to tight and expansionary monetary policy across different specifications and estimation methods for a group of 18 European countries. Furthermore, Karras (1996b) and Karras & Stokes (1999) estimated the effect of monetary policy shock on the two main subcomponents of output, ie, consumption and investment. Their findings indicate that while both consumption and investment respond asymmetrically to monetary shocks, the impact is more pronounced in the case of investment. Likewise, Garibaldi (1997) used federal funds rate as an indicator of monetary policy for the period 1972:2-1988:4 to examine the presence of nonlinearities on account of the effect of monetary policy on net employment and found that a tight monetary policy had a more pronounced effect on net employment relative to the expansionary monetary policy.

For Pakistan, Zakir & Malik (2013) reported the presence of asymmetry with respect to the direction of monetary policy such that tight monetary policy is found to be statistically significant while the positive monetary policy is not. We, however, notice three major weaknesses in their work. First, they chose to use M1 as the indicator of monetary policy.

We believe a short term interest rate is a more appropriate indicator of monetary policy stance, especially after the financial sector reforms starting from early 1990s (discussed in detail in Chapter 2). Second, they use two step OLS procedure to estimate the non-linear model. Mishkin (1982) however demonstrated that the two step OLS method to estimate such asymmetric behavior is likely to produce biased results and argued for system estimation of the non-linear model. Finally, and most importantly, Zakir & Malik (2013) use government borrowing from central bank as one of the explanatory variables in the equation for M1 growth. This specification overlooks the accounting identity whereby government borrowing from the central bank is a constituent unit of M1. Vidal (2007) discusses in detail the implications of estimating an equation in which both the dependent and the independent variables belong to an accounting identity and concludes that the estimated coefficients are not valid since these must adapt to satisfy the accounting identity. As a result, using government borrowing from SBP as an explanatory variable in the equation of M1 growth is not valid and would only produce biased estimates.

4.3. Empirical Methodology and Data

Empirical work on testing the asymmetric response of output to tight and easy monetary policies have largely used a procedure that can be seen as an extension of the 2-step OLS method earlier used by Barro (1977) to check for the US the effectiveness of anticipated vis-a-vis unanticipated monetary policy. Broadly speaking, this method entails specifying two equations; one for the monetary policy indicator (narrow monetary aggregate or the short-term interest rate) and the other for the output relationship. First, the relationship specifying the policy variable is estimated to capture the monetary policy shocks which are then grouped under negative and positive shocks to distinguish between tight and easy monetary policy. Then the two sets of monetary shocks are added to the output equation as explanatory variables and output equation estimated to determine if tight and easy monetary policies have dissimilar impact on real economic activity.

Specifically, this methodology can be summarized as below:

Firstly, the following relationship is estimated:

$$m_t = \phi_0 + \sum_{i=1}^{N} \phi_i^m m_{t-i} + \sum_{i=1}^{M} \phi_i^y z_{t-i} + \upsilon_t \qquad (3)$$

where m_t is the indicator of the monetary policy, z_t represents a vector of variables in the reaction function of the monetary authority like the aggregate output, exchange rate, inflation etc., ϕ_s reflect the parameters of the reaction function and υ_t defines the monetary policy shocks. Defining

$\upsilon_t^+ = \max(\upsilon_t, 0)$ and

$\upsilon_t^- = \min(\upsilon_t, 0)$

as the positive and negative monetary shocks, respectively, the output equation takes the form

$$y_t = \theta_0 + \sum_{i=1}^{Q} \theta_i^y y_{t-i} + \sum_{i=0}^{S} (\theta_i^+ \upsilon_{t-i}^+ + \theta_i^- \upsilon_{t-i}^-) + \mu_t \qquad (4)$$

where θs and μ_t defines the parameters of the output equation and the exogenous shock to the aggregate output respectively. Our primary asymmetry hypothesis consists of testing the equality of the parameters on the positive shocks θ_i^+ and on the negative shocks θ_i^- in equation (4). Additionally, we also perform tests to verify that θ_i^+ are jointly zero and θ_i^- are jointly zero (for all i); that $\sum \theta^+$ is zero and $\sum \theta^-$ is zero; and lastly $\sum \theta^+ = \sum \theta^-$.

Mishkin (1982) however cautioned that the two step OLS method outlined above ignores the cross-equation restrictions on coefficient estimates and therefore may give biased results. Mishkin (1982) noted system estimation of the two equations takes into account the cross-equation restrictions and therefore produces more efficient estimates. This paper therefore follows Mishkin (1982) and estimates equations (3) and (4) jointly using non-linear least squares (NLLS)[27] to test for the validity of nonlinear response of aggregate output to monetary policy shocks for the case of Pakistan.

We assume that inflation, output gap, exchange rate, and world commodity prices are the main variables included in the reaction function of the State Bank of Pakistan (see Chapter 2 for detailed discussion). As done in Chapter 2, we use call money rate as the indicator of SBP's monetary stance whereas GDP variable is transformed into the ratio of last 6 quarters' average real GDP. The consumer price index is used to calculate quarterly percentage changes in general price level, world commodity prices are proxied by oil prices, and exchange rate variable is represented by the nominal effective exchange rate. The data spans from 1973:3 to 2012:2. A negative exogenous shock to the call money rate signals easy monetary policy and vice versa.

[27] Mishkin (1982) notes that nonlinear least squares (NLLS) is superior than full information maximum likelihood (FIML) in such systems because NLLS easily implements the necessary covariance restriction and a desirable degree-of-freedom correction, which produces more conservative likelihood ratio statistics.

4.4. Empirical Results

We employ Akaike Information Criterion to select lag structure of the system. The system is first estimated using Barro (1977)'s 2-step procedure and the coefficients thus derived are treated as starting values in the estimation of joint non-linear least squares (NLLS) estimation of the system. Table 4.1 shows relevant estimated coefficients from the joint estimation of interest rate-output model and tests results of the asymmetry hypotheses listed above.

Table 4.1. Interest rate equation, NLLS estimates

θ_0+	-0.091
	(0.995)
θ_1+	0.023*
	(0.020)
θ_2+	0.037*
	(0.020)
θ_3+	0.001
	(0.002)
θ_4+	-0.003*
	(0.002)
θ_0-	-0.001
	(0.002)
θ_1-	-0.001
	(0.002)
θ_2-	0.003*
	(0.002)
θ_3-	0.001
	(0.001)
θ_4-	0.000
	(0.002)
Tests (χ^2)	
1. θ+= θ-	22.24*
2. θ+=0	32.53*
3. θ-=0	4.410
4. ∑θ+=0	3.09
5. ∑θ-=0	2.96
6. ∑θ+=∑θ-	3.89

*, **,*** indicate significant at 10%, 5%, and 1% respectively.

As reported, the results weakly confirm the presence of nonlinearity in the response of real aggregate output to contractionary and easy monetary policies. Our principal null hypothesis on the equality of the coefficients on positive shocks (representing tight monetary policy) and the coefficients on the negative shocks (representing easy monetary policy) is rejected only at 10% confidence level. Moreover, again at 10% confidence level, the hypothesis that the coefficient associated with tight monetary policy ($\theta+$) are jointly zero can be rejected but the same does not hold true for the hypothesis that the coefficient associated with easy monetary policy ($\theta-$) are jointly zero. These test results weakly confirm that while the tight monetary policy has a statistically significant effect on the real aggregate output in Pakistan, the easy monetary policy is likely to fail in stimulating the output.

4.5 Robustness Checks

Next we check the robustness of above results with regard to the measure of monetary policy stance and the selection of number of lags.

4.5.1. Monetary policy indicator

Table 4.2 presents results from joint estimation of (3) and (4) using M1 measure of monetary aggregate as the measure of monetary stance of the State Bank. Again, decision on the lag structure is governed by the Akaike Information Criterion (AIC).

The results reveal that the asymmetry earlier detected in the interest rate-output model is further weakened when a narrow measure of monetary aggregate is used as the

Table 4.2. Monetary aggregate equation, NLLS estimates

θ_0+	-0.018
	(0.025)
θ_1+	0.006
	(0.020)
θ_2+	0.002*
	(0.002)
θ_3+	-0.009
	(0.020)
θ_4+	-0.003*
	(0.002)
θ_0-	-0.002
	(0.017)
θ_1-	-0.010
	(0.017)
θ_2-	0.005*
	(0.025)
θ_3-	-0.008
	(0.007)
θ_4-	0.001
	(0.002)
Tests (χ^2)	
1. $\theta+= \theta-$	18.67*
2. $\theta+=0$	5.23
3. $\theta-=0$	5.01
4. $\sum\theta+=0$	2.79
5. $\sum\theta-=0$	2.23
6. $\sum\theta+=\sum\theta-$	3.51

*, **,*** indicate significant at 10%, 5%, and 1% respectively.

indicator of monetary policy. While the test still support, albeit at 10% significance level, that the coefficients associated with tight monetary policy are jointly different from the coefficients associated with easy monetary policy, we are unable to confirm that the former are jointly different than zero thereby eliminating the potency of tight monetary policy vis-à-vis the expansionary monetary policy.

4.5.2. Lag Structure

Next, to check if test results from our model are sensitive to the lag structure of the system, we re-estimate the two equations with fixed 2-lag structure (N=M=R=S=2). Table 4.3 presents the results from joint estimation of the interest rate- output model of (3) and (4) using two lags of the explanatory variables in the model together with two lags for shocks associated with tight and easy monetary policies.

Table 4.3. Interest rate equation, NLLS estimates

θ_0+	-0.011*
	(0.010)
θ_1+	0.003
	(0.006)
θ_2+	-0.005*
	(0.004)
θ_0-	-0.010
	(0.016)
θ_1-	0.020*
	(0.019)
θ_2-	0.002
	(0.085)
Tests (χ^2)	
1. $\theta+= \theta-$	28.15*
2. $\theta+=0$	18.22*
3. $\theta-=0$	7.380
4. $\sum\theta+=0$	5.66
5. $\sum\theta-=0$	6.54
6. $\sum\theta+=\sum\theta-$	5.88

*, **,*** indicate significant at 10%, 5%, and 1% respectively.

The results confirm that our earlier finding of the presence of weak asymmetry in the response of aggregate output to tight and easy monetary conditions is robust to the lag length selection. As before, the two null hypotheses regarding the equality of coefficients associated with tight and easy monetary policies and regarding the former coefficients being jointly zero are both rejected at 10% significance level.

4.6. Conclusion

A number of theoretical frameworks present scenarios in which the effectiveness of monetary policy hinges on the sign of monetary policy shock. In particular, these models predict that a tight monetary policy is likely to have a strong and significant impact on the aggregate economic activity in comparison to easy monetary policy shock. This paper aimed at estimating the impact of monetary policy on real output for the case of Pakistan and to explore if the results verify the proposition of differential effects of monetary policy shocks. While Zakir & Malik (2013) attempted to test the asymmetric response model for Pakistan, we found major weaknesses in their methodology. We correct for these weaknesses and estimate interest rate-output model using joint non-linear least squares (NLLS) methodology for quarterly data spanning from 1972:3 to 2012:2. To check the robustness of the results from this model, we also estimated models with M1 as the indicator variable for the monetary policy and also for a fixed lag length. Our results weakly supported the asymmetry proposition. In particular, the null hypothesis that the coefficients associated with tight monetary policy are jointly equal to the coefficients associated with easy monetary policy was rejected in all specifications, albeit at the 10% significance level. While estimates from interest rate-output model also rejected the hypothesis that the coefficients related to tight monetary policy are jointly different from zero, similar hypothesis on the coefficients of easy monetary policy could not be rejected. However, this last result regarding the coefficients of tight monetary policy does not hold true in the M1-output model. We also found that our results are robust to the selection of lag length.

The findings of this Essay that the expansionary monetary policy is less effective in Pakistan has important policy implications for the conduct of monetary policy by SBP. Specifically, when easy monetary policy shock has only a small or insignificant impact on real output, this would mean that the policy effects are largely absorbed by prices. Hence, a prolonged easy monetary policy by SBP is likely to require SBP a more strong tight monetary policy going forward to offset the impact on prices.

Appendix 4.1: 2-step Estimation for Obtaining the Starting Value of Coefficients in the Joint Nonlinear System Estimation

The following two equations form the economic system we want to estimate using nonlinear least squares (NLLS):

$$m_t = \phi_0 + \sum_{i=1}^{N} \phi_i^m m_{t-i} + \sum_{i=1}^{M} \phi_i^y z_{t-i} + \upsilon_t$$

$$y_t = \theta_0 + \sum_{i=1}^{Q} \theta_i^y y_{t-i} + \sum_{i=0}^{S} (\theta_i^+ \upsilon_{t-i}^+ + \theta_i^- \upsilon_{t-i}^-) + \mu_t$$

But this requires starting values for the system parameters to initiate the iteration process. Following Cover (1992) and other works in this area, we run 2-step OLS on the system and get coefficient estimates to act as the starting values in NLLS.

Step 1

We estimate the first equation on monetary policy indicator by Ordinary least squares over the sample period to get:

$$\hat{m}_t = \hat{\phi}_0 + \sum_{i=1}^{N} \hat{\phi}_i^m m_{t-i} + \sum_{i=1}^{M} \hat{\phi}_i^y z_{t-i}$$

Next we calculate the residuals as

$$\hat{\upsilon}_t = m_t - \hat{m}_t = m_t - \hat{\phi}_0 + \sum_{i=1}^{N} \hat{\phi}_i^m m_{t-i} + \sum_{i=1}^{M} \hat{\phi}_i^y z_{t-i}$$

$\hat{\upsilon}_t$ is our unanticipated monetary policy variable, representing the monetary policy shock.

We then generate the positive and negative monetary policy shocks as follows:

Positive monetary policy shocks $= \max(\hat{\upsilon}_t, 0)$ and

Negative monetary policy shocks $= \min(\hat{\upsilon}_t, 0)$

Step 2

Next, we estimate the following output equation over the sample period using OLS

$$y_t = \theta_0 + \sum_{i=1}^{Q} \theta_i^y y_{t-i} + \sum_{i=0}^{S} (\theta_i^+ \hat{\upsilon}_{t-i}^+ + \theta_i^- \hat{\upsilon}_{t-i}^-) + \mu_t$$

Coefficient estimates from this 2-step estimation are then used in joint estimation of the system through nonlinear least squares (NLLS)

Appendix 4.2: Estimation Results of 2-lag Model

Non-Linear System Estimation
Convergence in 9 Iterations. Final criterion was 0.0000129 <= 0.0001000
Quarterly Data From 1973:03 To 2012:02
Function Value 214.00000000

Dependent Variable CMR
Mean of Dependent Variable 3.2163015235
Std Error of Dependent Variable 3.6160670368
Standard Error of Estimate 3.2008176010
Sum of Squared Residuals 1096.2399647
Durbin-Watson Statistic 2.294296

Dependent Variable Y
Mean of Dependent Variable 1.2999163144
Std Error of Dependent Variable 1.9169939888
Standard Error of Estimate 1.4608686940
Sum of Squared Residuals 228.35269551
Durbin-Watson Statistic 1.956191

Variable	Coeff	Std Error	T-Stat	Signif
1 A0	2.883019	0.760629	3.790310	0.000150
2 CMR(1)	-0.007525	0.008674	-0.867530	0.385651
3 CMR(2)	-0.314089	0.075996	-4.132990	0.000036
4 INF(1)	0.333233	0.139007	2.397230	0.016520
5 INF(2)	0.349609	0.000000	0.000000	0.000000
6 Y(1)	0.144637	0.132818	1.088987	0.085318
7 Y(2)	0.089547	0.068378	1.309580	0.079285
8 ER(1)	-0.016018	0.000000	0.000000	0.000000
9 ER(2)	-0.048180	0.042136	-1.143451	0.075140
10 OIL(1)	0.014998	0.014976	1.001463	0.098104
11 OIL(2)	0.253832	0.574361	0.441938	0.900520
12 C0	3.881748	0.624164	6.219110	0.000000
13 Y(1)	-0.000687	0.005253	-0.130710	0.896006
14 Y(2)	-0.520955	0.090368	-5.764820	0.000000
15 P0	-0.010697	0.010310	-1.037489	0.089221
16 P1	0.003021	0.005702	0.529847	0.609145
17 P2	-0.004920	0.004024	-1.222606	0.073020
18 N0	-0.010421	0.015631	-0.666694	0.127255
19 N1	0.020410	0.019143	1.066186	0.096506
20 N2	0.001873	0.084620	0.022134	0.821639

References

Ball, L & Mankiw, NG (1994), "Asymmetric Price Adjustment and Economic Fluctuations," *The Economic Journal*, vol. 104, no. 423, Wiley on behalf of the Royal Economic Society, pp. 247–261.

Barro, RJ (1977), "Unanticipated Money Growth and Unemployment in the United States," *American Economic Review*, vol. 67, no. 2, American Economic Association, pp. 101–15.

Bernanke, B & Gertler, M (1989), "Agency Costs, Net Worth, and Business Fluctuations," *The American Economic Review*, vol. 79, no. 1, American Economic Association, pp. 14–31.

Cover, JP (1992), "Asymmetric Effects of Positive and Negative Money-Supply Shocks," *The Quarterly Journal of Economics*, vol. 107, no. 4, Oxford University Press, pp. 1261–1282.

Dell'Ariccia, G & Garibaldi, P (1998), "Bank Lending and Interest Rate Changes in a Dynamic Matching Model," *IMF Working Papers*.

DeLong, JB & Summers, LH (1988), "How Does Macroeconomic Policy Affect Output?," *Brookings Papers on Economic Activity*, vol. 19, no. 2, pp. 433–494.

Garcia, R & Schaller, H (1995), "Are the Effects of Monetary Policy Asymmetric?," *CIRANO Working Papers*.

Garibaldi, P (1997), "The Asymmetric Effects of Monetary Policy on Job Creation and Destruction," *IMF Working Papers*.

Hicks, JR (1937), "Mr. Keynes and the 'Classics'; A Suggested Interpretation," *Econometrica*, vol. 5, no. 2, The Econometric Society, pp. 147–159 CR – Copyright © 1937 The Econometri.

Jackman, R & Sutton, J (1982), "Imperfect Capital Markets and the Monetarist Black Box: Liquidity Constraints, Inflation and the Asymmetric Effects of Interest Rate Policy," *The Economic Journal*, vol. 92, no. 365, Wiley on behalf of the Royal Economic Society, pp. 108–128 CR – Copyright © 1982 Royal Economic.

Karras, G (1996a), "Are the Output Effects of Monetary Policy Asymmetric? Evidence from a Sample of European Countries," *Oxford Bulletin of Economics and Statistics*, vol. 58, no. 2, pp. 267–78.

Karras, G (1996b), “Why are the effects of money-supply shocks asymmetric? Convex aggregate supply or ‘pushing on a string’?,” *Journal of Macroeconomics*, vol. 18, no. 4, pp. 605–619.

Karras, G & Stokes, HH (1999), “Why are the effects of money-supply shocks asymmetric? Evidence from prices, consumption, and investment,” *Journal of Macroeconomics*, vol. 21, no. 4, pp. 713–727.

Mishkin, FS (1982), “Does Anticipated Monetary Policy Matter? An Econometric Investigation,” *Journal of Political Economy*, vol. 90, no. 1, The University of Chicago Press, pp. 22–51.

Morgan, DP (1993), “Asymmetric effects of monetary policy,” *Economic Review*, no. Q II, pp. 21–33.

Ravn, MO & Solà, M (1999), “Business cycle dynamics: predicting transitions with macrovariables,” in P Rothman (ed.), *Nonlinear Time Series Analysis of Economic and Financial Data*, Kluwer Academic Publishers: Boston, US., pp. 231–263.

SBP (2012a), "Monetary Policy Decision," February. State Bank of Pakistan

SBP (2012b), "Monetary Policy Decision," December. State Bank of Pakistan

Stiglitz, JE (1984), “Price Rigidities and Market Structure,” *The American Economic Review*, vol. 74, no. 2, American Economic Association, pp. 350–355 CR – Copyright © 1984 American Econom.

Sweidan, DO & Al-Rabbaie, A (2007), “The Tax System and the Asymmetric Effect of Monetary Policy,” *International Research Journal of Finance and Economics*, no. 10, pp. 97–106.

Vidal, FJS (2007), “The Problem Of Estimating Causal Relations By Regressing Accounting (Semi) Identities,” *Working Papers. Serie EC*, Instituto Valenciano de Investigaciones Económicas, S.A. (Ivie).

Zakir, N & Malik, WS (2013), “Are the effects of monetary policy on output asymmetric in Pakistan?,” *Economic Modelling*, vol. 32, no. C, Elsevier, pp. 1–9.

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CERTIFICATE

This is to certify that this thesis entitled: "Three Essays on Monetary Policy in Pakistan" submitted by Mr. Tasneem Alam is accepted in its present form by the Department of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree of **Doctor of Philosophy in Economics.**

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