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Monetary policy transmission mechanism in Bangladesh : an SVAR approach

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ABSTRACT

MONETARY POLICY TRANSMISSION MECHANISM IN BANGLADESH: AN SVAR APPROACH

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This study examined the impact of monetary policy shocks on real and nominal variables in Bangladesh using monthly data for the floating exchange rate period from June 2003 to June 2015. Structural vector autoregressive (SVAR) models and impulse response functions were used to identify the impact of domestic monetary policy shocks on output, interest rate, inflation and nominal exchange rate. Results from the baseline model suggest that a contractionary monetary policy shock leads to a rise in domestic interest rate and an appreciation of domestic currency. In response to the shock, both output and inflation fell, but the shock had a delayed effect on output and inflation. Unlike previous studies on Bangladesh, the identification scheme of this paper was able to solve the liquidity puzzle, the price puzzle and the exchange rate puzzle.

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MONETARY POLICY TRANSMISSION MECHANISM IN BANGLADESH: AN SVAR APPROACH

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DEDICATION

To my parents, with love and gratitude

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CHAPTER 1

INTRODUCTION

Monetary policy plays an important role in the management of the economy. Monetary policy actions can be transmitted to the real economy through different channels. To understand the impact of monetary policy, it is important to identify the mechanism through which monetary policy decisions influence the real economy and the time period required for such policies to affect real economic activities. The monetary policy transmission mechanism may vary from country to country depending on their economic and financial structure.

Monetary policy shocks can be identified through a monetary contraction, i.e., a fall in monetary aggregates or an increase in the interest rate, which are indications of a tighter monetary policy stance. This rise in the interest rate may not be very persistent as monetary contraction may lead to a deflation in price level. Whether such monetary development will affect real output in the short run depends on the neutrality of money. The effects of monetary contraction on exchange rate depend on the disturbances that lead to a change in interest rate (Kim & Roubini, 2000).

There is extensive literature on the effects of monetary policy or monetary policy transmission mechanism on industrialized countries. However, researchers have not yet reached any consensus regarding the variable they should consider as the monetary policy instrument or the statistical method they should use to extract the impact of any monetary policy shock. Sims (1980) proposed that one can use impulse responses from vector auto regressions (VARs) to analyze monetary policy, avoiding too many restrictions of large structural models. The traditional view suggests that central banks use some form of monetary aggregates to influence output and inflation. However, according to Bernanke and Blinder (1992)

and McCallum (1983), federal funds rate innovations, identified from recursive Choleski approach, can be a better indicator of monetary policy shocks compared to innovations in monetary aggregates. Bagliano and Favero (1998) recommended the long-term interest rate as a good indicator in expressing a change in monetary policy. Nevertheless, Gordon and Leeper (1994) argued for monetary aggregates to be used to analyze the dynamic responses of macroeconomic variables. On the other hand, Sims (1992), Strongin (1995), and Eichenbaum and Evans (1995) suggested the use of non-borrowed reserves to represent monetary policy shocks.

These authors mostly applied the recursive VAR approach. The recursive approach may be more suitable for the US economy which is quite large and relatively closed. But small, open economies can be vulnerable to external shocks and central banks in those countries may respond quickly to external economic development. Therefore, in a small, open economy context, external shocks may have considerable influence on domestic monetary policy. Earlier authors attempting to estimate the macroeconomic effects of monetary policy shocks using recursive VAR methodology and using only domestic variables encountered puzzling dynamic responses identified as the liquidity puzzle, the price puzzle, and the exchange rate puzzle.[1] Kim and Roubini (2000) and other studies (Cushman & Zha, 1997; Fung, 2002; Kim, 2003; Mishra & Mishra, 2010; Raghavan et al., 2009; Sims & Zha, 2006) suggested that these puzzles resulted from an inadequate identification of exogenous policy shocks. By incorporating some foreign variables they were able to solve the puzzles encountered by the previous studies.

Empirical research on monetary transmission mechanism in the context of developing countries can pose some further challenges. Mahadeva and Sinclair (2002) and Gaven and Kemme (2009) put forth some of these challenges. They mentioned about the poor quality of data and the low frequency of data collection that makes time series analysis less reliable

[1] See Kim & Roubini (2000).

in terms of providing appropriate policy advice. This stems mainly from the lack of funding and the lower importance given to data collection. On the other hand, monetary policy and its economic responses are a complex process, and developing countries may lack the expertise to analyze the method appropriately. Moreover, economic theory and empirical procedure are most often developed on the premises of industrialized countries with advanced financial systems and strong institutional capacities. Many developing countries lack such environment. In most developing countries institutions are underdeveloped and there is a presence of informal financial system. Therefore, these countries most often lack the pre-condition on which economic theories are based. Under such circumstances, researchers have to rely on economic theories that may not be very relevant for their countries or they may have to draw experience from research on other countries having similar economic conditions, which makes economic discovery in developing countries very challenging.

Nevertheless, researchers tried to understand the effect of monetary policy shocks in developing countries from different parts of the world through empirical works. Mishra and Montiel (2013) mentioned that it is important to choose the appropriate monetary policy target that matches with the one chosen by the central bank to decipher the impact of monetary policy on the economy.

Bangladesh Bank, the central bank of Bangladesh, is responsible for conducting monetary policy in Bangladesh. Like many other central banks, the Bangladesh Bank has clearly stated mandate as outlined in the Bangladesh Bank Order of 1972. According to this order, Bangladesh Bank should ensure sustained economic growth while maintaining reasonable price stability and external competitiveness of the domestic currency *taka* to maintain a stable balance of payment position. Though the goals of the central bank are clearly stated, achieving such goals may turn out to be quite difficult. One needs to understand the intricacies of the monetary policy transmission mechanism to take the correct monetary policy

stand in order to influence the target variables in the desired fashion. Empirical studies can be instrumental in understanding this mechanism.

Historically, Bangladesh Bank targeted monetary variables for the conduct of monetary policy. Prior to 1990, the conduct of monetary policy was based on direct control over various instruments such as the volume and direction of credit and interest rates. The monetary policy stance shifted towards indirect control of inflation and started targeting monetary aggregates with the adoption of the Financial Sector Reform Program in 1990. Since the country's independence in 1972, Bangladesh Bank used the exchange rate to serve as the nominal anchor. The exchange rate of Bangladesh's *taka* was fixed with the British pound sterling. As the pound sterling was floated with the US dollar later in 1972, the *taka* was also floated with the dollar via the pound sterling. In 1979, the *taka* was pegged with a basket of currencies of Bangladesh's major trading partners and the pound sterling as the intervention currency, which was later replaced by the US dollar in 1983. Bangladesh has adopted the floating exchange rate arrangement since May 2003.

Empirical studies on monetary policy shock in the case of Bangladesh are limited. These studies differ in terms of identifying the monetary policy instrument and the impact of a monetary policy shock on different macroeconomic variables. Most of these studies used data ranges which overlap different policy regimes. In such a case, the monetary policy shocks on macroeconomic variables may produce confusing results. To decipher the impact of policy shocks one needs to look at different policy regimes separately. Existing studies on the effects of monetary policy shocks in Bangladesh either do not include data from the floating exchange rate period or include a small segment of the floating regime. Changes in the exchange rate arrangement can alter the channels of transmission mechanism, and therefore including data from more recent periods can produce very different results. Most of the existing studies also did not include any foreign policy variable in their model to isolate

the effect such variables may exert on the domestic economy. Earlier studies also suffered from the various puzzles identified in the literature.

This paper investigates the effects of monetary policy shocks on output, inflation, interest rate and exchange rate in Bangladesh. Previous studies on Bangladesh mostly looked at the monetary policy transmission mechanism employing recursive vector auto regression (VAR) or error correction mechanism approach and used annual or quarterly data. They could not include enough data from the floating exchange rate period in Bangladesh which started from May 2003. Non-recursive approach can be more useful to identify monetary policy shocks because it allows incorporating the contemporaneous relationships among the variables included in the model. For example, money supply and exchange rate can both affect each other. To see the impact of money supply on exchange rate in a recursive VAR setting, one has to set exchange rate equation after the money supply equation. This implies that money supply is not contemporaneously affected by changes in exchange rate. But, in a small, open economy like Bangladesh, the central bank can be very vigilent in the foreign exchange market, and in the case of any unwarranted appreciation of the domestic currency the central bank usually reacts by increasing the money supply to ensure the competitiveness of domestic products in the international market. Though the results may not drastically change by using different econometric techniques, This study sought to explore whether structural identification can solve the puzzles. Understanding the contemporaneous relationship among different macroeconomic variables can also prove to be very useful to central bankers to formulate appropriate monetary policy decisions.

This paper employed a structural vector auto regression (SVAR) methodology and used impulse response functions (IRFs) to find the impact of domestic monetary policy shock on major macroeconomic variables in Bangladesh. Monthly data from June 2003 to June 2015 was used to better reflect the dynamics of the floating exchange rate period. Two foreign variables, the US federal funds rate and the world commodity price index, were incorporated

to control for exogenous shocks on domestic monetary policy. The identification scheme appears to be successful in solving the puzzles mentioned above.

The rest of the paper is organized as follows. Chapter 2 provides a review of empirical studies of the monetary policy transmission mechanism. This review covers studies on developing countries from different parts of the world, namely sub-Saharan Africa, the Middle East and North Africa, Central Asia, and the Indian sub-continent. Countries in these regions share some common characteristics that are also present in Bangladesh and studying the monetary policy transmission mechanism in these countries may prove to be useful for understanding the effect of monetary policy in Bangladesh. These studies used different policy variables and employed mostly the VAR and SVAR methodology. Most of these studies did not find any significant impact of monetary policy on output or price level.

Chapter 3 gives an overview of economic and financial structure and the monetary policy framework of Bangladesh. Bangladesh has enjoyed an average growth of six percent per annum over the last two decades. Its economic structure has shifted more towards industry and service sectors. With a growth of per capita GDP and the attainment of middle-income country status, the need for financial intermediation has also grown at a high pace. But financial deepening of the economy still remains at a nascent stage. While the banking industry dominates the financial sector, the poor performance of government-owned banks puts pressure on the financial stability and weakens the effectiveness of monetary policy.

Bangladesh Bank's monetary programming is derived from the classical quantity theory of money. Reserve money and broad money are the operating target and intermediate target of Bangladesh Bank. Following monetary targeting, as opposed to interest rate targeting, is considered to be more suitable for Bangladesh as interest elasticities of private saving and money demand are believed to be insignificant, and therefore any change in short-term interest rate is not expected to pass through the real economy.

Chapter 4 describes the data. The domestic variables considered are the quantum index of manufacturing production (qi) representing GDP, inflation (π), reserve money (rm), broad money ($M2$), the call money rate (cmr), the lending rate (i^L), and the nominal exchange rate (er). The foreign variables are world commodity price index (wpi) and US federal funds rate (i^f). Besides providing the graphical presentation and summary statistics of the data, this chapter also discusses the stationary properties of the data. To check the stationarity of the data, the augmented Dickey Fuller (ADF) test, Phillips Peron (PP) test, and Kwiatkwski-Phillips-Schmidt-Shin (KPSS) test were used.

Chapter 5 illustrates the methodology. A seven-variable SVAR model was employed to decipher the impact of monetary policy shocks on the domestic economy. The SVAR model is equipped to impose theoretically motivated restrictions and can capture the contemporaneous relationship among the macroeconomic variables. The restrictions used in this paper were motivated by Kim and Roubini (2000).

Chapter 6 describes the results. The baseline model using reserve money as the monetary policy variable was able to solve all three puzzles. Impulse response functions from this model showed that a monetary contraction was followed by a fall in output and inflation rate. The interest rate increased and domestic currency appreciated. When M2 was used to generate monetary policy shock, the IRFs produced similar results but there was a mild presence of the price puzzle. The paper also uses interest rates to represent monetary policy shocks. A positive call money rate innovation reduced output and inflation, but the reduction of output was very small. The exchange rate depreciated leading to the exchange rate puzzle. A positive lending rate shock led to both price and exchange rate puzzles.

Chapter 7 provides a basis for the conclusion.

CHAPTER 2

LITERATURE REVIEW

In the case of industrialized countries, many researchers found that monetary policy exerts significant impact on macroeconomic variables and identified different channels of transmission mechanism, but the experience of developing countries is different. In most cases, authors did not find monetary policy has a significant impact on macroeconomic variables, and in many cases, variables reacted to monetary policy in a confusing way, contrary to what economic theory would suggest. To understand the impact of monetary policy shocks in developing countries we would turn our attention to various studies of monetary policy transmission mechanism in developing countries from different parts of the world. We will include studies on countries from sub-Saharan Africa, Middle East and North Africa (MENA), Central Asia, and the Indian sub-continent. Mishra and Montiel (2013) pointed out that low income countries from these regions share some common characteristics. These countries usually do not have well developed financial markets and in most of these countries bond market is weak or absent. The markets for equities are shallow and volatile and there is little or no access to international capital market. The foreign exchange market is also heavily influenced by central bank intervention. Under such conditions, their financial sectors are dominated by banks with little possibility for alternative sources of fund. These characteristics are also present in Bangladesh. Therefore, studying the effects of monetary policy in these countries may shed some light on the expected effects of monetary policy innovation in Bangladesh.

This review includes recent studies that mostly use the recursive or structural VAR methodology to extract the impact of monetary policy. The review starts with literature

on sub-Saharan African countries. Abradu-Otoo et al. (2003) employed the recursive VAR approach to explore the effect of monetary policy in Ghana using quarterly data from 1969 to 2002. They used both broad money ($M2$) and T-bill rate as their monetary policy variable. They did not find any significant effect of monetary policy on price or output. Rather, impulse response functions (IRF) showed that a contractionary monetary policy leads to increase in inflation and a depreciation of the currency. Cheng (2006) looked at Kenyan economy using monthly data from 1997 to 2005. He applied both the recursive and structural VAR approach taking policy interest rate as the monetary policy variable. He reports that innovation in interest rate significantly affects exchange rate and price level in Kenya, but the policy rate fails to have any impact on output. Mugume (2011) employed the SVAR technique on Uganda's economy using quarterly data from 1999 to 2009. He found that monetary policy innovation moves price level in the right direction, but the effect is insignificant. The effect on output is significant but the output seems to oscillate following the monetary policy shock. Finally, Davoodi et al. (2013) considered a set of African countries namely Uganda, Rwanda, Kenya, Tanzania and Burundi. They drew monthly data from 2000 to 2010 and used both short term interest rate and reserve money as the monetary policy instrument. They got mixed results for different countries. But the common thread is that neither reserve money nor interest rate generates significant effect on output or price level.

Economic conditions of developing countries in MENA are similar to that of sub-Saharan African countries except that some of these countries have a well developed equity market, for example Bahrain (Mishra & Montiel, 2013). Poddar et al. (2006) investigated monetary policy transmission in Jordan using quarterly data from 1996 to 2005. They employed a recursive VAR technique using interest rate differential between Jordan and USA as the policy innovation. They used different specification with different variables like foreign exchange reserve, exchange rate, and lending rate and included output and policy

rate, i.e., the spread between 3-month CD rates and the U.S. federal funds rate, in all of those specifications. None of the specifications seems to generate any significant impact of monetary policy on output or other variables. Neaime (2008) looked at multiple countries, namely Lebanon, Jordan, Egypt, Tunisia, and Morocco from 1990 to 2006. He applied a four variable recursive VAR with T-bill rate as the policy variable. Except for Morocco, which is not a low income country, monetary policy does not have any significant impact on output and price level, but in general, monetary policy innovation in these countries moves output and price in the expected direction. Moursi et al. (2007) employed the semi-structural VAR approach on Egyptian data and conclude that monetary policy shock has ambiguous and negligible effects on output and price level. In a similar study on Egypt Al-Mashat & Billmeier (2007) found monetary policy shock has an insignificant effect on price or output.

Countries in Central Asia share comparable economic conditions with the previous two groups of countries discussed above as most countries in this region are low income with weak institutions. Dabla-Norris & Floerkemeier (2006) used monthly data from 2000 to 2005 to investigate the impact of monetary policy in Armenia. They used monetary aggregates and repo rates as their policy variable. They found that the impact of monetary policy on output and price level vary depending on the choice of policy variable. Their results suggest that innovation in repo rate affects the price level but does not influence the level of output. Use of monetary aggregates as the policy variable affects only output but not the price level. A follow up study by Bordon & Weber (2010) using monthly Armenian data from 2000 to 2010 shows that, for the larger sample size, monetary policy shock produces a significant effect on output only. Bakradze & Billmeier (2007) studied monetary policy in Georgia using currency in circulation as the policy variable. They used quarterly data from 1999 to 2006. They found monetary policy shock positively affects output but the response is significant only for the first two quarters.

We now turn our attention to studies from the Indian sub-continent, i.e., studies on India and Pakistan. Mallik (2009) employed both recursive and structural VAR to identify the impact of monetary policy shock in India. He used the central bank 91 day treasury bill rate as the monetary policy variable. Using recursive approach he found that contractionary monetary policy shock in terms of positive innovation in treasury bill rate has a small but significant effect on output. The impact on price level was rather confusing as price level increased as a result of monetary tightening. In the case of structural VAR, he found no statistically significant effect on output. As in case of recursive VAR, the price level under structural identification still responds positively to contractionary policy. Barnett et al. (2015) also applied both the recursive and structural VAR to evaluate monetary policy in India. They used monthly data from 2000 to 2008. They considered the short term domestic interest rate as the policy variable. They used different specifications including and excluding monetary aggregates and using different monetary aggregates. They found that while all the recursive models generate confusing results regarding the expected impact on output and price level, structural identification has the expected impact on price level.

Alam & Waheed (2006) explored the monetary transmission mechanism in Pakistan using quarterly data from 1973 to 2003. They followed the recursive VAR approach and used the central bank policy rate as the policy variable. They found a small and insignificant impact of monetary policy shock on output, but the output moved in the right direction. Altering the sample period or including different variables in the model did not change their results. Agha et al. (2005) used monthly data from 1996 to 2004 and T-bill rate as the policy instrument for Pakistan. They found that a contractionary policy reduces output but increases the price level.

Economic literature on monetary policy in Bangladesh is limited. Some previous authors explored the realm of monetary policy in Bangladesh using a bi-variate Granger causality tests. Among them are Parikh & Starmer (1988) who used monthly data from November

1973 through November 1986 to explore the relationship between narrow money supply ($M1$) and price level, measured by the cost of living index in Dhaka city. They found that price level granger-cause money supply in Bangladesh and the causality is unidirectional, i.e., the causality does not flow from money to price level. Therefore, they argued that the monetarist perspective of excess money supply creating inflation does not seem to hold in the case of Bangladesh. Rather, structural constraints lead to an increase in price level which then necessitates an increase in money supply to support the increasing budget deficit. They suggested that money supply is not exogenous, and it reacts to other economic development.

One of the earliest studies using VAR methodology is Chowdhury et al. (1995). They employed quarterly data from 1974 to 1992 to find the relationship between money and other macroeconomic variables namely output, exchange rate, and inflation in Bangladesh. They found that the causal relationship between inflation and $M2$ flows in both direction while inflation rate causes $M1$ growth. Their results suggest monetary aggregates have a strong influence on output and also that money supply and inflation can explain a large portion of changes in exchange rate. They opined that neither the monetarist nor the structuralist view can solely explain the inflation in Bangladesh.

Ahmed & Islam (2004) investigated whether bank lending channel and exchange rate channel exist in the economy to influence aggregate output and prices. They used a recursive VAR technique on quarterly data from 1979 to 2005. To find the efficacy of the bank lending channel, they used reserve money, private sector credit, real GDP, and CPI and to explore the exchange rate channel, they considered reserve money, CPI, nominal exchange rate, export, import, and real GDP. They used reserve money as the monetary policy variable and generated IRF and variance decomposition to determine the relationship among different variables. In the case of bank lending channel, they found that reserve money cannot explain the fluctuation of output, private sector advances or price level but private sector credit can affect output in the very short term. Again, for the exchange rate channel, they did not

find any predictive power of reserve money on other variables except for nominal exchange rate. Exchange rate response to reserve money is negative while price responds to nominal exchange rate positively. They concluded that there is weak existence of both channels in Bangladesh.

Ahmed et al. (2006) examined the effect of contractionary monetary policy shock on the stock price index using structural VAR approach and found that the contractionary monetary policy shock, measured by increases in short term policy interest rates, has a small, negative, and short-lived effect on the stock price index. The studies mentioned above did not include any foreign variable to control for the exogenous policy influence on domestic economy. Younus (2009) explored the impact of domestic and foreign monetary policy shocks on the Bangladesh economy. She considered Bangladesh's $M2$ and India's $M2$ as domestic and foreign monetary policy variables respectively. The major focus of this article is to determine what portion of the forecast error variance in interest rate, price level, output and exchange rate of Bangladesh is explained by innovations in Bangladesh's and India's $M2$. She derived variance decompositions from a near VAR technique using quarterly data from 1976 to 2002. She concluded that changes in domestic $M2$ can explain a significant portion of the variation in domestic price level only, while India's $M2$ mostly explain the output and exchange rate variations in Bangladesh.

Alam (2015) inspected the effectiveness of the monetary policy in Bangladesh using a SVAR approach. He employed quarterly data on the three month T-bill rate, reserve money, $M2$, nominal exchange rate, CPI, and industrial production index from 1995 to 2011. He considered T-bill rate as the monetary policy instrument and found that shock in T-bill cannot explain the variation of any variable by more than 10 percent and that the effects are not significant. The paper fails to solve the price puzzle or the exchange rate puzzle and concludes that monetary policy is not effective in controlling short-run economic fluctuations in Bangladesh.

From the above discussion on the literature we get a mixed experience regarding the effectiveness of monetary policy in Bangladesh. Previous authors used both interest rate and different forms of monetary aggregates to represent the monetary policy instrument. While some studies found a causal relationship from $M2$ to price level (Chowdhury et al., 1995; Younus, 2009), others (Ahmed et al., 2006; Ahmed & Islam, 2004; Alam, 2015) found monetary policy to be mostly ineffective.

CHAPTER 3

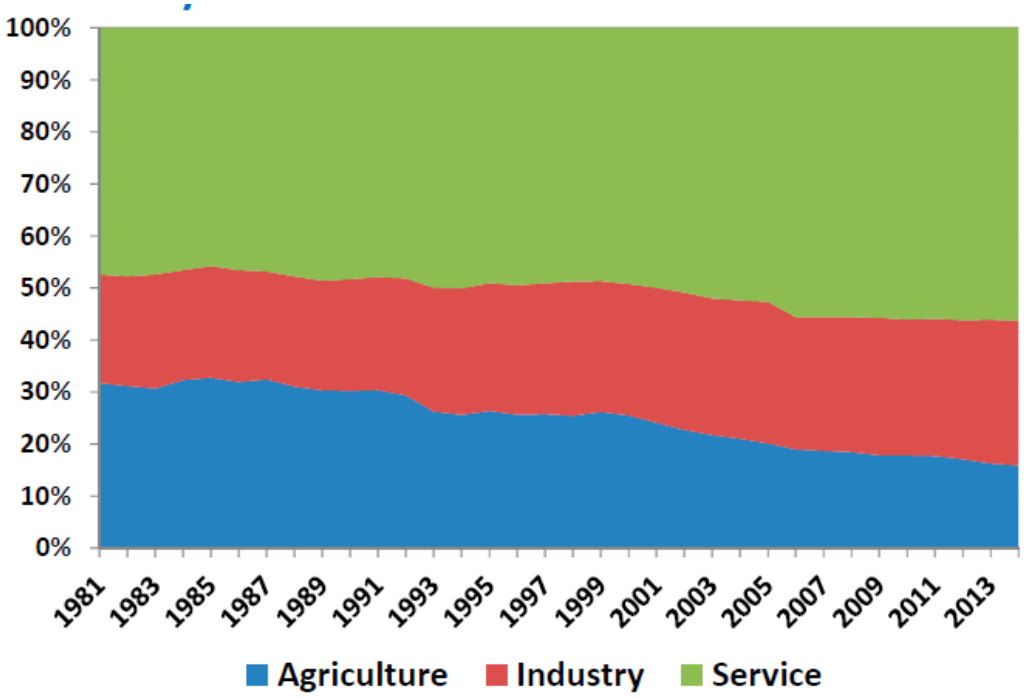
AN OVERVIEW OF THE BANGLADESH ECONOMY

This chapter provides an overview of the Bangladesh economy. First, the economic and financial structure of Bangladesh will be discussed. Second, the monetary policy framework followed by Bangladesh Bank will be described.

3.1 Bangladesh's Economic and Financial Structure

Bangladesh can be considered a small, open economy with a GDP of 195 billion US dollar which is about 1.2 percent of the US economy. Having a population of 160 million, Bangladesh's per capita GDP rose to 1,314 US dollars at the end of fiscal year 2015 from a mere 107 US dollars in 1971, the year the country became independent. Though Bangladesh has attained lower middle income status in 2015 by the World Bank definition, 31.5 percent of the population still lives below the poverty line. Starting as an agriculture-based economy, Bangladesh's economic activities shifted more towards industry and service sector over the course of time. The sectoral composition of Bangladesh economy over the past two decades is presented in Figure 3.1. The figure shows that agriculture's share in GDP reduced from over 33 percent in 1981 to around 16 percent in 2014. In contrast, the share of industry increased from 20 percent to 30 percent and service sector grew from 48 percent to 54 percent of total GDP.

After independence, Bangladesh faced the daunting challenge of fixing the war-torn economy. With a hope to better manage the economy, the government turned towards



Source: Monetary Policy Statement, July-December 2015; Bangladesh Bank.

Figure 3.1: Sectoral composition of Bangladesh economy.

nationalization of banks and other major industries. During the mid-1980s, the government started encouraging privatization. From 1991 to 1993, Bangladesh followed an enhanced structural adjustment facility (ESAF) with the International Monetary Fund (IMF). During the late 1990s, the government moved towards liberalization and increasingly pursued open economic policies abiding by the agreements of WTO. These changes in economic policy and structure helped the country to achieve higher economic growth as can be seen in Table 3.1, which shows the sectoral growth of GDP for the last three and a half decades. Among the three broad sectors, industry growth was most robust in recent years, which contributed more towards pulling up the GDP of the country.

While the average growth of the agricultural sector hovered around a little over 3 percent, growth of industrial sector paced up from 5.13 percent in 1981 to 9.6 percent in

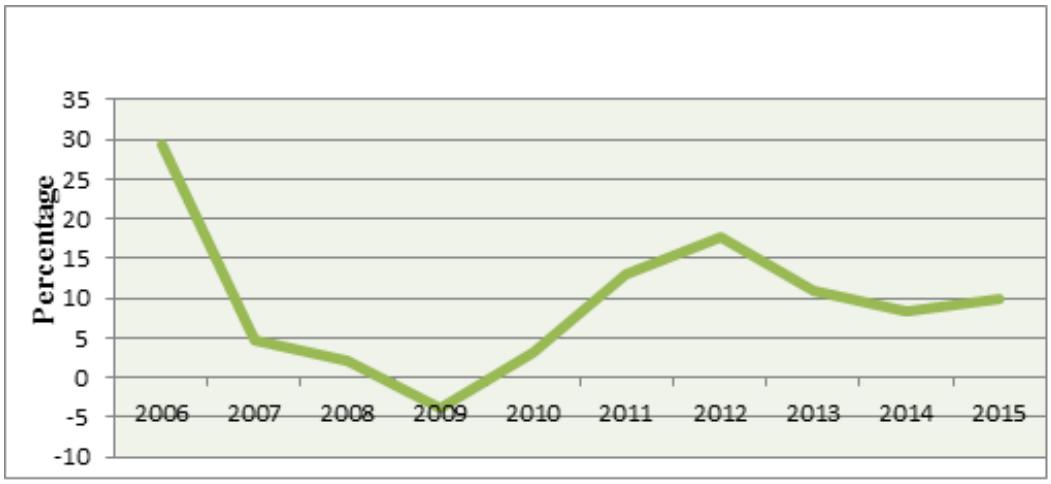
Table 3.1: Growth of GDP and Its Broad Sectors

	1981	1986	1991	1996	2001	2006	2011	2015
GDP	3.74	3.34	3.24	4.47	5.41	7.18	6.64	6.50
Agriculture	3.31	3.31	2.23	3.10	3.14	5.50	4.46	3.00
Industry	5.13	6.72	4.57	6.98	7.45	9.80	9.02	9.60
Service	3.55	4.10	3.28	3.96	5.53	6.60	6.22	5.80

Source: Bangladesh Economic Review 2014 and Bangladesh Bank Annual Report 2014-2015

2015. The industrial sector is led by the export-oriented garment industry, which brings around 85 percent of the total export earnings for the country, along with pharmaceuticals, shipbuilding, ceramics, and leather goods. The service sector also progressed steadily and had an average growth of around 6 percent over the last 15 years. Under the service sector, monetary intermediation by banks comprises 2.9 percent of GDP. To keep up with the economic growth of the country, the need for monetary intermediation is increasing. Monetary intermediation observed a growth of 9.8 percent in 2015. Figure 3.2 shows the growth of monetary intermediation in Bangladesh over the last decade. Except for the period of global financial crisis from 2007 to 2010, Bangladesh experienced substantial growth of financial intermediation, which remained close to 10 percent per annum.

Despite the high rate of growth of financial intermediation in recent years, financial development in Bangladesh is still at a nascent stage, as can be seen through the financial indicators listed in Table 3.2. The broad money to GDP ratio of 51.96 percent indicates that the money market is shallow compared to many emerging economies. The secondary market for government securities is thin, and private bond market is non-existent. Hence, the supply of credit is dominated almost entirely by banks. In addition, there is a large market for informal credit and financial services in the rural area that is not influenced by monetary



Source: Bangladesh Economic Review 2014 and Bangladesh Bank Annual Report 2014-2015.

Figure 3.2: Growth of financial intermediation in Bangladesh.

policy. This, coupled with the underdeveloped formal financial market, puts constraints on the monetary policy transmission mechanism in Bangladesh.

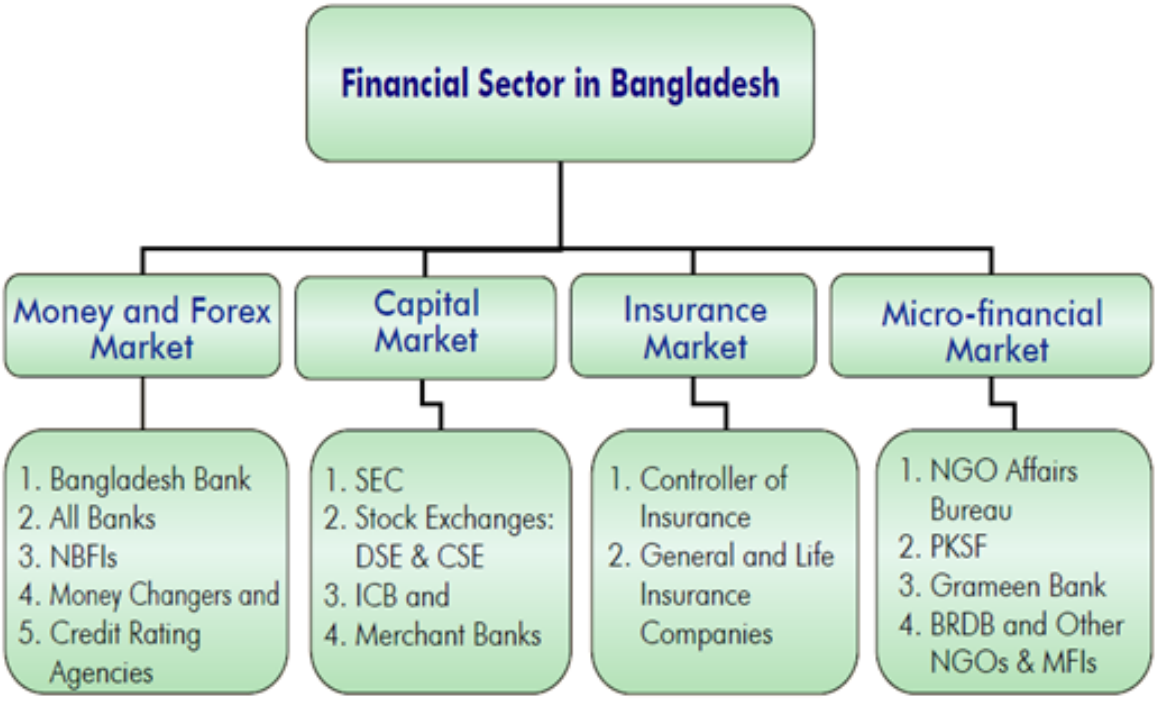
Bangladesh's financial system is comprised of banks, non-bank financial institutions, co-operative banks, insurance companies and two stock exchanges. Figure 3.3 presents a schematic diagram of the financial sector of Bangladesh. The financial system is dominated by banks. Bangladesh Bank is the supervisory authority of the banking system. There are four categories of banks. There are six state-owned commercial banks (SCBs), two specialized banks (SBs) for agricultural credit, 39 domestically owned private commercial banks (PCBs) and nine foreign commercial banks (FCBs).

After the country's independence in 1971, all banks were nationalized. The first private bank was established in 1982, but the major share of the banking industry belonged to SCBs. Though SCBs have become less dominant in the fund market over the years, they still hold 28.8 percent of the total assets of the banking industry while PCBs hold 63.3 percent. SCBs and SBs are known to be vulnerable to directed credit by the government. The non-performing loan (NPL) ratio for the SCBs was 21.9 percent in 2015 and return on equity

Table 3.2: Financial Development Indicators of Bangladesh

Broad Money (% of GDP)	51.96
Private Sector Credit (%of GDP)	49.00
Credit to Private Sector Provided by Banks(%)	99.00
Bank Deposits (% of GDP)	46.12
Private Bond Market (% of GDP)	0.00
Market Capitalization of Listed Companies (%of GDP)	17.82

Source: Bangladesh Bank Annual Report 2014-2015 and authors calculation



Source: Financial Sector Review, May 2006, Bangladesh Bank.

Figure 3.3: Financial sectors in Bangladesh.

(ROE) was a negative 22.5 percent[1]. The poor performance of SCBs along with SBs as a group, which constitutes almost 30 percent of the banking industry, put a substantial strain on the financial system. PCBs and FCBs operate much more efficiently as reflected by their NPL ratios of 5.7 and 8.2 respectively and ROEs of 9.7 and 15.7. Besides banks, 32 non-bank financial institutions (NBFIs) operate in Bangladesh. Of these, three are owned by the government, 19 are privately owned, and the rest are joint ventures with foreign investment. Most of the early NBFIs started primarily as leasing companies and gradually extended their operation into other forms of investment and merchant banking.

3.2 Monetary Policy Framework in Bangladesh

It is very important to include appropriate variables in the model to identify the monetary policy shock and correctly decipher the impact of such a shock in an economy. To do that, we need to understand the monetary policy framework of the central bank in question so that we know the policy variables that the central bank take into consideration while conducting monetary policy. Before going into detail on the policy framework and targets chosen by Bangladesh Bank, the common practice of central banking elsewhere will be briefly discussed.

Throughout their long history, central banks have performed a variety of functions. Central banks have control over the monetary management. They control the supply of money and credit and can effectively influence the interest rate. They ensure price stability. They determine the exchange rate and maintain the value of the currency. They manage the foreign exchange reserve. In some countries like Bangladesh they perform the supervisory role over the financial system and try to keep the system stable. They take deposits from

[1]Annual Report 2014-2015, Bangladesh Bank.

other commercial banks and serve as the lender of last resort. They are the government's bankers and agents. But in the most modern perspective, "the practice and theory of modern central banking revolve around the inflationary tendencies inherent in the conflict between the short- and long-run effects of monetary expansion and in the temptations of monetary financing of government spending" (Capie et al., 2008). This statement basically refers to the role of the central banks as a solution to the dilemma of dynamic inconsistency, which is described below.

In the past, it appeared that the government might want to increase employment and output to more than the natural level. If a politically influenced central bank increases the money supply to achieve that goal, inflation increases. But wage settlers, both unionized, and non-unionized become aware of inflation and increase wages. Therefore, the economy may experience excessive inflation without having any effect on employment both now and in the future. The inflation bias of monetary policy in the presence of the employment objective is due to this dynamic inconsistency. The problem of dynamic inconsistency arrives when a policy, that seems to be best for a future period is no longer best when that period actually comes. For example, setting an inflation target equal to zero is best before nominal wage contracts are signed but once they are signed, it may no longer seem the best short-run policy for central banks to pursue zero inflation, as they can achieve a higher employment by increasing inflation.

To avoid the short- and long-run inflationary bias produced by dynamic inconsistency, monetary policy tries to find a nominal anchor to serve as a target so that the central bank does not pursue a strategy of raising output unexpectedly with expansionary monetary policy. Mishkin and Posen (1997) argue that an inflation target can be used as a nominal anchor for the path of price level. Inflation targets may have an important advantage as the public can easily understand such a target. Targets may play a role in keeping inflation

expectations low and stable. Then the question arises, How might central banks achieve a targeted level of inflation?

One common approach in analyzing central bank behavior is to estimate reaction functions, which are equations that try to model central bank behavior. When a central bank conducts policy by changing the interest rate it, attaches some weights to the changes in inflation and some weights to changes in unemployment. A central bank that cares only about inflation will attach zero weight to unemployment and vice versa. A central bank can also respond to both inflation and unemployment. According to Taylor (1993), the central bank can implement the following rule:

$$i_t = \bar{r} + \pi_t + a(\pi_t - \pi^*) + b(y_t - y_t^*), \tag{3.1}$$

where i_t = nominal interest rate, $\bar{r}$ = equilibrium real interest rate, π_t = rate of inflation, π^*= target rate of inflation, y_t = level of output,and y_t^*= potential level of output.

Blanchard (2000) describes the Taylor rule as follows:

$$i_t = i^* + a(\pi_t - \pi^*) + b(u_t - u_t^*), \tag{3.2}$$

where i^* = targeted nominal interest rate, $i^* = \bar{r} + \pi_t$, u_t = unemployment rate, and u_t^*= natural rate of unemployment.

According to equation (3.2), if the inflation rate is equal to the target ($\pi_t = \pi^*$) and the unemployment rate is equal to the natural rate ($u_t = u_t^*$), the central bank should set the nominal interest rate, i equal to the target rate i^*. If inflation is higher than the target ($\pi_t > \pi^*$), it should be increased above i^*. When the nominal and real interest rate is increased, unemployment increases and inflation decreases. If unemployment is higher than the natural rate ($u_t > u_*$), the nominal interest rate should be decreased, which will in-

crease economic activity and eventually decrease the unemployment level, hopefully without generating inflation.

Coefficient a shows the response a central bank makes to an increase in inflation relative to unemployment, and b shows the response made to an increase in unemployment relative to inflation. If any central bank puts a weight of zero for unemployment (i.e., $b = 0$), the bank cares only about inflation, which is not very practical. In practice, central banks of most industrial nations follow a flexible inflation targeting; that is, instead of caring only about inflation, they also emphasize other economic indicators. A central bank does not necessarily follow the rule strictly. It may depend on the economic condition of a particular country and may vary from country to country.

One needs to bear in mind that domestic monetary policy is not well equipped to fight inflationary impact of external shocks. Therefore, while setting inflation targets, many central banks focus on the core measure of inflation which does not include the more volatile components of CPI like food or energy prices. Bangladesh does not have any measure of core inflation at present, and the construction of one faces two major obstacles. First, the weight of food items in CPI is nearly 60 percent. Hence, deducting food items from CPI is not very practical in the case of Bangladesh. On the other hand, Bangladesh government sets the energy prices which are highly subsidized and do not reflect the volatility of international energy prices. Though there is periodic adjustment to energy prices by the government, such adjustment does not reflect world market changes either in terms of time line or magnitude. The non-food component constitutes 41.6 percent of CPI, and it will not be prudent to treat that as the core measure of inflation. Hence, in the absence of any measure of core inflation, it may not be very practical for Bangladesh Bank to pursue an inflation-targeting policy.

While the major concern of monetary policy in mature economies is to keep unemployment close to its natural rate and actual output close to potential output, in developing countries the main challenge is to maintain higher economic growth through increasing pro-

ductive capacity. Growth is an overriding concern in such countries facing acute poverty. Therefore, relying solely on low inflation environment may not help a country like Bangladesh to achieve its poverty and growth targets. Rather, a suitable monetary policy for Bangladesh is a combination of sustained growth and a stable price level. At the current stage of economic development, Bangladesh is focusing more towards an export-led growth strategy, which is common for most emerging economies. Hence, maintaining a stable value of the exchange rate also becomes a necessary part of monetary policy strategy. However, Bangladesh has adopted the floating exchange rate arrangement since May 2003, and therefore the equilibrium value of the exchange rate is determined in the foreign exchange market. Yet the central bank can intervene in the foreign exchange market to curb the liquidity when and as needed.

Bangladesh Bank is responsible for formulation and implementation of monetary policy in Bangladesh. According to the Bangladesh Bank Order of 1972, Bangladesh Bank should ensure sustained economic growth while maintaining reasonable price stability and to ensure external competitiveness of the domestic currency *taka* to maintain a stable balance of payment position. Though in major industrialized countries monetary policy chooses short-term interest rates, like the federal funds rate in the case of US, interest rate intervention may not be the most suitable tool to influence aggregate demand in Bangladesh. Private-sector credit constitutes about 75 percent of total credit in Bangladesh, and the share of investment credit is even smaller. Therefore, though investment demand can be interest sensitive, changes in interest rate may not effectively influence domestic demand to a great extent.

Commercial bank lending dominates Bangladesh's fund market. The private bond market is virtually non-existent, and there is no secondary market for existing government securities. Only financial institutions can participate in the auction of short-term government securities (treasury bill, Bangladesh Bank bill), and general people can only invest in long-

term bonds and saving certificates which offer non-market interest rates. People do not have confidence in the stock market mainly due to two scandalous crashes and alleged insider trading. In the absence of alternative investment opportunities, most people keep their savings in bank deposits, which are the major source of fixed income in Bangladesh. On the other hand, investors mostly turn to banks for funds. Thus, interest elasticities of private saving and money demand are insignificant, and any change in short-term policy interest rate is not expected to directly pass through to lending and deposit rates of commercial banks. Hence, it is more practical for Bangladesh Bank to focus on monetary targeting while conducting monetary policy. Figure 3.4 concisely describes the monetary policy framework of Bangladesh.

The monetary programming of Bangladesh Bank is derived from the classical quantity theory of money, i.e.,

$$MV = PY, \tag{3.3}$$

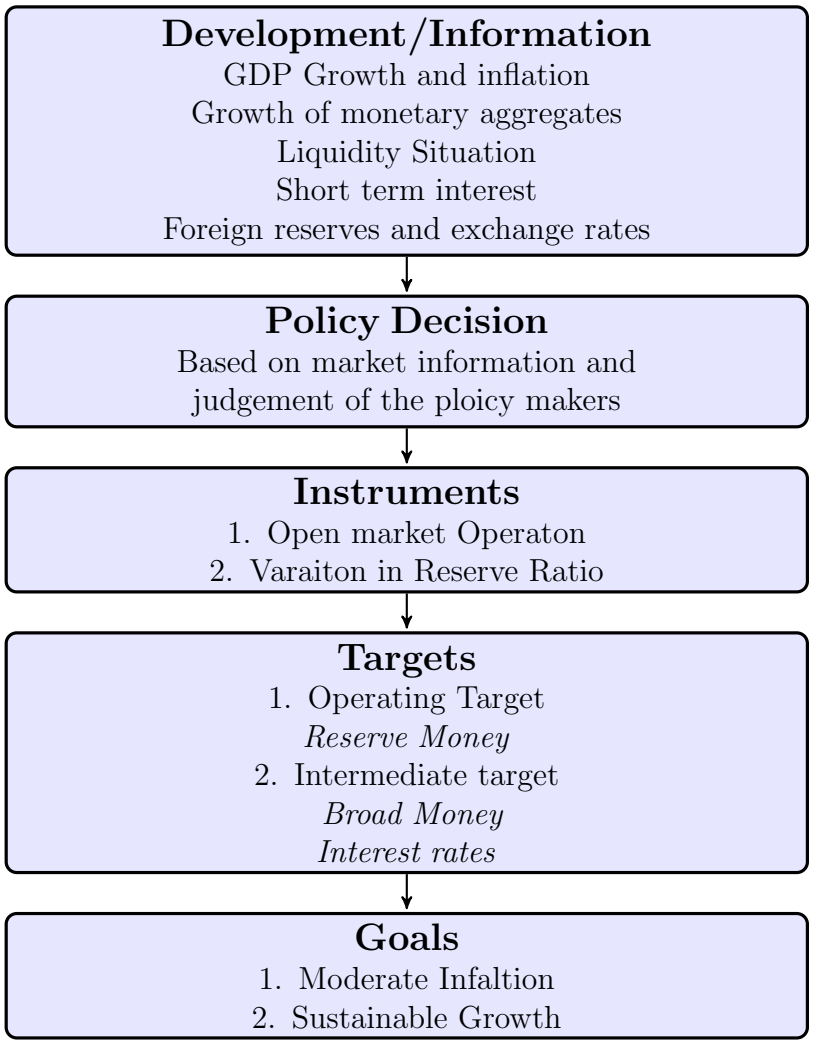
where M, V, P, and Y are money demand, velocity of money, price level, and real output. In growth-form (3.3) can be written as

$$g_M + g_V = g_P + g_Y, \tag{3.4}$$

$$g_M = g_P + g_Y - g_V, \tag{3.5}$$

where g_M, g_P, g_Y, and g_V are growth rates of money demand, expected inflation, anticipated growth of real output, and expected growth of income velocity of money respectively.

It appears that Bangladesh Bank follows a modified version of the quantity theory of money. According to this simple approach, Bangladesh Bank estimates inflation and GDP forecast to manage liquidity in the private credit market. As mentioned in the Monetary Policy Statement of July –Dec, 2009 (page 3), Bangladesh Bank focuses on reserve money



Source: Monetary Policy Statement, July-December 2015; Bangladesh Bank.

Figure 3.4: Monetary policy in Bangladesh.

as the operating target and $M2$ as the intermediate target. Reserve money can influence the growth path of $M2$ through the money multiplier. This type of monetary programming can be considered as a variant of the monetary policy rule offered by Taylor (1993).

A central bank may have different goals to achieve but it cannot directly influence such goals. Therefore, it uses different instruments that can affect the goals through the target variables. Bangladesh Bank has various instruments at its disposal to achieve the

estimated target growth of $M2$. These instruments include bank rate, the rate at which commercial banks can borrow from Bangladesh Bank; statutory liquidity requirement (SLR), the mandatory reserve requirement; and open market operation (OMO). Bank rate and SLR are rarely adjusted. The last times these rates changed were in November 2003 and June 2014. For day-to-day liquidity management, Bangladesh Bank uses OMO through repo (repurchase agreement), reverse repo (the counterpart of repo), and the weekly auction of treasury bills and Bangladesh Bank bills.[2] This adjustment of liquidity ultimately affects the interbank call money rate (overnight rate) and consequently deposit and lending rates.

One has to keep in mind that there can be substantial lag in the conduct of monetary policy, and it may take several quarters for the policy action to eventually influence the course of its goals. Hence, policy makers also keep an eye on the development of other indicative macrovariables like short-term interest rate, foreign exchange reserves, and liquidity situation to determine whether to revise its policy measures. Regardless of what type of monetary programming a central bank is pursuing, they always need to use judgment in deciding current and future policies.

[2]Repo allows financial institutions to borrow funds from Bangladesh Bank collateralized by treasury bills or Bangladesh Bank bills for an agreed time period; and at maturity, financial institutions will re-purchase those securities. Therefore, repo injects liquidity in the market. Reverse repo is the counterpart of repo where financial institutions purchase securities with a commitment to sell it back to Bangladesh Bank upon maturity. So reverse repo is used to reduce money supply.

CHAPTER 4

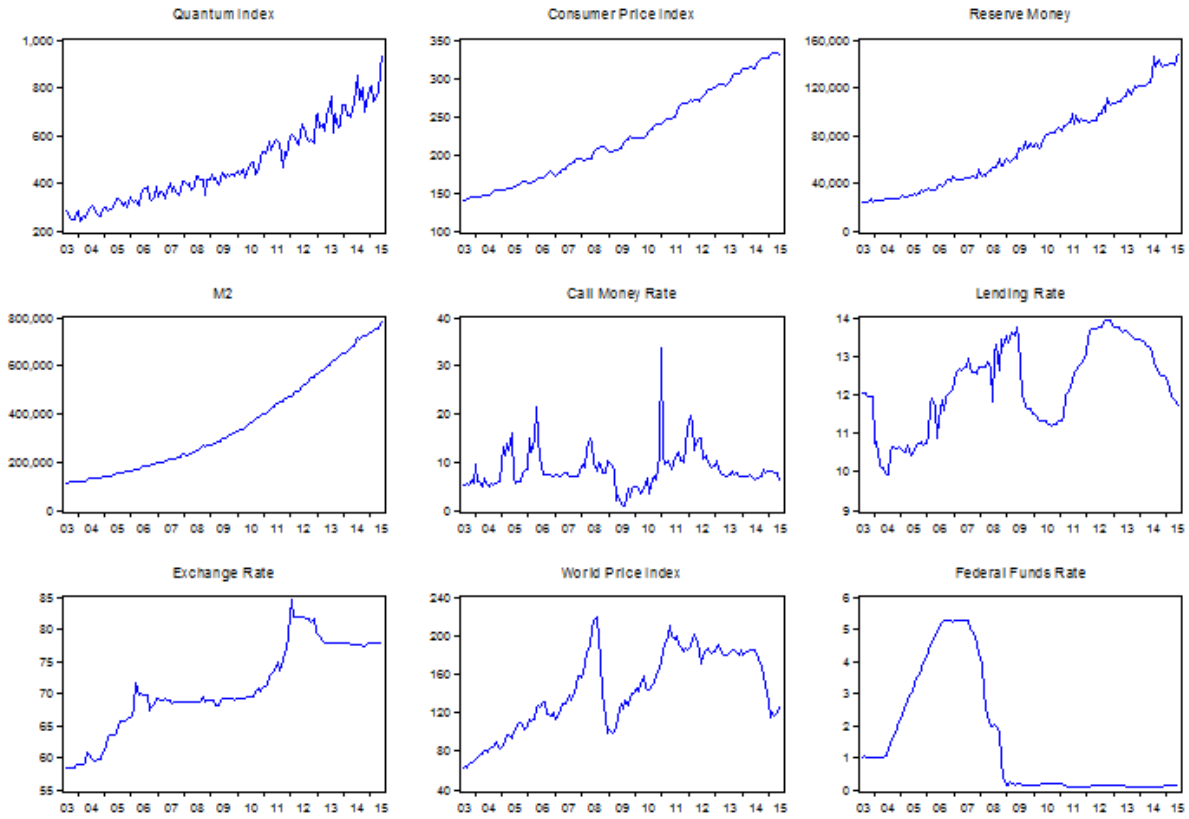
DATA

The data runs monthly from June 2003 through June 2015. Bangladesh Bank has adopted floating exchange rate arrangement since May 31, 2003. Hence, the data period was chosen to avoid any major policy shift and to focus solely on the effect of monetary policy shock under the floating exchange rate regime. The domestic variables considered are quantum index of manufacturing production (qi) representing GDP, inflation (π), reserve money (rm), broad money ($M2$), call money rate (cmr), lending rate (i^L), and nominal exchange rate (er). Two foreign variables, world commodity price index (wpi) and US federal funds rate (i^f), were used to isolate the effect of foreign policy shocks on the Bangladesh economy.

Bangladeshi GDP data is available only on an annual basis. Therefore, the quantum index was used as a proxy for GDP. Though this index was rebased to 2005-06 =100 recently, data for this new base is only available from 2012 onward. So, the series having a base of 1988-89 = 100 was used. Data for this series is collected from *Monthly Statistical Bulletin*, a publication of Bangladesh Bureau of Statistics. Data for all other domestic variables were extracted from different issues of *Economic Trends*, a monthly publication of Bangladesh Bank. Inflation was calculated from CPI data. Reserve money and $M2$ was used alternatively to represent monetary aggregates as they are the operating target and intermediate target of Bangladesh Bank. The interest rates used were call money rate and lending rate. Call money rate is the inter-bank overnight borrowing rate. This is the Bangladeshi equivalent of US federal funds rate. Lending rate is the weighted average lending rate of advances from commercial banks. World Commodity Price Index has a base of 2005=100 and includes both

fuel and non-fuel price indices. This data is taken from the IMF website. The US federal funds rate data is taken from the Federal Reserve Bank of St Louis website.

The graphical presentation and summary statistics of the variables in Figure 4.1 and Table 4.1 respectively provide a preliminary idea at the data.



Note: The figure shows the trends of the variables used in the study.

Figure 4.1: Plot of different variables.

During the sample period, quantum index reached a value of 941.41 from 240.62 while CPI increased from 139.58 to 333.76. Though both indices show regular fluctuation throughout the sample period, there was not a severe drop of value in any of them. Reserve money and $M2$ are stock variables and had upward trends for the whole sample period. Reserve money started from a value of 241 billion *taka* and reached a value of 1.48 trillion *taka*

Table 4.1: Summary Statistics of Variables

	qi	cpi	wpi	rm	$M2$	er	cmr	i^L	i^f
Mean	475.05	224.18	142.39	712.13.	3567.73	70.77	8.49	12.23	1.48
Median	429.15	212.08	140.83	681.2	2972.97	69.24	7.49	12.33	0.19
Maximum	941.41	333.76	219.9	1484.82	7876.14	84.47	33.54	13.95	5.26
Minimum	240.62	139.58	63.03	240.6	1139.48	58.41	0.74	9.91	0.07
Std. Dev.	165.96	59.91	41.21	371.34	2023.27	6.66	4.09	1.1	1.87

Note: qi, cpi and wpi are quantum index, consumer price index and world commodity price index respectively. rm and $M2$ represent reserve money and broad money in billion *taka*. er represents exchange rate expressed in *taka* per US dollar. cmr, i^L and i^f are call money rate, lending rate and federal funds rate respectively.

while $M2$ reached 7.87 trillion *taka* from 1.14 trillion *taka* during the sample period. After Bangladesh Bank adopted the floating exchange rate arrangement in May 2003, exchange rate remained relatively stable until mid-2004. Then it exhibited an upward trend from mid-2004 until the end of 2005. The foreign exchange market remained quite steady from early 2006 to the later part of 2010. The exchange rate depreciated in late 2010, and the trend continued until late 2011. The exchange rate started appreciating gradually until early 2013 and remained stable until the end of the sample period.

Starting from a value of 63 in July 2003, the world price index reached its peak value of 220 in July 2008. Following the financial crisis of 2007 to 2008, world price index fell sharply to a value of 98 by December 2008. The index then had an upward trend until April 2011. From April 2011 to June 2014, the index had a value between 210 and 170. After June 2014, the index plummeted again and reached a value of 115 by January 2015, and the index remained at this value until the end of the sample period. The US federal funds rate was 1 percent at the beginning of the sample period. The federal funds rate increased steadily from June 2004 and reached 5.3 percent by August 2006. It remained stable until July 2007. Following the financial crisis, the federal funds rate dropped quickly and was only

0.1 percent by the beginning of 2009. The federal funds rate remained around 0.1 percent until the end of the sample period.

Of the domestic interest rates, the lending rate exhibits a similar pattern to that of WPI. While its value fluctuated between 9.9 percent and 13.9 percent, it had an increasing trend from July 2004 to May 2009 when it reached 13.8 percent. The lending rate fell gradually to 11.2 percent by October 2010. Then it started rising again until November 2012 and reached 13.9 percent. It descended again afterwards and was 11.7 by June 2015. It seems like lending rate was influenced by the movement of WPI with a lag. The call money rate fluctuated around its mean value of 8.49 percent, having a minimum and maximum value of 0.74 percent and 33.54 percent respectively throughout the sample period. It did not exhibit any pattern similar to those of the world variables.

The stationary properties of the data are reported in Table 4.2. The table shows the test statistics for the augmented Dickey Fuller (ADF) test, Phillips Peron (PP) test, and Kwiatkwski-Phillips-Schmidt-Shin (KPSS) test.

The null hypothesis for ADF test and PP test is non-stationarity of the time series while KPSS test holds a null of stationarity. Each variable was tested both at log level and log difference level. The interest rate data were tested at level and first difference level. The quantum index (qi) and CPI were not stationary at log level but were stationary at log difference level according to all three tests considered. The reserve money (rm) was not stationary at log level. The ADF test could not reject the null of unit root in log-differenced reserve money even at 15 percent level, but the PP test rejects the null of unit root at the 0 percent level and the KPSS test could not reject the null of stationarity even at the 10 percent level. Therefore, the log-differenced reserve money is stationary. There were similar results for $M2$ where log level $M2$ was found to be a unit root process but log difference level of the series was considered to be a stationary process following the PP and KPSS test. All three tests found the log of exchange rate (er) to be a unit root process and log-

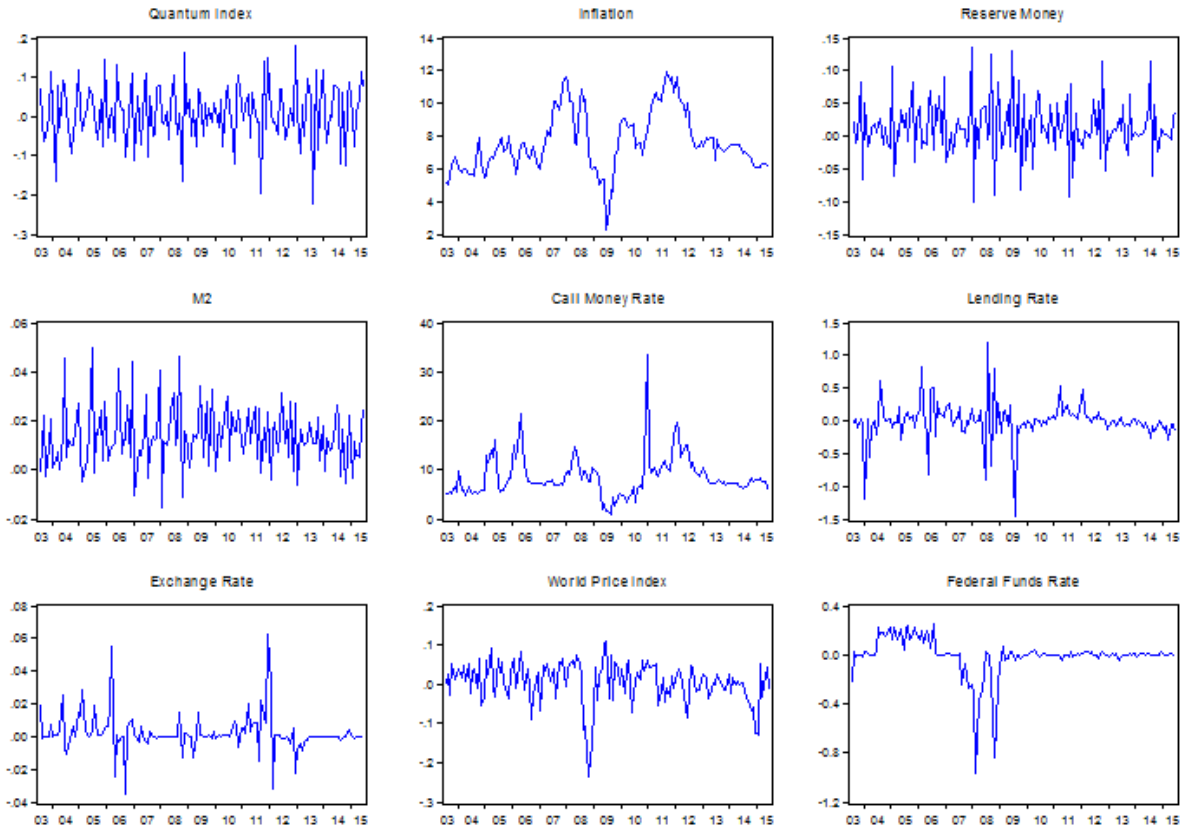
Table 4.2: Unit Root Tests of Variables

Variable	ADF	P value	Phillips Peron	P value	KPSS
Ln(qi)	1.338816	0.9988	0.263051	0.9756	1.405546
Dln(qi)	-4.653394	0.0002	-29.88356	0.0001	0.270415
Ln(CPI)	-0.04813	0.9517	-0.355223	0.9123	1.412153
Dln(CPI)	-3.18777	0.0227	-7.799282	0	0.117887
Ln(rm)	-1.099931	0.7147	-0.569143	0.8726	1.405729
Dln(rm)	-2.364952	0.1538	-21.93193	0	0.101666
Ln($M2$)	-1.029317	0.7418	-0.060661	0.9505	1.414349
Dln($M2$)	-1.604754	0.4776	-16.97092	0	0.18263
cmr	-5.457227	0	-5.478781	0	0.097577
i^L	-1.533312	0.514	-1.658198	0.4503	0.666632
D(i^L)	-5.890065	0	-12.15217	0	0.122812
Ln(er)	-1.951443	0.3081	-1.925808	0.3197	1.216935
Dln(er)	-10.80564	0	-10.80564	0	0.221521
Ln(wpi)	-2.534249	0.1095	-2.403149	0.1427	1.050072
Dln(wpi)	-5.541879	0	-7.824706	0	0.256783
i^f	-2.828987	0.0567	-1.003401	0.7512	0.704512
D(i^f)	-1.882043	0.34	-4.940523	0.0001	0.203108

Note: Asymptotic critical values for KPSS test at 1%, 5% and 10% level are 0.739, 0.463 and 0.347 respectively. Ln refers to log of a variable and Dln refers to log difference. D represents first difference.

differenced exchange rate series to be stationary, which is also true for the world price index (wpi). Among the interest rate series, all three tests found the call money rate (cmr) to be stationary at level. The lending rate (i^L) is non-stationary at level but becomes stationary at first difference. The ADF test could not reject the null of unit root in the US federal funds rate data at the 5 percent level. The PP and KPSS test also found this series to be

non-stationary. The series was found to be stationary at first difference level by the PP and KPSS test. The first difference level of the federal funds rate was considered to be stationary. Figure 4.2 shows the stationary series.



Note: The figure shows growth rate of quantum index, reserve money, $M2$, exchange rate and world price index. Inflation is calculated from CPI. Call money rate is in level, lending rate and federal funds rate are in first difference.

Figure 4.2: Stationary series of different variables.

The figure shows similar patterns in world price index and domestic inflation especially from 2007 to 2010. It seems like domestic inflation is following the world price index. The lending rate also seems to have some similarities with the federal funds rate in terms of fluctuations, but the call money rate shows a very different pattern.

CHAPTER 5

METHODOLOGY

Vector autoregressive models (VARs) are widely used for understanding the effects of monetary policy on the economy (Jääskelä & Jennings, 2011). VAR can also be used as a macroeconomic forecasting tool. The literature suggests that there are two identification structures, namely recursive and non-recursive, which can be imposed on the contemporaneous matrix.

Recursive Structure. The recursive structure assumption is established based on the successive relationship between variables, and it implies that monetary policy shocks are orthogonal to the information set of the monetary authority. To recover the structural shocks from the VAR residuals one can use Cholesky decomposition, where the variables are to be ordered in a particular sequence so that variables placed higher in the ordering, have contemporaneous impact on the variables that are lower in the ordering, and not vice versa. These identifying assumptions correspond to the notion that economic variables are determined in a block-recursive way.[1] But in reality, monetary and financial variables placed lower in the ordering can have contemporaneous effect on the variables placed higher in the ordering which cannot be captured through a recursive VAR settings. Therefore, the notion of recursive relationship may not be appropriate to identify the simultaneous contemporaneous relationships between policy instruments and money market variables (Zha, 1997).

[1]For details, see Christiano et al. (1999), Dungey and Pagan (2000).

Non-recursive Structure. To identify structural shocks of monetary policy, another useful tool is non-recursive SVAR, which relaxes the assumption taken in the recursive model. The non-recursive structure allows contemporaneous interactions between policy variables and other information market variables. For example, in the recursive VAR ordering, to obtain the effect of interest rate innovation on the exchange rate, one has to put the interest rate after the exchange rate, which implies that interest rate cannot respond to contemporaneous changes in the exchange rate.[2] But in the case of SVAR we can trace out the contemporaneous relationship between interest rate and exchange rate in either direction.

The SVAR approach stemmed from the seminal contributions of Cooley and LeRoy (1985), Sims (1986) and Blanchard and Watson (1986), who made use of economic theory to estimate the structural parameters and to recover the underlying independent structural disturbances. There are several ways to do that. One approach is to identify a SVAR to use the restrictions that are implied by a fully specified theoretical macroeconomic model. For example, Blanchard and Watson (1986) used economic theory to incorporate short-run restrictions, while Shapiro and Watson (1988) and Blanchard (1989) used economic theory to justify the inclusion of long-run restrictions. An SVAR model can help to impose theoretically motivated restrictions on the potential relationship among the macroeconomic variables. This study, thus, followed the SVAR model.

A seven-dimensional time series x_t was considered, where $x_t = [wpi, i^f, qi, \pi, m, i^d, er]$, representing the following variables: world commodity price index (wpi), US federal fund rate (i^f), quantum index of manufacturing production (qi), CPI inflation (π), monetary aggregate (m), domestic interest rates (i^d), and nominal exchange rates (er) respectively. The component of x_t varied depending on the set of variables used to represent the SVAR model. These models are presented in Table 5.1. The four SVAR models considered in this paper differed in terms of the different measure of monetary aggregates and domestic interest

[2]See Sims and Zha (2006), Kim and Roubini (2000).

Table 5.1: SVAR Models

SVAR Model	Variable Used	Policy Varaibles
Model 1	wpi, i^f, qi, π, rm, i^L, er	rm
Model 2	wpi, i^f, qi, π, $M2$, i^L, er	$M2$
Model 3	wpi, i^f, qi, π, rm, cmr, er	cmr
Model 4	wpi, i^f, qi, π, rm, i^L, er	i^L

Note: Models 1, 3 and 4 used reserve money as the monetary aggregate, while Model 2 used $M2$. Lending rate was used to represent the domestic interest rate except for Model 3, which used call money rate.

rates. The models also differed depending on the variable chosen as the policy variable or monetary policy instrument of the central bank. For example, in the case of Model 1, rm is considered to be the monetary policy variable that the central bank chooses to conduct monetary policy. The IRFs will then generate the response of other variables included in the model to any change in this policy variable rm.

The structural vector autoregressive model can be written as

$$B_0 x_t = B_1 x_{t-1} + B_2 x_{t-2} + ... + B_p x_{t-p} + u_t, \tag{5.1}$$

where $u_t = [u_t^{wpi}, u_t^{if}, u_t^{qi}, u_t^{\pi}, u_t^{m}, u_t^{id}, u_t^{er}]'$, representing the vector of structural shocks, which consists of world price index shocks (u_t^{wpi}), foreign interest rate shocks (u_t^{if}), domestic output shocks (u_t^{qi}), domestic inflation shocks (u_t^{π}), money supply shocks (u_t^{m}), domestic interest rate shocks (u_t^{id}) and exchange rate shocks (u_t^{er}) respectively. It is assumed that these shocks u_t are serially uncorrelated and unconditionally homoskedastic. The structural shocks are also mutually uncorrelated.

The variance-covariance matrix of the structural shocks is normalized as

$$E(u_t u_t^{'}) \equiv \Sigma_u = I_n, \tag{5.2}$$

where I_n is an n dimentional identity matrix.[3]

Equation 5.1 can be re-written as

$$B(L)x_t = u_t, \tag{5.3}$$

where $B(L) = B_0 - B_1 L - B_2 L^2 - ..... - B_p L^p$ is the autoregressive lag polynomial of order p.

Equation 5.1 implies

$$x_t = A_1 x_{t-1} + A_2 x_{t-2} + ... + A_p x_{t-p} + \epsilon_t, \tag{5.4}$$

where ϵ_t is the shocks from the reduced model, $A_i = B_0^{-1} B_i$ for $i = 1, 2, ..., p$, and $\epsilon_t = B_0^{-1} u_t$.

Equation 5.4 can be written as

$$A(L)x_t = \epsilon_t, \tag{5.5}$$

where $A(L) = I - A_1 L - A_2 L^2 - ..... - A_p L^p$ is the autoregressive lag polynomial of order p. The reduced-form parameters A_i, the reduced-form shocks ϵ_t and their variance-covariance matrix $E(\epsilon \epsilon_t^{'}) \equiv {I_n}^4$ can be estimated.

To obtain the IRFs it is necessary to find structural shocks u_t. Structural shocks u_t can be recovered from reduced-form shocks ϵ_t as reduced-form shocks are composites of

[3]This normalization does not involve a loss of generality, as long as the diagonal elements of B_0 remain unrestricted.

[4]See Lütkepohl and Krätzig (2004).

structural shocks. The SVAR method uses economic theory to place appropriate restrictions on the B_0 matrix to recover the structural shocks u_t.

The variance of ϵ_t is $E(\epsilon\epsilon_t^{'}) = B_0^{-1}E(u_t u_t^{'})B_0^{-1'}$, which implies $\Sigma_\epsilon = B_0^{-1}\Sigma_u B_0^{-1'}$. By construction, $\Sigma_\epsilon = B_0^{-1}B_0^{-1'}$ as $\Sigma_u = I_n$. As Σ_ϵ is a function of B_0^{-1}, this system can be solved for the unknown parameters in B_0^{-1} as long as the unknown parameters in B_0^{-1} are less than or equal to the number of equations in the system. To ensure that, one needs to impose additional restrictions on selected elements of $B_0^{-1'}$ (or equivalently B_0). These types of restriction may take the form of exclusion restrictions, proportionality restriction, or other equality restrictions. The most common approach is to impose the zero restrictions, i.e., forcing some of the contemporaneous coefficients of the B_0 matrix to be equal to zero. These restrictions are motivated by economic theory or institutional knowledge.[5] To identify the Bangladesh SVAR models, we can have the following restrictions:

$$\begin{bmatrix} u_t^{wpi} \\ u_t^{i^f} \\ u_t^{qi} \\ u_t^{\pi} \\ u_t^{m} \\ u_t^{i} \\ u_t^{er} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ b_{31} & 0 & 1 & 0 & 0 & 0 & 0 \\ b_{41} & 0 & b_{43} & 1 & 0 & 0 & 0 \\ 0 & 0 & b_{53} & b_{54} & 1 & b_{56} & b_{57} \\ b_{61} & 0 & 0 & b_{64} & b_{65} & 1 & b_{67} \\ b_{71} & b_{72} & b_{73} & b_{74} & b_{75} & b_{76} & 1 \end{bmatrix} \begin{bmatrix} \epsilon_t^{wpi} \\ \epsilon_t^{i^f} \\ \epsilon_t^{qi} \\ \epsilon_t^{\pi} \\ \epsilon_t^{m} \\ \epsilon_t^{i^d} \\ \epsilon_t^{er} \end{bmatrix}, \tag{5.6}$$

where the left hand side of the equation represents the structural shocks as described above and ϵ_t^{wpi}, $\epsilon_t^{i^f}$, ϵ_t^{qi}, ϵ_t^{π}, ϵ_t^{m}, $\epsilon_t^{i^d}$, ϵ_t^{er} are the residuals in the reduced-form equations that actually represent unexpected movement of each variable.

The restrictions on B_0 matrix are motivated by Kim and Roubini (2000). The world price index (wpi) and the US federal funds rate (i^f) are considered to be contemporaneously

[5] See Kilian (2011).

exogenous world shock variables; i.e., none of the domestic variables can contemporaneously affect these world variables. Of these two variables, the world price index is assumed to affect the US interest rate as world event shocks but not vice versa. Of the domestic variables the quantum index is considered to be affected contemporaneously only by the world price index, which includes fuel and energy price. Domestic production may respond to domestic price level only with a lag. Inflation is contemporaneously affected by the world price index and domestic production. Money supply (m) equation is considered to be the reaction function of the central bank. Bangladesh Bank sets money supply in response to output (qi), inflation (π), domestic interest rate (i^d), and exchange rate (er). Domestic interest rate is contemporaneously affected by world price index (wpi), money supply (m) and exchange rate (er). Exchange rate is considered to be a forward-looking asset price, and therefore all variables have a contemporaneous effect on exchange rate.

Given the restrictions on B_0 described above, we can express the structural system of contemporaneous variables as follows:

$$
\begin{aligned}
& wpi_t = u_t^{wpi} \\
& b_{21} wpi_t + i_t^f = u_t^{if} \\
& b_{31} wpi_t + qi_t = u_t^{qi} \\
& b_{41} wpi_t + b_{43} qi_t + \pi_t = u_t^{\pi} \\
& b_{53} qi_t + b_{54} \pi_t + m_t + b_{56} i_t^d + b_{57} er_t = u_t^{m} \\
& b_{61} wpi_t + b_{64} \pi_t + b_{65} m_t + i_t^d + b_{67} er_t = u_t^{i^d} \\
& b_{71} wpi_t + b_{72} i_t^f + b_{73} qi_t + b_{74} \pi_t + b_{75} m_t + b_{76} i_t^d + er_t = u_t^{er}
\end{aligned}
\tag{5.7}
$$

Moving all the contemporaneous independent variables to the right-hand side of each equation, (5.7) can be equivalently written as

$$
\begin{aligned}
wpi_t &= u_t^{wpi} \\
i^f &= -b_{21} wpi_t + u_t^{i^f} \\
qi_t &= -b_{31} wpi_t + u_t^{qi} \\
\pi_t &= -b_{41} wpi_t - b_{43} qi_t + u_t^{\pi} \\
m_t &= -b_{53} qi_t - b_{54} \pi_t - b_{56} i_t^d - b_{57} er_t + u_t^m \\
i_t^d &= -b_{61} wpi_t - b_{64} \pi_t - b_{65} m_t - b_{67} er_t + u_t^{i^d} \\
er_t &= -b_{71} wpi_t - b_{72} i_t^f - b_{73} qi_t - b_{74} \pi_t - b_{75} m_t - b_{76} i_t^d + u_t^{er}
\end{aligned}
\tag{5.8}
$$

Equations (5.8) imply that *wpi* is not contemporaneously affected by any other variables in the system. In the US federal funds rate (i^f) equation, -b_{21} is assumed to be positive as an increase in the world price may create upward pressure in US domestic price level and the Fed may respond by increasing the interest rate. Quantum index (*qi*) is contemporaneously affected only by *wpi* and -b_{31} is assumed to be positive as upward pressure in world prices may be transmitted to local prices, which may induce an increased supply. -b_{41} is positive as domestic inflation is assumed to be positively affected by *wpi* while -b_{43} is negative, as an increase in output should decrease domestic inflation. In the money supply equation, -b_{53} is assumed to be positive as increase in output may warrant a higher money supply. -b_{54} is assumed to be negative as the central bank usually reduces money supply in the face of increased inflation. -b_{56} is assumed to be positive as the central bank may increase money supply when interest rate is increasing to ease up the fund market. We expect -b_{57} to be negative. Exchange rate is defined as *taka* per US dollar, and therefore an increase in *er* refers to depreciation of local currency and in such a case the central bank may want to reduce money supply to maintain the par value of *taka*.

The sixth equation is the interest rate equation. -b_{61} is negative as an increase in world price may increase import prices and the central bank may want to decrease interest rate to facilitate import through increased funds in the fund market. -b_{64} is expected to be positive

as the central bank may go for a tighter monetary policy stance in the face of increased domestic inflation. -b_{65} is negative as an increased money supply is supposed to decrease interest rate. -b_{67} is expected to be negative because when the domestic currency is being depreciated, the central bank may increase domestic interest rate to attract foreign capital, which will eventually lead to an appreciation of domestic currency.

The seventh equation is the exchange rate equation. We expect -b_{71} to be negative as an increase in foreign price level may increase the demand for domestic goods and services and therefore may increase the demand for domestic currency, which may result in an appreciation of domestic currency. The sign of -b_{72} is ambiguous as it depends on what leads to the increase in foreign interest rate. -b_{73} is assumed to be negative as an increase in domestic output necessitates increased demand for domestic currency, which may lead to an appreciation of *taka*. -b_{74} is also expected to be negative as domestic inflation leads to increased demand for liquidity. -b_{75} is expected to be positive as increased money supply may dampen the value of domestic currency, and finally -b_{76} is expected to be negative as increased domestic interest rate may attract foreign investment and increase the demand for local currency, which may lead to an appreciation of domestic currency.

The contemporaneous co-efficient of the right-hand side of the equations of the system constitutes the B_0^{-1} matrix. The B_0^{-1} inverse matrix of our baseline model (Model 1) will be studied in the next chapter.

CHAPTER 6

RESULT ANALYSIS

Structural VAR techniques were used to explore the impact of monetary policy shock on the Bangladesh economy. The structural approach of this paper allows a greater degree of contemporaneous interaction among the variables, which makes this model different from the existing approaches in the literature on Bangladesh. First, the estimated coefficients of the B_0^{-1} matrix of Model 1, which is considered to be the baseline model, are reported in Table 6.1. These coefficients can be instructive to understand the usefulness of the SVAR approach. Second, impulse response functions will be generated from all four models considered in this paper, listed in Table 5.1, to discover the impact of monetary policy shock on different macroeconomic variables.

Table 6.1 shows that most of the coefficients of B_0^{-1} matrix are significant at the 5 percent level. More importantly, all of the contemporaneous coefficients of the financial variables, namely money supply, the interest rate, and the exchange rate are highly significant. It reveals the importance of using a structural identification, which allows financial variables to interact simultaneously, over a recursive approach.

The first two rows of Table 6.1 represent the foreign variables incorporated in the model. The first row represents the world price index equation. The world price index is not affected by the US interest rate or any of the domestic variables. The second row shows the US federal funds rate, which is assumed to be contemporaneously affected by world price index only. None of the domestic variables of a small economy like Bangladesh should have enough fire power to affect the policy rate of the biggest economy of the world. The coefficient of the world price index ($-b_{21}$) in the US federal funds rate equation was found

Table 6.1: Estimated Contemporaneous Coefficients

Parameter	-b_{11}	-b_{12}	-b_{13}	-b_{14}	-b_{15}	-b_{16}	-b_{17}
Estimate	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
(SE)	_	_	_	_	_	_	_
Parameter	-b_{21}	-b_{22}	- b_{23}	-b_{24}	-b_{25}	-b_{26}	-b_{27}
Estimate	0.547848**	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
(SE)	[0.0830]	_	_	_	_	_	_
Parameter	-b_{31}	-b_{32}	-b_{33}	-b_{34}	-b_{35}	-b_{36}	-b_{37}
Estimate	0.135111**	0.000000	1.000000	0.000000	0.000000	0.000000	0.000000
(SE)	[0.0830]	_	_	_	_	_	_
Parameter	-b_{41}	-b_{42}	-b_{43}	-b_{44}	-b_{45}	-b_{46}	-b_{47}
Estimate	0.00278	0.000000	-0.002773	1.000000	0.000000	0.000000	0.000000
(SE)	[0.0838]	_	[0.0830]	_	_	_	_
Parameter	-b_{51}	-b_{52}	- b_{53}	-b_{54}	-b_{55}	-b_{56}	-b_{57}
Estimate	0.000000	0.000000	2.66801**	-7.401051**	1.000000	0.547412**	-92.93144**
(SE)	_	_	[0.1958]	[0.416]	_	[0.233]	[5.456]
Parameter	-b_{61}	-b_{62}	-b_{63}	-b_{64}	-b_{65}	-b_{66}	-b_{67}
Estimate	-0.202806**	0.000000	0.000000	24.67044**	-32.89985**	1.000000	-0.050893
(SE)	[0.0833]	_	_	[1.495]	[1.989]	_	[2.971]
Parameter	-b_{71}	-b_{72}	-b_{73}	-b_{74}	-b_{75}	-b_{76}	-b_{77}
Estimate	-0.317656**	-1.015628**	-1.613500**	-7.968092**	7.374005**	-4.515764**	1.000000
(SE)	[0.0986]	[0.1022]	[0.1272]	[2.132]	[2.805]	[0.278]	_

Note: Entries correspond to the contemporaneous-coefficient matrix, B_0^{-1} of Model 1. Figures in parenthesis indicate standard errors.

to be positive and significant at the 5 percent level. It indicates that when world prices increase, the US responds by increasing its target rate to control domestic inflation.

Rows three through seven represent the domestic variables of the model. The third row stands for domestic output equation. It is assumed that domestic output is contemporaneously affected only by the world price index. The co-efficient of the world price index (-b_{31}) in this equation is significant at the 5 percent level and positive. The fourth equation is the inflation equation. Domestic inflation is assumed to be contemporaneously affected by world price index and domestic output. The coefficient of the world price index (-b_{41}) is positive and that of domestic output (-b_{43}) is negative. Therefore both the coefficients bear the expected sign but they are not statistically significant at the 5 percent level.

The contemporaneous interactions of financial variables listed in rows five through seven are more important because they show the interactions of the domestic financial variables. Row five represents the equation for monetary aggregate (reserve money for our base-line model). All the coefficients in this equation are significant at less than the 5 percent level and bear the correct sign. The coefficient of output (-b_{53}) is positive, indicating that as output increases, the central bank reacts to that increase in output by increasing money supply to facilitate transaction. The negative coefficient of inflation (-b_{54}) in the equation means that the central bank decreases money supply when they encounter inflationary pressure. Domestic interest rate (-b_{56}) has a positive sign, which means the central bank increases the money supply in case of an increased interest rate to ease up the economy. And finally, the coefficient of the exchange rate (-b_{57}) is negative. An increase in exchange rate in the model would refer to a depreciation of the currency. Therefore, a negative coefficient of the exchange rate means that when the exchange rate increases (domestic currency depreciates), the central bank reacts to that movement by decreasing the money supply. This may create a shortage of domestic currency in the foreign exchange market leading to a subsequent appreciation of domestic currency. Therefore it shows that the central bank of Bangladesh is very much concerned about the par value of the domestic currency.

The sixth row of the table represents the domestic interest rate equation. All the coefficients in this equation are significant at less than the 5 percent level except for the coefficient of the exchange rate. The coefficient for inflation is positive (-b_{64}), indicating a tighter interest rate policy in the face of a higher price level. The coefficients of monetary aggregate (-b_{65}) and exchange rate (-b_{67}) bear negative signs. This can be an indication that interest rate in Bangladesh is determined by monetary developments and not vice versa. That is, an increase in money supply results in a decrease in domestic interest rate. The insignificant coefficient of the exchange rate indicates that the interest rate does not respond to movement in the value of domestic currency. This may indicate that the central bank of

Bangladesh conducts monetary policy through monetary aggregates rather than changing the interest rate.

Finally, the seventh row represents the exchange rate equation. All the coefficients in this equation are significant at the 5 percent level. The coefficients of output (-b_{73}) and inflation (-b_{74}) bear negative signs. It stipulates that as output or inflation increases, the demand for domestic currency increases as well, which results in its appreciation. Monetary aggregate (-b_{75}) has a positive sign in this equation. This is expected as an increase in money supply should lead to a depreciation of domestic currency. The coefficient of interest rate (-b_{76}) bears a negative sign, which indicates that a tighter monetary condition in the domestic economy leads to a dearth of domestic currency, which results in its appreciation.

The principal objective of this paper is to identify the effects of monetary policy shocks on major macroeconomic variables through IRFs. To find the IRFs from different models, B_0 matrices of each of the models mentioned in Table 5.1 were estimated. The main purpose of reporting B_0^{-1} matrix of Model 1 was to establish that the SVAR methodology can better capture the reality by allowing the contemporaneous relationship among different variables. B_0^{-1} matrices of other models are very similar to that of Model 1 in terms of explaining the interaction among different variables, although the coefficient values differ in alternative models. Therefore, B_0^{-1} matrices of Models 2, 3 and 4 are not reported as that will overburden the analysis without providing any additional useful information.

Before presenting our impulse responses, the theory of open-economy monetary transmission mechanism will be discussed. Following the seminal work of Obstfeld and Rogoff (1995), there has been a considerable amount of literature on open-economy monetary transmission mechanisms (e.g., Chari et al., 2002; Gali & Monacelli, 2005; Kollmann, 2001). These models assume stickiness in prices and wages.

According to these models, in response to a contractionary monetary policy shock, the market interest rate is expected to rise, leading to an inflow of foreign capital to the domestic

economy. This would create an excess demand for domestic currency and domestic currency should appreciate vis-à-vis foreign currency. As a result, prices of domestic products may rise compared to that of foreign products leading to a fall in net exports. On the other hand, increase in the domestic interest rate leads to a reduction in interest-sensitive consumption and investment, which leads to a reduction in aggregate demand.

In the short run, output is determined by aggregate demand. Hence, a fall in aggregate demand following a contractionary monetary policy causes a fall in aggregate output. This slack in economic activity may lead to a fall in labor demand and can eventually reduce wages and prices even in a sticky price setting. Hence, cost of production will fall and inflation should eventually decrease. Therefore, according to the theory, a contractionary monetary policy has an immediate effect on the interest rate and the exchange rate but a delayed effect on output. Inflation is supposed to be affected by an even further delay.

To understand the monetary policy stance of the central bank we need to find an observable indicator. Choosing the monetary policy indicator remains controversial in the literature. The final goal of a central bank could be to influence growth of output through aggregate demand or to have a stable price level. In practice, central banks choose a financial variable as an intermediate target that they think is linked to their final goal. This intermediate target can be monetary aggregates ($M1$ or $M2$) or short-run or long-run interest rates. Central banks try to influence the value of this financial variable with a hope to ultimately achieve their final goal through monetary transmission mechanisms. But central banks cannot directly influence these intermediate targets. Therefore, they choose some other variables, termed as operating targets, which they can influence more directly through their policy tools. The operating target can be some form of reserve aggregates like reserve money or short-term interest rate like the federal funds rate. Mishkin and Posen (1997) suggested that if the central bank chooses a monetary aggregate as an intermediate target, then the operating target should also be some form of monetary aggregate like reserve money.

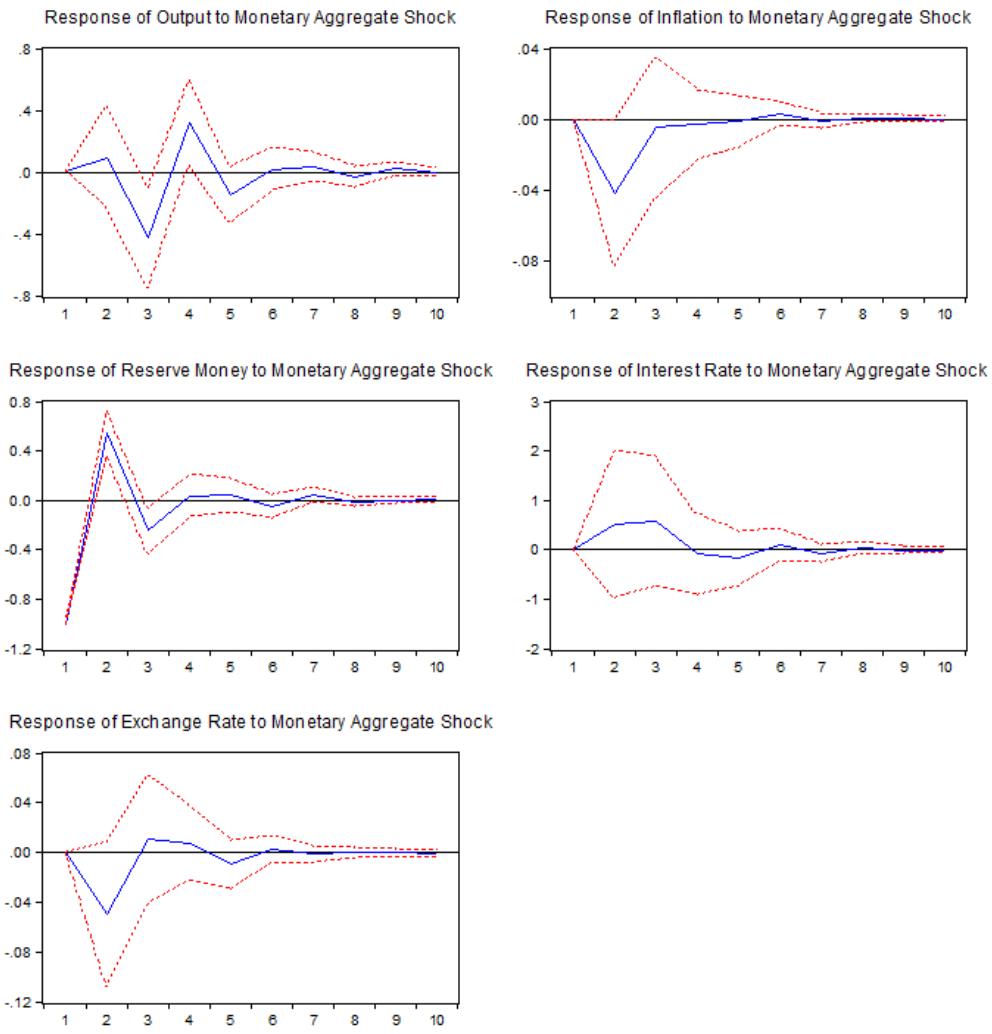
On the other hand, if the intermediate target is an interest rate, then the operating target should be an interest rate as well because interest rates will be more closely linked to each other.

Mishra and Montiel (2013) cautioned that while conducting empirical research on monetary policy transmission mechanisms, one should choose the operating or intermediate target carefully so that these targets match with the actual targets of the central bank. For example, choosing a short-term interest rate as a monetary policy variable, when the central bank actually chooses monetary aggregates as an intermediate target, may lead to misidentification of the policy instrument. In the July-December 2009 issue of the monetary policy statement of Bangladesh Bank, it is clearly stated that while formulating monetary programming, Bangladesh Bank considers reserve money and $M2$ as the operating target and intermediate target respectively. Therefore, to understand the effect of monetary policy changes in Bangladesh, Models 1 and 2 used reserve money and $M2$ respectively to identify monetary policy shock.

There is an increasing tendency to use the short-term interest rate as the monetary policy instrument in the current literature. To check the robustness of the results, the interest rate was used to identify monetary policy shocks in Models 3 and 4. Sims (1992) and Bernanke and Blinder (1992) suggested the use of the federal funds rate as the monetary policy instrument for the US economy. In a developing country context, Cheng (2006), Davoodi et al. (2013), Alam and Waheed (2006), and Alam (2015), among others, used short-term interest rate to identify monetary policy shocks. For the current study, the call money rate (short-term inter-bank borrowing rate) and the bank lending rate were used as representative interest rates in Models 3 and 4 respectively. In Bangladesh, call money rate is the equivalent of the federal funds rate in the US. Bangladesh Bank may also be concerned about the commercial bank lending rate because in the absence of any active private bond market, the lending rate can serve as the major interest rate for the fund market.

Impulse responses from different models were compared to see whether these models can solve the liquidity, the price, and the exchange rate puzzles. According to economic theory, an expansionary policy is supposed to lower the interest rate. The liquidity puzzle occurs when an increase in money supply increases the interest rate rather than decreasing it. The price puzzle is the phenomenon where an increase in interest rate, caused by a restrictive monetary policy, leads to an increase in the price level. This is at odds with monetary theory, which predicts a reduction in the price level in response to a monetary contraction. The exchange rate puzzle arises if an increase in interest rate causes a depreciation of the currency rather than the currency being appreciated.

Impulse Responses from Model 1. The impulse responses from Model 1 are presented in Figure 6.1. The figure shows the impulse response function of the domestic variables to one unit negative reserve money shock. In response to this money supply shock, the interest rate rises immediately and the stock of money falls.The response of stock of money is very significant, which lasts seven months, but the response of interest rate is not significant. The increase in interest rate is not very persistent either. Interest rate rises up to the three-month horizon, and then it starts declining. The response dies down within seven months. This is because, as we can see from Figure 6.1, the monetary contraction leads to a deflation in price level. The money supply shock leads to a negative change in exchange rate which, in this case, refers to an appreciation of domestic currency since the exchange rate was defined as unit of domestic currency, *taka*, per US dollar. Dornbusch (1976) explained that right after the monetary policy shock, the exchange rate usually overshoots its long-run equilibrium level but then gradually adjusts towards its initial value. The movement of exchange rate in our figure follows Dornbusch's prediction. The exchange rate comes back to its initial value after six months.



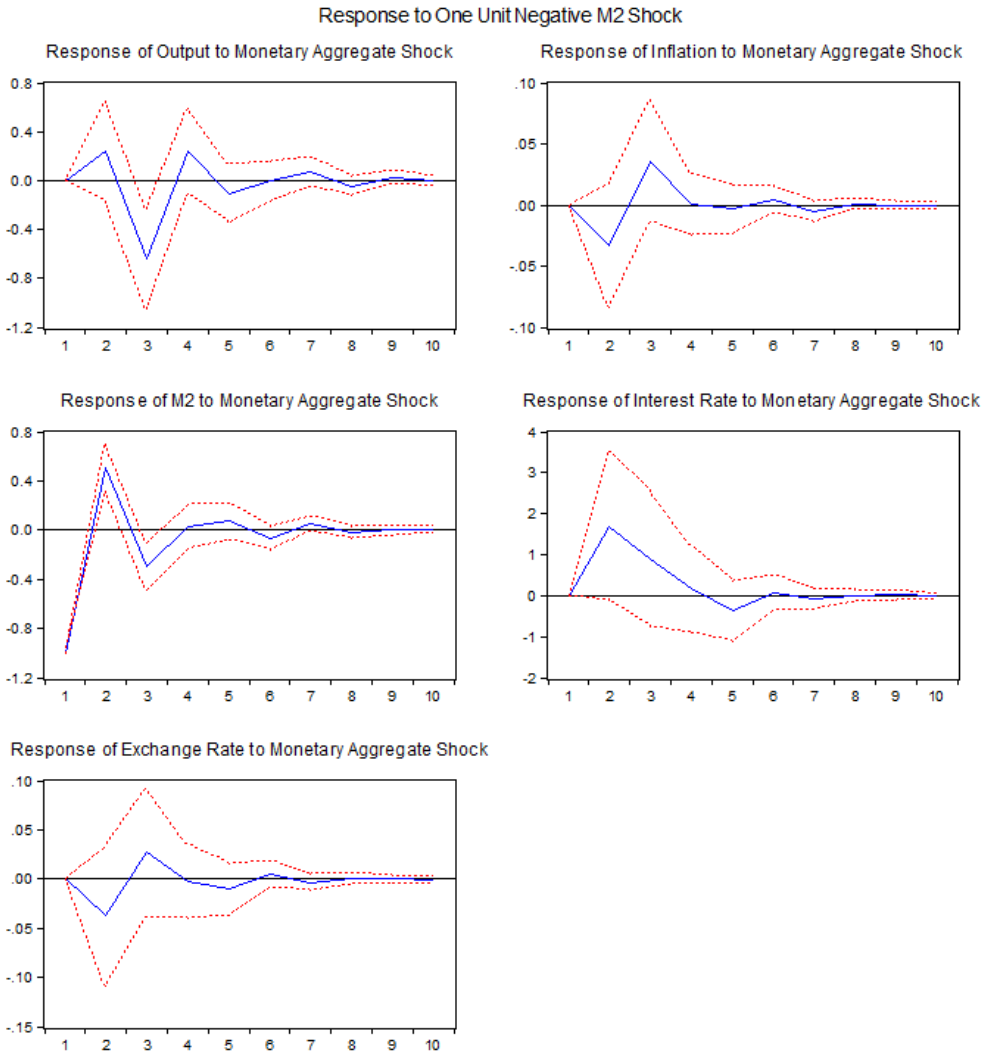
Note: The solid lines are impulse responses of domestic macroeconomic variables to one unit negative reserve money shock. The upper and lower dashed lines plotted on each graph are two-standard-error bands. The response horizon is in months.

Figure 6.1: Impulse response function to reserve money shock.

After the monetary contraction, initially output increases for the first two months, but then it starts to fall. Therefore, the effect of the negative money supply shock on output kicks in with a lag of two months. This delayed response of output to money supply shock is quite expected as real variables do not respond to changes in nominal variables instantaneously. After the money supply shock, there is a persistent fall in inflation until the next five months, which matches with the results of Kim and Roubini (2000) for most countries. Therefore, these responses of the domestic variables to contractionary monetary policy shock are consistent with the prediction of Obstfeld and Rogoff (1995) and others as described above. In the case of all variables, the impact of monetary policy shock dies off within a nine-month horizon. These results also match with the empirical work of Cushman and Zha (1997) and Kim and Roubini (2000), who found similar results of monetary contraction in Canada and non-US G7 countries respectively.

Model 1 was able to solve all three puzzles. Following the model, a contraction in money supply increases domestic interest rate which conforms to the theory. Therefore, the liquidity puzzle was not encountered. As a result of the monetary contraction, inflation becomes negative, i.e., price level falls, so a contraction in money supply increased interest rate and reduced the price level, which indicates the absence of any price puzzle. Figure 6.1 shows that monetary policy shocks reduce exchange rate, which refers to an appreciation of the domestic currency. So, exchange rate appreciates as an initial impact of the monetary shock but then starts depreciating. Therefore, the exchange rate puzzle is not present. The structural identification of Model 1 was successful in resolving all three puzzles.

Impulse Responses from Model 2. Bangladesh Bank considers $M2$ as its intermediate target. Therefore, Model 2 uses $M2$ to generate monetary policy shocks and find out its impact on domestic variables. Figure 6.2 shows the impulse responses of domestic variables to one unit negative $M2$ shock.



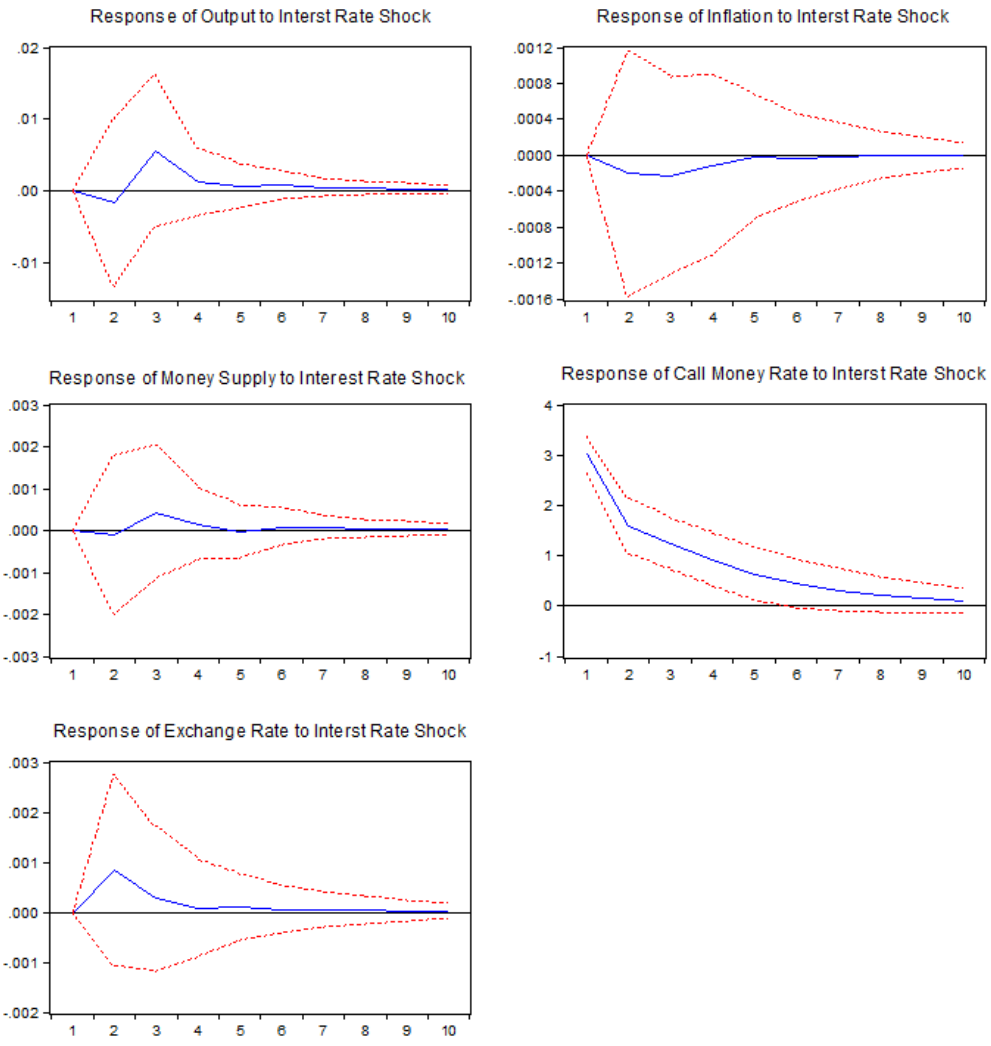
Note: The solid lines are impulse responses of domestic macroeconomic variables to one unit negative $M2$ shock. The upper and lower dashed lines plotted on each graph are two-standard-error bands. The response horizon is in months.

Figure 6.2: Impulse response function to money supply ($M2$) shock.

Impulse responses in Figure 6.2 are similar to those of reserve money shocks. The response of money stock is negative and significant. Interest rate increases as a result of this tight monetary policy stance, but the response is not significant. The exchange rate appreciates, and in this case the overshooting is less pronounced than the reserve money shock. Output shows a delayed response as before and has the usual J shape. The response of output dies down after nine months. Inflation falls at the beginning but then shoots up before it comes down again after three months. All the impulses die down within the eight-months horizon. Therefore, Model 2 did not encounter the liquidity or exchange rate puzzles. But some elements of the price puzzle were present as the contractionary policy did not lead to a sustained decrease in inflation.

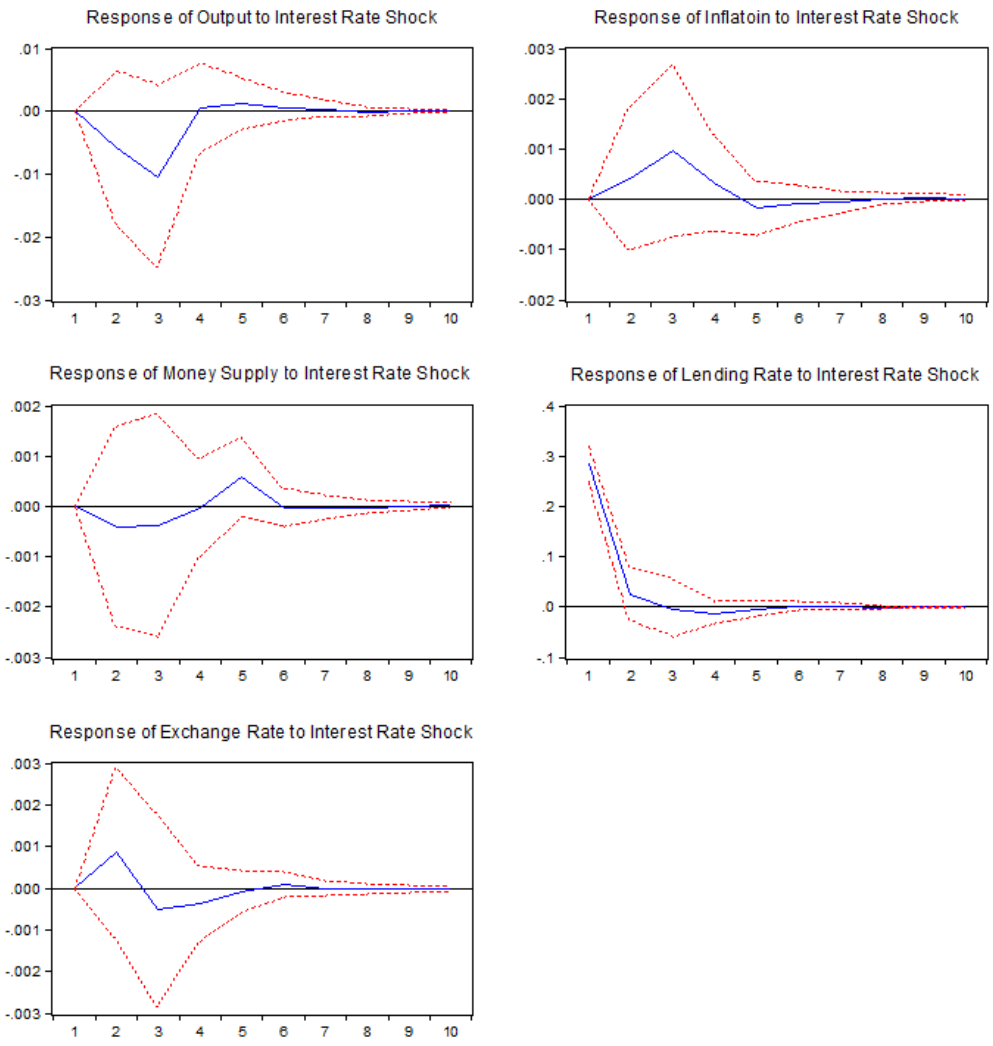
Impulse Responses from Model 3. Figure 6.3 shows the impulse responses of domestic variables to one standard deviation positive call money rate (*cmr*) shock. The call money rate shock produces very unusual results. Money supply fell negligibly as an immediate effect of increase in the interest rate but then rose within the second month. Interest rate increases significantly as a result of the monetary policy innovation and fell gradually over a ten-month horizon. The exchange rate increased, which means domestic currency depreciated as a result of the increase in the interest rate. So the exchange rate puzzle was encountered. Output fell slightly as a result of tight monetary policy but increased quickly thereafter. Price level declined and the response died down within four months. Except for the call money rate, no other response to monetary policy shock is significant.

Impulse Responses from Model 4. Model 4 used the lending rate as the monetary policy instrument to identify monetary policy shock. Figure 6.4 shows the impulse responses of such shocks. Impulse responses in Figure 6.4 are different in many respects compared to those in Figure 6.3. In this case of lending rate shock, the decrease in the money supply is more noticeable and prolonged. The interest rate increased significantly as a result of



Note: The solid lines are impulse responses of domestic macroeconomic variables to one unit positive *cmr* shock. The upper and lower dashed lines plotted on each graph are two-standard-error bands. The response horizon is in months.

Figure 6.3: Impulse response function to call money rate (*cmr*) shock.



Note: The solid lines are impulse responses of domestic macroeconomic variables to one unit positive i^L shock. The upper and lower dashed lines plotted on each graph are two-standard-error bands. The response horizon is in months.

Figure 6.4: Impulse response function to lending rate (i^L) shock.

tighter policy but then declined very sharply to reach its initial level within three months. The exchange rate had an impact depreciation leading to the exchange rate puzzle. Output started to decline within a month and came back to its initial level after seven months. Inflation increased as a result of the monetary policy shock leading to the price puzzle.

From the four models described, the baseline model having reserve money as monetary aggregates and bank lending rate representing domestic interest rate produced most sensible results. When reserve money is used to represent monetary policy innovation, no puzzling dynamic response of domestic macroeconomic variables was encountered, as is usually the case in the literature of monetary policy shock in developing countries. Using $M2$ instead of reserve money as the money supply shock produces similar results but the price puzzle is encountered to some extent. Though inflation falls at the beginning, it shoots up after the second month of the shock before coming down again.

Having the interest rate as a source of monetary policy innovation also produces some forms of puzzle. When the call money rate is used as the monetary policy instrument, the exchange rate puzzle was present. Lending rate shock produced both the price puzzle and the exchange rate puzzle. The above discussion is summarized in Table 6.2.

Table 6.2: Summary of Results from the IRFs of Different Models

SVAR Model	Policy Variable	Liquidity Puzzle	Price Puzzle	Exchange Rate Puzzle
wpi, i^f, qi,π, rm, i^L, er	rm	None	None	None
wpi, i^f, qi,π, $M2$, i^L, er	$M2$	None	Slightly	None
wpi, i^f, qi,π, rm, cmr, er	cmr	None	None	Yes
wpi, i^f, qi,π, rm, i^L, er	i^L	None	Yes	Yes

Note: The table shows the relative performance of different SVAR models used in terms of their ability to solve the puzzling dynamic responses of domestic macroeconomic variables. wpi, i^f, qi,π, rm, i^L, and er represent world price index, the US federal funds rate, quantum index of industrial production in Bangladesh, domestic inflation, reserve money, broad money, call money rate, bank lending rate, and the nominal exchange rate respectively.

In addition to the models discussed above, some other different identification schemes were applied to the SVAR model. $M2$ was used as the monetary aggregate in models using interest rate as policy variables and call money rate in models using monetary aggregates as policy variables. The recursive approach was tried with different orderings of variables and with models without foreign variables. All these alternative approaches generate one or more of the puzzles similar to those documented in previous studies. Therefore, the impulse response functions generated in the baseline model of reserve money shock is superior in matching the theoretical predictions. This may be due to a more accurate identification scheme of the SVAR model.

However, even in our baseline model the impact of monetary policy does not seem to be significant except for the case of output and money supply. This is in line with the findings of Ahmed and Islam (2004), Younus (2009) and Alam (2015), who also did not find the impulse responses of domestic variables to monetary policy shock to be very significant. There are several possible explanations for such an outcome. The biggest banks in Bangladesh are state-owned commercial banks (SCBs). These banks are subject to directed credits at concessional rates, much of which turns out to be non-performing loans (NPL). During June 2015 the ratio of NPL in SCBs was 21.9 percent.[1] This along with the presence of excess liquidity position in the banking system distorts the monetary transmission channel in Bangladesh and may leave monetary policy less effective (Ahmed & Islam, 2004). The Bangladesh government also relies heavily on domestic financing from the banking system. According to the Annual Report 2015 of Bangladesh Bank, the Bangladesh government borrowed 317.1 billion *taka* for deficit financing in 2015 while the same year the banking sector advanced 537.6 billion *taka* to the private sector. Therefore, government deficit financing from the banking sector was more than half of the total advance to private sector. Alam (2015) also mentioned that there are a large number of un-regulated micro-finance institutions in Bangladesh that

[1] Annual Report 2014-2015, Bangladesh Bank

provide credit to informal sectors, sometimes at a discounted rate. Any change in policy by the central bank can hardly affect the volume or pattern of such micro-credit. This adds to the inefficiency of the formal money market.

CHAPTER 7

CONCLUSION

This paper examined the impact of monetary policy shock on different macroeconomic variables in a small, open economy - Bangladesh. The effect of unanticipated monetary policy shocks has remained an unresolved issue, especially for developing countries. Though credible results have been found for the United States for shocks identified as domestic monetary policy shocks, results from small, open economies have contradicted the standard economic theory. These economies are relatively open compared to the United States, and they are vulnerable to external shocks. Therefore, some earlier authors suggested that these anomalies mainly resulted from an inadequate identification scheme.

Though there is a large number of studies on monetary policy transmission mechanisms in advanced countries, studies on developing countries are limited. Current literature on monetary policy transmission mechanism in Bangladesh differs widely in their results. The results varied depending on factors like the choice of monetary policy variables, model specification, econometric technique used, and exchange rate arrangement associated with the data period chosen. This study employed a seven-variable SVAR model to identify the effect of monetary policy shocks in Bangladesh. The domestic variables included were quantum index, inflation, monetary aggregates, interest rate and nominal exchange rate. Two foreign variables, the world price index and US federal funds rate, were also included to control for the exogenous monetary policy shocks. Using reserve money as the monetary policy variable in the baseline model, the study did not encounter the liquidity, price, or exchange rate puzzles. The paper also used $M2$, call money rate, and lending rate to generate monetary policy shock to compare the relative performance of the models depending on the

choice of the monetary policy variable. In the latter cases, the models experienced one or more of the puzzles.

Most of the contemporaneous co-efficients of the baseline model appeared to be significant at the 5-percent level with the correct signs. The principal findings of the paper are that a negative money supply shock reduced output and inflation. But in the case of M2 shock, inflation increased after the initial decrease, which is an indication of the presence of price puzzle. The interest rate increased as a result of the tighter monetary policy stance. The exchange rate over-shot right after the monetary policy shock but gradually adjusted towards the initial value. This movement of the exchange rate matches Dornbusch's (1976) prediction. When monetary policy shock was generated through positive innovation in call money rate, the model experienced the exchange rate puzzle as the exchange rate depreciated as a result of the interest rate hike. Using lending rate as the monetary policy variable produced both the price and the exchange rate puzzles. But in this case the response of money supply was more pronounced compared to the call money rate innovation.

In terms of matching the theoretical prediction, the baseline SVAR model of this study produced better results than found in the existing literature on monetary policy shocks in Bangladesh. This may be due to the better identification scheme. Unlike previous studies, foreign variables were incorporated in the SVAR model to separate out the influence of foreign policy shocks on domestic monetary policy. Bangladesh Bank has adopted the floating exchange rate arrangement since May 2003. This study used monthly data from June 2003 to June 2015. Therefore, the data does not overlap with any major policy shift and solely reflects the effect of monetary policy shocks under the floating regime.

However, the impact of monetary policy shocks is largely found to be insignificant. There are many external constraints that may weaken the effectiveness of monetary policy. Among these constraints are heavy government borrowing from the banking sector, the significant amount of non-performing loans, excess liquidity in the banking sector, and the

presence of a large informal sector that is not influenced by changes in monetary policy. This suggests that Bangladesh should not rely too much on the central bank's policy for domestic macroeconomic stability and that monetary policy should be implemented cautiously.

This paper suffers from some limitations. In the absence of quarterly or monthly data for GDP, the paper used the quantum index, which had a base of 1988-89, as a proxy. This base is quite old and the shares of different industries in the overall industrial sector have changed significantly since then. Even with a recent base, the quantum index can only reflect changes in the industrial sector leaving agriculture and service sector out of the picture. No expectation variable was included in the model to represent the forward-looking monetary policy changes, as Bangladesh Bank does not conduct surveys on expectation variables. Real effective exchange rate (REER) may be a better option than the nominal exchange rate but REER data was also not available on a monthly basis for the given sample period.

This paper did not address several issues which can be addressed by my future research. First, this study looked at the effect on monetary policy on the overall output level but did not go for any sub-sectoral analysis. It may be interesting to find out whether monetary policy affects different sub-sectors of the economy differently. This knowledge can be useful to take policy actions addressing the need of some key sectors. For example, textile and garments industries are the two biggest employers of marginalized women and also the major sources of foreign exchange earnings in Bangladesh. Appreciation of domestic currency can adversely affect these industries as they may lose external competitiveness for their exports. Hence, in the phase of an appreciation of the domestic currency, the central bank may actively purchase foreign exchange from the market and increase the domestic money supply to avert appreciation. But how beneficial such a policy action would be for the textile and garment industries would depend on the impact of monetary policy on that particular sector. Second, Blanchard and Perotti (2002) developed an SVAR for fiscal policy analysis, and according to Rossi and Zubairy (2011), it is important to consider monetary and fiscal

policy shocks together. Hence, one can incorporate fiscal policy into the picture to study the joint effect of both types of policies on the economy and can measure their relative strengths and weaknesses.

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