Dynamic Interactions of Money, Interest Rate, Prices, and Real Aggregate Economic Activity in Selected SAARC Countries

by

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Signature of the Author

Dedicated to my father and mother

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ABSTRACT

This study investigates the dynamic interactions among key aggregate macro variables in three South Asian Association for Regional Cooperation (SAARC) countries, namely, Bangladesh, India, and Pakistan. In particular, several monetarist's hypotheses and relative strength of supply shocks and demand shocks are investigated. A related purpose has been to examine how well theoretical predictions of IS-LM model fit the developing countries data. Another objective has been to determine the role of key variables in the post financial liberalization era of the three countries as they adopted neo-liberal prescriptions for financial reform at the beginning of 1990s. Structural Vector Autoregressive (SVAR) models are estimated and the objectives are accomplished in three different ways: i) by conducting bivariate, multivariate and block causality tests; ii) by estimating variance decompositions and impulse response functions under the recursive and the non-recursive identification schemes; and iii) by applying historical decomposition technique.

The results do not suggest a monocausal explanation of cyclical fluctuations. Neither the real business cycle view that focuses primarily on aggregate supply shock nor an extreme monetary view that focuses on monetary action is supported. Contribution of monetary policy to price and output movement depends on the identification strategy. While adoption of certain identification scheme produces puzzling dynamic effects, adoption of another scheme might help solve this problem. The dynamic properties of the estimated models support most of the theoretical predictions of IS-LM model. Contractionary monetary policy has a negative impact on output in all the three countries and for all the identification schemes adopted.

The results also suggest that monetary policy plays a leading role in determining price in all the three countries after they have adopted neo-liberal prescriptions for financial reform at the beginning of 1990s. Interest rate plays a major role in output determination in both Bangladesh and Pakistan while it does not play any role in India in the post liberalization period.

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Chapter 1

Introduction

Money plays three principal roles in the economy: money is the medium of exchange, it is the unit of account, and a means of storing purchasing power for future use. Explanatory power of money over the real aggregate economic activity has been the subject of considerable debate among economists for many years. Yet, to date, there has not emerged any consensus despite a large and growing body of both theoretical and empirical research. The main hypothesis of currently popular real business cycle paradigm is that money is irrelevant. It assumes that there are large random fluctuations in the rate of technological change. Each economic agent rationally alters his level of labor supply and consumption in response to random fluctuations in technology. The business cycle, according to this theory, is the result of dynamic effect of aggregate supply shocks in a competitive economy. This theory is very much in line with the classical school of thought.

In classical models, money plays no significant role. These models show how employment, production and relative prices are determined. But one can append money into the system by specifying a money demand function and exogeneously given money supply. Money demand is specified as a function of the level of output and the price level. Real variables such as employment, output, relative prices and the real interest rate are determined by the Walrasian system. Equilibrium in the money market determines nominal variables such as price level, nominal wage and nominal interest rate. Introducing money in this way, leads to the classical dichotomy of separating the nominal from the real. Of course, since wages and prices adjust instantly the nominal variables do not affect the real variables. Accordingly, there is true dichotomy between the real and the nominal sectors. This view of the economy suggests that for most policy discussions, the money market can be ignored.

The Keynesian view defies the classical view by assuming that wages and prices adjust slowly to clear the market. This approach is motivated by the observation that, in general, nominal wages are fixed by long term labor contract and that product prices remain unchanged for a long period of time. Once the rigidity of prices and wages are admitted into the macro model, the classical dichotomy and the irrelevance of money quickly disappears. The assumption of stickiness of wages and prices is, however, by no means confined to the Keynesians; it can be found in Hume (1752) whose account of the effects of increase in money stock on output relies on slow price adjustment which was also discussed in Fisher (1933) and more recently in Friedman (1992).

Two views of monetarism as expressed by Friedman and Schwartz (1963) and Poole (1978) are related to money-price and money-output. One view claims that price movement is purely a monetary phenomenon and movements in money are the primary determinants of movements in price level at least in the medium-to-long time horizon. They, however, admit that nonmonetary influences- e.g. natural calamities- can temporarily impact on the price level. According to this view, price level will ultimately return to its original level unless it is affected by a permanent change in the rule of monetary expansion. The other view of monetarism is: changes in the quantity of money are the primary cause of business cycles because these changes cause, lead and are positively related to changes in output at least in the short-to-medium time horizon. A narrower view of monetarism is that monetary policy is the central cause of business cycle and the time path of money stock is a good single index of monetary policy. The broader view of monetarism, however, includes not only money stock but also other policy variables, such as interest rate, exchange rate as index of monetary policy. All these claims are equally applicable to developed and developing economies.

Economists divide money growth into two components: systematic or anticipated money growth and surprise or unanticipated money growth. Anticipated money growth, like anticipated changes in aggregate demand, in general, would already have been taken into consideration in the economic agent's behavior and as a result it would be unable to influence real variables. Its influence is confined to changes in price level. On the other hand, surprise money growth and growth in aggregate demand, in general, will positively influence the real economic variables with no effect on the rate of inflation; see Lucas (1973).

The rational expectations school of thought comprising of economists like Lucas, Wallace, and Sargent combined the monetary neutrality hypothesis with rational expectations hypothesis[1]. They argue that neither monetary policy nor any other aggregate demand management policy is able to influence the real variables. However, these policies may be effective in controlling inflation. But the view of the rational expectations school of thought has not been universally accepted. Many theorists and empiricists state that anticipated money has real effects. Monetary empiricists like Romer and Romer (1994), Hall and Mankiw (1994) and more recently Cochrane (1998) claim that anticipated money may have real effects. Theorists like Taylor (1979), Rotemberg (1994), Alverez and Atkinson (1996) have constructed overlapping contract models, sticky price models, and limited participation models in which anticipated monetary shocks have also real effects.

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1 Rational expectations hypothesis suggests that borrowers and lenders will make use of all of the relevant information available. In particular they will consider current and future fiscal and monetary policies and the likely future actions by policy makers (see Lucas, 1972).

Recent disinflation episodes of many developed countries are strongly suggestive of real effects of money. The evidence accumulated in particular by Friedman and Schwartz (1963) has led to wide acceptance of the view that movements in money can have large effects on output. The quantitative evidence on the role money growth in this disinflation episode is, however, inconclusive. It is frequently asserted that money is more important in developing economies because credit and security market are less complete than in developed economies.

In a developed economy, monetary management is relatively uncomplicated. If all the structural parameters are known, the policy maker can achieve the desired level of target variables simply by manipulating any set of instruments under his control according to the policy reaction function implied by the model. The problems of monetary management are more acute in developing countries than they are in developed countries. Often they are the source of major political unrest. The survival of national governments in developing countries often depends on how these problems are addressed. Some peculiar characteristics of developing countries coupled with externally imposed policy prescriptions have made it interesting to investigate the impact of money on output and prices and examine whether the results are fundamentally different from that of developed countries.

This study attempts to investigate into the dynamic relationship among key aggregate economic variables like output, price level, interest rate and the stock of money. In particular, two views of monetarism as described earlier and relative strength of supply shocks and demand shocks are investigated. A related purpose of this study is to examine how well the dynamic properties of the estimated models of the developing countries match to the theoretical predictions of IS-LM model. Like the developed countries, the IS-LM framework remains important for students to learn in the developing countries because of the benefits it offers in clarifying their thinking about the implications for practical policy issues. The framework remains a vital didactic element of most intermediate macroeconomics texts[2]. The IS-LM model, as a vehicle for policy analysis, also has a substantial influence on the policy makers and academicians. Mankiw (1990, p. 1645) notes that "[t]he IS-LM model, augmented by the Phillips curve, continues to provide the best way to interpret discussions of economic policy in the press and among policy makers." Robert Solow (1997), Blanchard (1997) and Blinder (1997) more recently expressed similar views to those of Mankiw. They explicitly mentioned the IS-LM model as a core of practical macroeconomics that we should all believe. Gali (1992, p. 737) concludes that

[2] Some of the popular textbooks that use the IS-LM model are: Dornbusch and Fischer (1994), Hall and Taylor (1993), Mayer, Duesenberry, and Aliber (1993), Mishkin (1995), Dornbusch, Fischer, and Startz (1998).

the US data seem to support the empirical relevance of IS-LM Phillips curve paradigm.

Three major South Asian Association for Regional Co-operation (SAARC) countries viz. Bangladesh, India, and Pakistan are selected as cases for this study. They share the following common features[3]:

First, the degree of monetization is very low in these economies. Second, the capital market is very much underdeveloped and confined to a small number of investors. Third, most of the real economic activities are in the hands of illiterate peasants, small scale primary producers and that the market mechanism along with response to market signals are not as evolved as in the case of developed economies. This means that economic agents lack the capability of making optimal forecasts about the future economic conditions that make rational expectations hypothesis controversial. Fourth, domestic tax base is underdeveloped and that the budget deficit is financed through government borrowing from the banking system. For example, in India and Pakistan, the public sector comprising of government and public sector corporations has borrowed as much as Rs[4] 805.1 billion and Rs 129.29 billion respectively from the domestic banking system in the year 1998; see IMF, International Financial Statistics, Year Book 2000. Fifth, All these economies utilize fixed exchange

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[3] Some of the features are discussed in detail in chapter 2.

[4] Rs stands for Rupees. Rupee is the unit of currency of India and Pakistan.

rates. In open economies with fixed exchange rates, changes in domestic money supply may be offset through the balance of payments. So central bank's ability to enact an independent monetary policy is to some extent limited. The central bank, however, may sterilize foreign reserve flows to maintain its monetary independence. Sixth, the financial system has a dual structure, which consists of the official banking system or the organized money market and the unorganized money market. So transmission of interest rate changes via changes in bank rate or over-night rate or any other rate are questionable and hence deserves further empirical investigation. Finally, All the three countries adopted neo-liberal prescriptions for financial reform at the beginning of 1990s. Another objective of this study is to determine the role of key macro variables in the post financial liberalization era of the three countries.

While there has been substantial empirical work on the linkages between money, prices and aggregate real economic activity in developed economies, empirical study on the dynamic impact of monetary policy in developing countries like Bangladesh, India, and Pakistan is still in its infancy. Jones and Sattar (1988), Parikh and Starmer (1988), Chowdhury *et.al* (1995) were among the few studies that are conducted on Bangladesh. Sharma (1984), Kamas and Joyce (1993) were among the few studies that are conducted on India. Jones and Khilji (1988), Masih and Masih (1997) were among the few studies that are conducted on Pakistan. The above-mentioned studies suffer from two major methodological deficiencies: i) most of these studies are mainly anchored upon dealing with causal relationship in a bivariate framework and thus raising the possibility of omitted variable bias; and ii) a very few studies discussed the economy's response to unexpected shocks by employing a recursive structure. The recursive structure is not sensible in economic terms. It seldom represents the actual structure of an economy.

In summary, the objectives of this study are: (a) to test validity of two views of monetarism and relative strength of supply shocks and demand shocks; (b) to examine how well rational expectations monetarists / IS-LM predictions fit the developing countries data; (c) to re-examine the issue of causality among money, interest rate, prices and output in the SAARC economies in a multivariate framework; (d) to determine the role of certain variables in price and output movement in the post financial liberalization period that all the three SAARC countries adopted in the beginning of 1990s; and (e) to spell out some policy prescriptions.

To address the above-mentioned issues for three developing economies those adopted neo-liberal prescriptions for financial reform, this study applies structural vector autoregressive (SVAR) approach. SVAR is useful tool to analyze the macroeconomic response of an economy to specific policy shocks. Compared to large-scale macroeconomic models, SVAR requires a minimum number of identifying restrictions in order to separate the movements of the model's variables into parts due to underlying shocks. Our model explicitly accounts for the variables included in core macroeconomic models developed in the Keynesian flavour and specifies identification schemes, which capture some features of the developing economies in general and the three SAARC countries in particular. Since three SAARC countries adopted neo-liberal prescriptions for financial reform at the beginning of 1990s our approach can decompose the actual movement of variables in the system into expected path, given information known up to pre-liberalization period, and the unexpected movement attributable to shocks in each variable; thus separates the role of different variables in the post financial liberalization period in the three countries. The appropriateness of such a technique to determine the role of policy variables in post financial liberalization era of the three countries is, therefore, justified.

The plan of the dissertation is as follows. A brief overview of three SAARC economies and their respective monetary policies are presented in chapter 2. A critical review of the selected previous studies is presented in chapter 3. Methodology and data used in the present study are discussed in chapter 4. Empirical results are reported and discussed in chapter 5. Chapter 6 summarizes the findings and provides a guideline for the policy maker. In addition, some venues for future research the author intends to pursue are also indicated.

Chapter 2

Overview of the Macro-Financial System in Selected SAARC Countries

According to Lucas (1976) the effect of any given policy action depends greatly on expectations it engenders: Is the intended policy temporary or permanent? Under what circumstances will it change? Expectations about policy in turn depend on public's perception of policy strategy, which is jointly determined by policy maker's choice, and political and institutional factors. A clear view of monetary policy, the various reform measures and the overall state of the economy is important not only for the politicians but also for the policy makers. This chapter gives a brief discussion of recent conduct of monetary policy, the various reform measures and the behavior of key macro-variables of Bangladesh, India and Pakistan. This historical information can be valuable to research problems and we hope to gain some insight into the objectives and constraints that determine central bank behavior in those countries. Thus this chapter is a complement to formal theoretical modeling and subsequent empirical work that has been done in the following chapters[5].

[5] The figures in this chapter are constructed on the basis of data from IMF, International Financial Statistics (IFS), CD-ROM.

2.1 Bangladesh

Bangladesh emerged as an independent country on March 26, 1971. Before 1971, it was a rural economy with a few public sector industries. The role of manufacturing in the development process was marginal; pattern of industrialization was dominated by import substitution policies. After the war of independence, socialism in the form of state ownership was followed as the guiding principle in the Bangladesh constitution. Banks, financial institutions, various private sector industries were nationalized. However, after 1975, the country made a clear departure from her earlier policies. Since the early 1980s de-nationalization and market-based reform policies were followed. But still the public sector exercises a dominant influence on industry and the economy. Most public sector industries, including textiles, jute processing, and sugar refining, are perennial money losers, which drain the treasury. Their militant unions have succeeded in setting relatively high wages, which their private sector counterparts often felt compelled to meet the offer of union action. Nonetheless, during the 1990's Bangladesh has steadily liberalized its economy, and increasingly the private sector has assumed a more prominent role as the climate for free markets and trade has improved. The Awami League government, which came to power in June 1996, largely continued the market-based policies of its predecessor, the Bangladesh Nationalist Party. It placed a high priority on increasing foreign direct investment in the economy, and made some regulatory and policy changes toward that end.

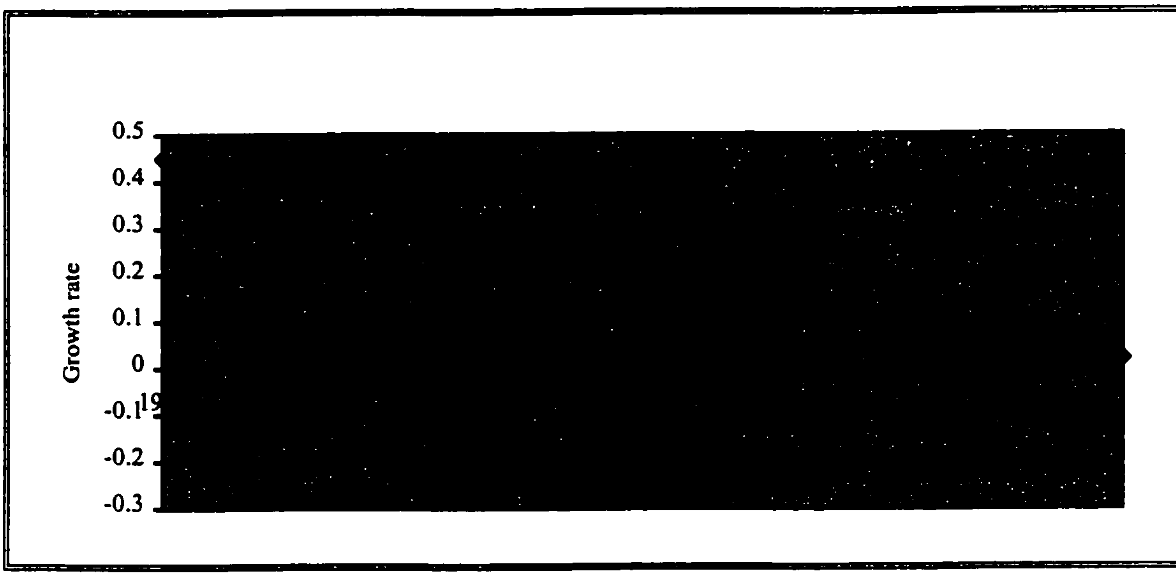
Although one of the world's poorest and most densely populated country with per capita GDP of US$ 370, Bangladesh has made major strides to meet the food needs of her increasing population through increased domestic production augmented by imports (World Development Report, 2001). The land is devoted mainly to rice and jute cultivation, although wheat production has increased in recent years; the country is largely self-sufficient in rice production. Bangladesh's predominantly agricultural economy depends heavily on an erratic monsoon cycle, with periodic flooding and drought. Floods, drought and pests hurt agricultural output in the early 1970s and during the recent years as well. Infrastructure to support transportation, communications, and power supply is poorly developed. The country has large reserves of natural gas and limited reserves of coal and oil. While Bangladesh's industrial base is weak, unskilled labor is inexpensive and plentiful. Various problems have kept Bangladesh's progress below its potential. Domestic political instability has stunted foreign investment. Policy inconsistency and weak implementation have, along with reports of improper official influence in business and economic decisions, dampened investor interest and economic growth.

While Bangladesh has managed to maintain a laudable measure of macroeconomic stability in the early 1990s, its macroeconomic position at the end of 2000 remained vulnerable, with relatively high fiscal deficits which is 6.2% of GDP, unexpected deterioration in the trade balance with total import of US$ 8.4 billion against total export of US$ 5.7 billion, and stagnant tax revenues with 9% of GDP in 1999 to 8.5% of GDP in 2000 (World Development Report, 2001). Progress on other important economic reforms has been halted, though the government has instituted reforms of the capital market and taken some market-friendly decisions to encourage foreign investment. The successes and problems affected the interactions among key macro variables in the economy of Bangladesh since its independence. A review of the performance of key macro variables, financial sector reforms and conduct of monetary policy since independence of Bangladesh are presented in the following sub-sections.

GDP growth

Bangladesh registered an annual average real GDP growth rate of 5% over the period 1975-98. Annual average growth rate of GDP was around 10% during the 1970s, around 3% in the 1980s and 5% during the period 1991-98 (see figure 2.1). High growth rate in the 1970s was highly biased to 1975 and 1978 and thus did not reflect the true picture of the country though it reflected the extreme volatile economic situation of the country during that period. If we exclude this period, average growth rate is below 4%. This average growth rate is well below the growth rate of East and South Asia. GDP growth has been dampened over the years by a number of factors: low productivity growth in the agricultural sector, political and policy instability, poor infrastructure, corruption, and low domestic savings and investment.

Figure 2.1: Annual real GDP growth rate of Bangladesh



Drawbacks to investment in Bangladesh include low labor productivity, poor infrastructure, excessive regulations, and uncertain law and order. The lack of effective commercial laws makes enforcement of business contracts difficult. Officially, private industrial investment, whether domestic or foreign, is completely deregulated, and the government has significantly streamlined the investment registration process. However, while registration has been simplified, domestic and foreign investors typically must obtain a series of approvals from various government agencies in order to implement their projects. Bureaucratic red tape, compounded by corruption, slows and distorts decision-making and procurement. Existing export processing zones have successfully facilitated investment but are still too small to have changed significantly the overall investment picture in the country.

Inflation

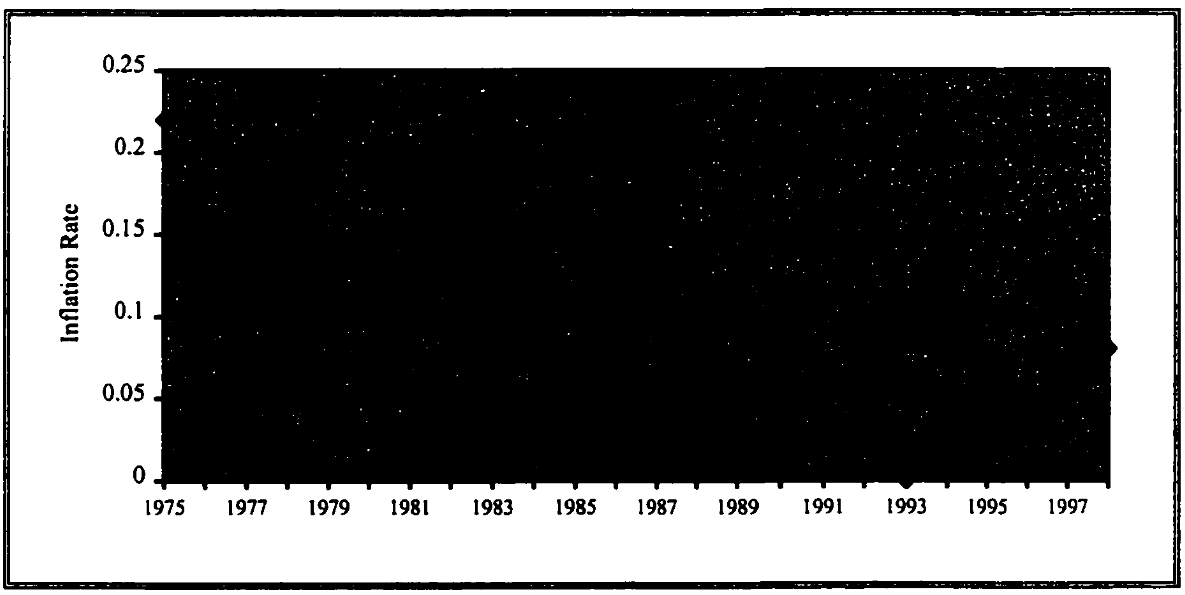
The most widely used measure of inflation is the movement in Consumer Price Index (CPI). It includes prices of representative goods and services. Annual average rate of inflation as measured by CPI in Bangladesh over the period 1975-98 is around 9 per cent.

During the seventies, the average decadal rate of inflation was very high, around 10%, with the rate varying in a wide range from a low value of 2 per cent to a high value of 22%. The maximum inflation rate of 22% was recorded in 1975 and was mainly attributed to devastating flood and the consequent poor agricultural output and the hike in crude oil prices in 1973. The decade was the most tumultuous as far as the price situation was concerned. The minimum inflation rate for the decade at 2 per cent was recorded in the following year, 1976, in response to the substantive anti-inflationary measures taken by the then government.

During the eighties, the average decadal rate of inflation was also high at 11%. For this decade the maximum inflation rate of 16% in 1981 was mainly attributed to devastating drought, poor agricultural output and demand pressures. The minimum inflation rate for the decade was 9 per cent in 1988. The whole decade experienced double-digit inflation except for 1983 and 1988. What is very conspicuous is that variation in prices was small compared to that in the preceding decade.

The period 1990 to 1998 witnessed a low to moderate inflationary tendencies showing price rises between 0 and 8 per cent. As reform measures began to show positive impact on prices, and the average inflation rate for the nineties up to 1998 was 5 per cent.

Figure 2.2: Annual inflation rate of Bangladesh

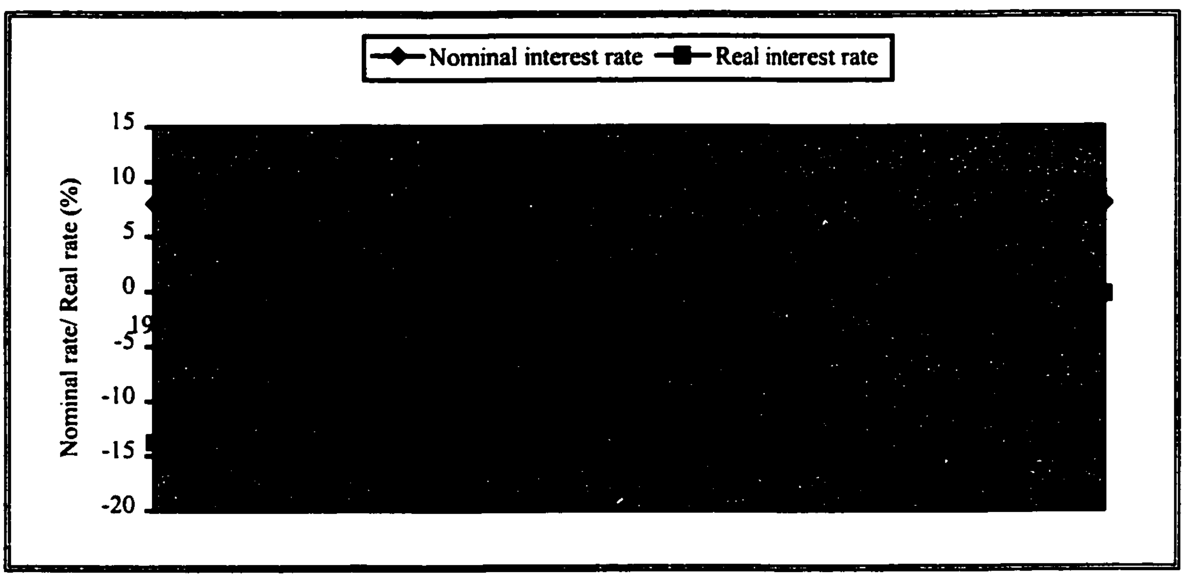


Thus the high pressures of inflation in Bangladesh were felt on almost all occasions, due to exogenous shocks like the oil price hike and domestic supply shocks such as adverse monsoon conditions. However, it is possible to suggest that progressively, over the period, the impact of monsoon conditions on volatility of prices is getting increasingly moderated perhaps due to expansion of irrigated agriculture, flood control measures and buffer stock operations.

Interest rate

Figure 2.3 shows the movement of nominal and real interest rates (bank rate) since 1975. It demonstrates that real rate of interest remained negative for most of the period from late seventies to mid eighties.

Figure 2.3: Nominal and real interest rates of Bangladesh



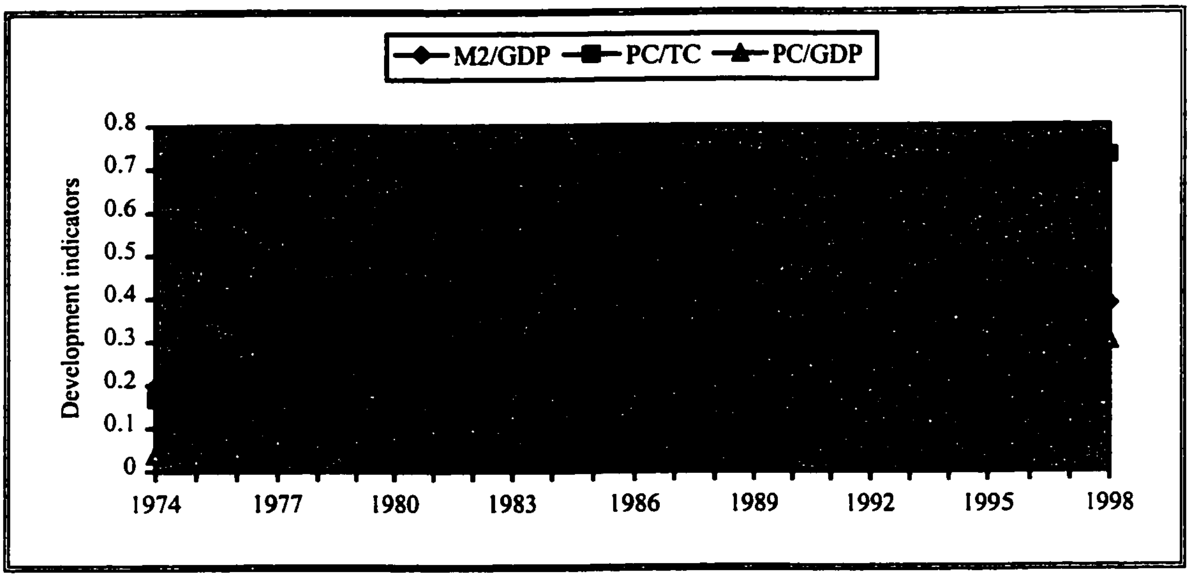
Real rate started becoming positive and shows an increasing trend since the late 1980s. Although nominal rate decreased after 1990 when liberalization measures were first taken, real interest rate increased because of low rate of inflation.

Financial development

The financial development in Bangladesh over the last two and half decades as measured by three different indicators of financial development [see Levine, (1997)] is shown in figure 2.4. The first measure, the ratio of M2 to GDP (M2/GDP) is widely used as an indicator of financial development. This ratio is indicative of the absolute size of the banking system that reinvests funds, in potentially new directions, from old loans as they mature. Although there had been a massive growth of M2, the growth in M2/GDP ratio had been much more modest. This ratio was smaller than 20% in the seventies, smaller than 30% in the eighties, and over 30% in the nineties. The figures do not show any significant increase in M2/GDP ratio in the post financial liberalization period. These ratios are still far smaller than those in other East and South East Asian economies like Indonesia, Malaysia, Philippines, Singapore and Thailand which have 57%, 144.3%, 43.4%, 86.3%, and 78.1% respectively in 1997 (IFS, 2000).

The second measure is the ratio of credit allocated to private enterprise to total domestic credit (PC/TC). The third measure is the ratio of credit to private enterprise to GDP (PC/GDP). These two measures partially address concerns about the allocation of credit. Gradual increase in PC/TC ratio from 20% in 1974 to over 70% in 1998 demonstrates the growing importance of the private sector in Bangladesh.

Figure 2.4: Indicators of financial development of Bangladesh



Financial sector, reform measures and conduct of monetary policy

The financial sector in Bangladesh consists of the banking sector, the non-bank financial institutions and the stock market. The banking sector dominates the financial sector accounting to around 96% of total assets. The banking institutions in Bangladesh comprise the central bank, four nationalized commercial banks, four government owned specialized development banks, 18 private domestic banks and 12 foreign banks (IMF country report on Bangladesh, 1998). The specialized banks and financial institutions are created with specific objectives to address the financial needs of agriculture and industrial sectors. The country has two stock exchanges - one in Dhaka and the other in Chittagong.

Government policy towards the financial sector in Bangladesh since independence can be divided into two regimes. The first regime (1972-1990) was characterized by i) direct control on interest rates, ii) high statutory reserve and liquid asset requirements, both designed to absorb liquidity and to provide government deficit finance, iii) aggregate and individual credit ceilings, iv) lack of close control on the large refinance programs, and v) relaxation of lending criteria for special groups, etc.

During this period the government controlled loan pricing, and credit allocation but not the banking authority. Until the early 1980s, the financial system was controlled and directed by government with the objective of directing credit to the politically motivated priority sector. This was done with the help of nationalized banks. From independence right up to the early 1980s, all the banks in Bangladesh were nationalized. The nationalized banks faced serious solvency problems because of poor recovery performance. Non-economic factors and political considerations rather than sound economic considerations guided loan allocation. Nationalization of financial institutions can be considered as the major step to promoting inefficiency in the financial system. Since there was no competition from private banks, the nationalized banks lacked incentive to become efficient. Direct control as an instrument of monetary control inhibited efficient resource allocation (Ahmed and Kabir, 1996). Credit control measures and other direct control measures forced financial institutions into portfolio positions that would not otherwise be accepted. Moreover, direct control measures and high reserve requirements encouraged unregulated financial intermediaries and instruments to compete with the regulated ones.

A well-developed functioning stock market is important for effectiveness of monetary policy. Corporate sector is often advised to reduce dependence on bank credit and to tap other sources of finance, particularly the permanent and redeemable share capital. One important benefit of financial liberalization is mobilization of domestic and foreign capital, and a well-developed stock market can aid such a process. Developed stock market is, therefore, an essential ingredient of a viable financial system and a strong and prosperous economy. During the direct control regime, little attention was paid to develop stock markets, which is the pulse of the corporate sector and an indicator of the degree of decentralization in the economy. The Dhaka Stock exchange, reactivated in 1976, was constrained by the sluggishness of the general business environment on the one hand and a weak private sector on the other.

The second regime (1990-) is characterized by certain major reforms in the financial sector. Since the early 1980s, the government of Bangladesh started a series of financial liberalization measures, in accordance with an agreement with the World Bank and the International Monetary Fund. Though reform process was initiated in the early eighties, measures to liberalize the financial sector took a formal shape in the late 1980s. The early efforts of financial reform were mostly concerned with the privatization of nationalized banks and allowing private banks and joint ventures foreign banks to operate. Private banks were allowed to operate for the first time in 1984 marking a reversal of the nationalization policy adopted in 1972 after the independence of Bangladesh. Before 1989, interest rates for both deposits and loans were set by Bangladesh Bank, the central bank of Bangladesh. Since the early 1980s, interest rates on deposits were raised to provide a positive real rate of return. The broad features of the Financial Sector Reform Programme (FSRP) that started at the end of 1989 are: i) liberalization of interest rates, ii) less reliance on direct control to allocate credit and removal of other discriminatory regulations that segment the financial system, iii) high standards for supervision of bank portfolios, iv) shift toward a system of market based instruments, and v) development of new financial instruments and revitalization of stock market (Bangladesh Economic Review, 1995, 1996).

In the early 1990s, based on the recommendations of the National Banking Commission, the government of Bangladesh initiated a managed interest rate policy by letting the interest rate to be set by the forces of the market but at the same time guiding the interest rate to achieve macro economic stability. It is to fulfill the latter objective that the government has introduced both a ceiling and a floor on the interest rate - a floor in order to ensure that the savers earn an adequate rate of return and a ceiling primarily from the concern that too high an interest rate will affect investment adversely and invite high risk investors. Effective from January 1990, the government has set interest rate bands for both deposits and loans within which commercial banks were permitted to fix their own rates. The floors on deposits were set close to the inflation rate and ceilings were established to prevent excessive increase in interest rate. These bands on loans were calculated on the basis of the average cost of funds, administrative expenses and other operational costs of the bank, the cost of provision of bad and doubtful debt and an allowance for profit. Sectors like agriculture and small industry had different rates in recognition of higher operating costs of these sectors (Ahmed and Kabir, 1996). An important objective of financial sector reform program is to make the financial system more responsive to market forces and become more competitive.

Bangladesh Bank, the monetary authority of Bangladesh, is responsible for formulating monetary policy and is empowered to implement it. The objectives of monetary policy are described in the preamble of the Bangladesh Bank order 1972 "to regulate the issue of currency and keeping of reserves and manage the monetary and credit system of Bangladesh with a view to stabilizing domestic monetary value; preserving the par value of Bangladesh Taka[6]; promoting and maintaining a high level of production, employment and real income in Bangladesh; fostering growth and development of the country's productive resources in the best national interest". These monetary policy objectives may be summarized as follows: i) growth of the economy; ii) maintaining external value of national currency; iii) price stability; and iv) creation of productive capacity in the long run (Bangladesh Economic Review, 1996).

Monetary policy requires the establishment of a relationship between the monetary instrument that the authorities control and their monetary objectives. Instruments on hand of Bangladesh Bank are: i) open market operations; ii) interest rate; iii) bank rate/ discount rate; and iv) statutory reserve requirement. Introduction of new monetary instruments is an important step in the development of a market-based financial system. In order to avoid distortions created by direct controls, some economists suggested the introduction of new

[6] Taka is the unit of currency of Bangladesh.

monetary instruments early in the reform process. The central bank can anticipate reserve developments and through open market operations using a newly developed monetary instrument, it can absorb or provide bank liquidity at its own initiative and in a flexible manner. To achieve this objective, the Bangladesh bank introduced a new short-term instrument in December 1990, viz the "91-day Bangladesh Bank Bill".

The financial sector reform, which was launched in 1990, was continued till the end of 1990s as improvement in regulation of bank supervision. In order to strengthen credit discipline and bring loan classifications in line with the international standard, a five-phase program was announced in December 1994 and was implemented in December 1995. However, political interference in highly technical economic management issues still places a barrier on the free functioning of Bangladesh Bank on grounds of expediency. Excessive borrowing by government from the banking system to mitigate budget deficits speaks of the helplessness of the Bangladesh Bank regarding its efforts to contain monetary and credit expansion.

2.2 India

On 15 August 1947, India became a dominion within the British Commonwealth with Jawaharlal Nehru as Prime Minister. According to its constitution, India is a "sovereign, socialist, secular, democratic republic." Like the United States, India is a federation of states. However, the central government in India has greater power in relation to its states, and its central government is patterned after the British parliamentary bicameral legislative system.

From independence to early 1980s, India was mainly a mixed economy marked by a highly protected trade, investment and financial sectors. India embarked on a series of economic reforms in 1991 in reaction to a severe foreign exchange crisis. Those reforms have included liberalized foreign investment and exchange regimes, significant reductions in tariffs and other trade barriers, reform and modernization of the financial sector, and significant adjustments in government monetary and fiscal policies.

The reform process has had some very beneficial effects on the Indian economy, including higher growth rates, lower inflation rates, and significant increases in foreign investment. Foreign portfolio and direct investment flows have risen significantly with a total of US$ 103 million in 1990 to US$ 5102 million in 2000 and have contributed to healthy foreign currency reserves (World Development Report, 2001). Significant liberalization of its investment regime since 1991 has made India an attractive place for foreign direct and portfolio investment. Proposals for direct foreign investment are considered by the Foreign Investment Promotion Board and generally receive government approval. Automatic approvals are available for investments involving up to 100% foreign equity depending on the kind of industry. Foreign investment is particularly sought after power generation, telecommunications, ports, roads, petroleum exploration and processing, and mining. India's economic growth is constrained, however, by inadequate and substandard infrastructure and cumbersome bureaucratic procedures.

India's trade has increased significantly since reforms began in 1991, largely as a result of staged tariff reductions and elimination of non-tariff barriers. Total trade volume increased from US$ 46.39 billion in 1990 to US$ 104.15 billion in 2000 (World Development Report, 2001). Principal imports of India are aircraft and parts, advanced machinery, fertilizers, ferrous waste and scrap metal, and computer hardware. Major exports from India include textiles and ready-made garments, agricultural and related products, gems and jewelry, leather products, chemicals and computer software. A review of the performance of key macro variables, financial sector reforms and conduct of monetary policy of India is presented in the following sub-sections.

GDP growth

Average annual real GDP growth rate of India over the period 1963-97 is 4.6 per cent. This figure is 3.82 per cent in the 1960s, 4.2 per cent in the 1970s, 5.38 per cent in the 1980s, and 6.26 per cent in the 1990s (see figure 2.5).

Decade-wise steady and gradual increase in GDP growth rate reflects India's strong economic potential and entrepreneurial skill. While its GDP is low in dollar terms, India has the world's 13th-largest GNP. About 62% of the population depends directly on agriculture. Industry and services sectors are growing in importance and account for 26.2% and 48.5% of GDP, respectively, while agriculture contributes about 25.3% of GDP. Around 35% of the population lives below the poverty line, but a large and growing middle class of 150-200 million has a sizeable disposable income for consumer goods (World Development Report, 2001).

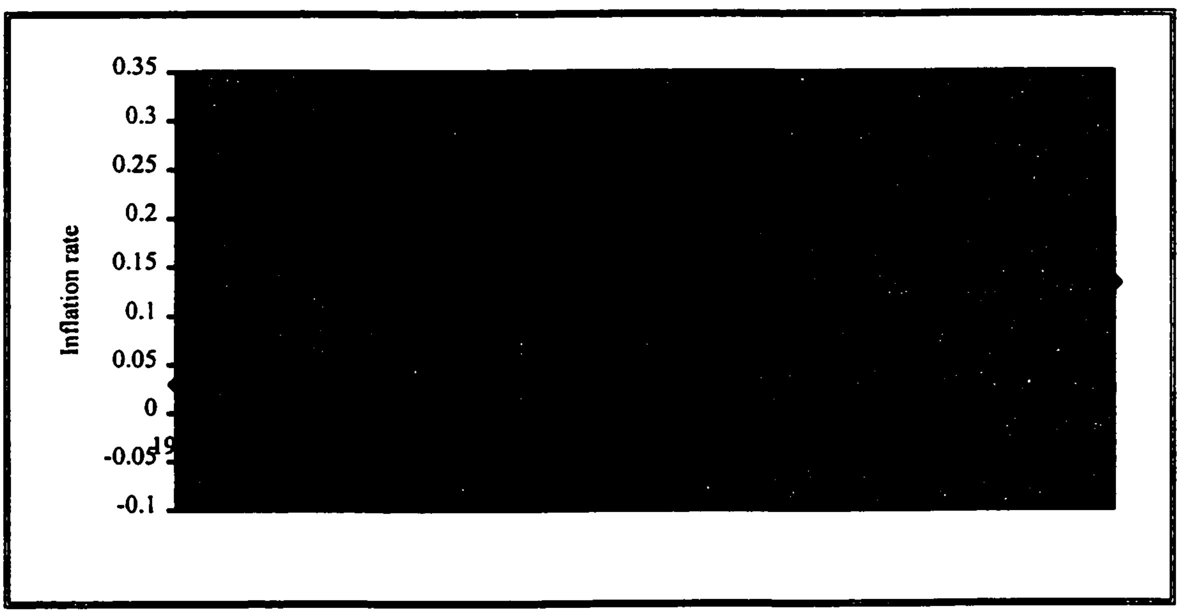
A welcome feature of India's macroeconomic development in recent years is a substantial acceleration in the growth of industrial output, particularly her manufacturing output.

Figure 2.5: Annual real GDP growth rate of India

Inflation

The annual rate of inflation as reflected in the movements in the Consumer Price Index (CPI) is shown in figure 2.6. The annual average inflation rate has been around 8 per cent since 1963. This rate was 7.3 per cent in the 60s, 8.16 per cent in the 1970s, 8.8 per cent in the 1980, and 10.2 % for the period 1991-96. A relatively high growth of output, fuelled by sustained industrial recovery, combined with moderate inflation and high reserves, provided a positive environment for monetary management in recent years in India.

Figure 2.6: Annual inflation rate of India

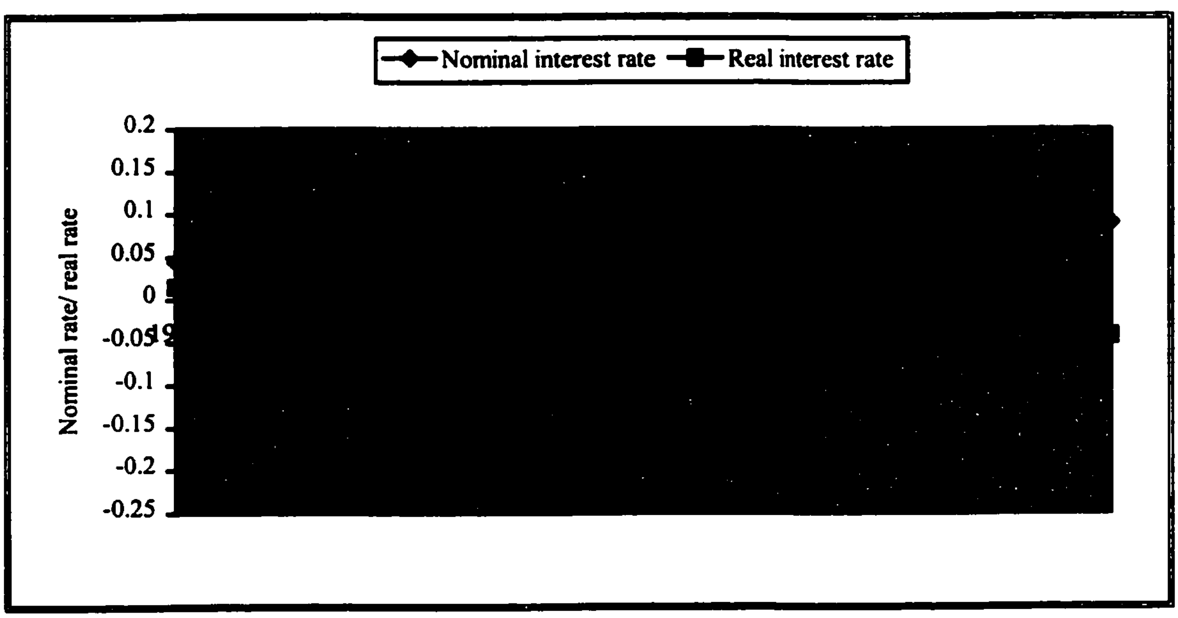


Attention to the possibility of inflation targeting in India has heightened recently, partly in view of such an approach being adopted by a number of central banks in many industrialized countries and partly because of the analytical rigor behind such an approach. Although technically this seems to be a sound proposition, there are several constraints in the Indian context in pursuing a single objective like inflation targeting. First, there are the twin functions of fiscal dominance and debt management which are inextricably linked with the monetary management function while steering the interest rates. If the two functions were to be separated as was suggested by some experts, it is almost certain that the prevailing interest rates in the market would be substantially higher than considered desirable from monetary stability and/or growth points of view. Secondly, Indian financial market is still imperfect and segmented. In the absence of fully integrated financial markets, the transmission channel of policy is rather weak and yet to evolve fully. Thirdly, the high frequency data requirements including those on the core consumer price index for targeting purposes are not yet available. Under these circumstances, it is necessary to carefully measure and balance among possible outcomes, after taking into account movements in a variety of monetary and other indicators. Some economists opine that operationally inflation targeting in India should wait until financial sector reform is completed.

Interest rate

India can be regarded as a financially repressed economy as its real interest rate has been very low or negative for most of the period since 1963; see figure 2.7. Real interest was higher than nominal rate only in 1976 because of high disinflation. Low or negative real interest rate is detrimental to savings. The theory is that a positive real interest rate should deepen the market by encouraging saving in the form of various financial assets. Some neo-structuralists (Wijnbergen (1983), Taylor (1983)), however, dispute this view and argue that high positive real interest rate will encourage funds to be drawn from the informal credit markets. This might have adverse effect on investment. Some economists (Bencivenga and Smith,1992), on the other hand, suggest an optimal degree of financial repression.

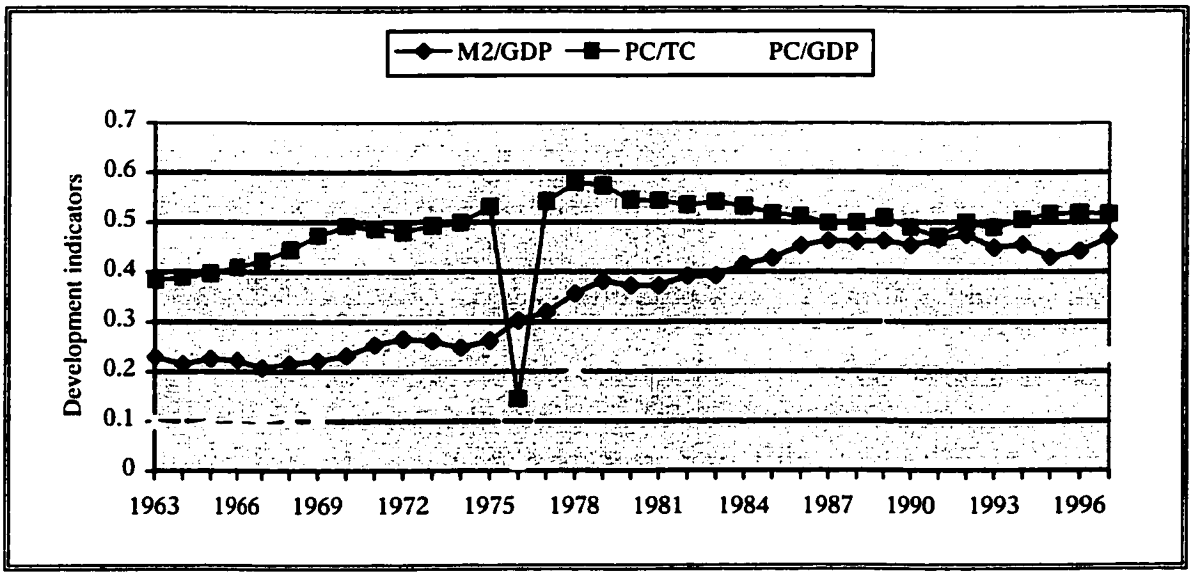
Figure 2.7: Nominal and real interest rates of India



Financial development

The financial development in India since 1963 as measured by the three different indicators of financial development is shown in figure 2.8. The M2/GDP ratio was just over 20% in the 1960s and 30% in the 1970s, less than 40% up to mid 1980s and reached over 40% in the 1990s. The figures do not show any significant increase in M2/GDP ratio in the post liberalization period. M2/GDP ratio has been growing steadily. This ratio is still far behind those in mature industrial economies like Canada and the United Sates (54% and 60% respectively in 1994; IFS, 2000).

Figure 2.8: Indicators of financial development of India



In the industrialized economies, non-bank financial markets are highly developed and therefore the actual contribution of the financial sector is much larger than the M2/GDP ratio would suggest.

On the other hand, developing economies like India has a big informal financial market, the exact size and contribution of this market is not known with accuracy. The other two ratios PC/TC and PC/GDP do not show any substantial increase from 1963 to 1997. PC/TC increased from just below 40% in 1963 to just over 50% in 1997. So the role of private sector in the Indian economy over the decades remains almost stagnant.

Financial sector, reform measures and conduct of monetary policy

Indian government policy towards financial sector can be divided into two regimes: from independence to 1992 and the period thereafter. The first regime (1947-1992) was characterized by i) tightly regulated interest rates in government securities market and the credit market, ii) high statutory reserve and liquid asset requirements designed both to absorb liquidity and to provide government deficit finance, iii) credit ceilings, iv) lack of depth in money market with only overnight interbank market in place, and v) the creation of 91- day ad hoc treasury bills and subsequently funding them into non-marketable special securities at a very low interest rate, etc; Narasimham committee (1991).

The second regime (1992-), the financial sector reforms were undertaken following the recommendation of the Narasimham committee (1991). Although the reform of the financial sector was initiated in mid 1980s, the process was hastened following the economic crisis in the summer of 1991. Two other committees, Chakravarty Committee (1985) and Vaghul Group (1987), were also involved in the process.

The reform process initiated with placing more emphasis on i) broadening and deepening money market, ii) the development of bond market, especially the government securities market, iii) shifting away from direct instruments of monetary control to indirect measures such as open market operations and market related interest rates, iv) strengthening prudential and supervisory norms, while at the same time providing banks and financial institutions maximum autonomy in operational matters, v) improving credit delivery system, and vi) developing the technological and institutional infrastructure for an efficient financial sector.

In government securities market the measures include i) a substantial reduction in maturity period of government paper, ii) setting up a system of primary dealers for dealing in government securities, iii) introducing a delivery versus payment system in respect of government securities settlement, iv) introducing zero coupon bonds, partly stock and capital indexed bonds v) conducting auctions to impart greater transparency in operations, and vi) issuing guidelines for setting up satellite dealers[7].

Open market operations gained considerable momentum as the Reserve Bank of India responded more flexibly to market yields when drawing up its price lists. Interest rate structure was rationalized. Banks are free to determine their domestic term deposit rates and prime lending rates except for certain categories of export credit and small loans. In addition to this, all money markets rates are also made free. The most significant development in this area has been the reactivation of the bank rate by linking it to all other rates including the Reserve Bank refinance rate. The discount and finance house of India was set up to promote a secondary market. Monetary instruments, viz. 14-day, 91-day and 364-day treasury bills were introduced.

Introduction of Liquidity Adjustment Facility (LAF) replacing Interim Liquidity Adjustment Facility (ILAF) is another aspect of reform process. Pursuant to the recommendations of the Narasimham Committee Report on Banking Reforms (Narasimham Committee II), it was decided in principle, to introduce a LAF operated through repo and reverse repos in order to set a corridor for money market interest rates. The ILAF was operated through a combination of repo, export credit refinance, collateralized lending facilities and

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[7] For surveys on the process of reform in Indian financial sector see Reddy (1999), and Reserve Bank of India Annual Report, Various Issues.

open market operation. ILAF provided a mechanism for injection and absorption of liquidity available to banks and primary dealers to overcome mismatches in supply and demand from time to time.

The objectives of monetary policy are described in the preamble to the Reserve Bank of India Act 1934 "...to regulate the issue of bank notes and the keeping of reserves with a view to securing monetary stability in India and generally to operate the currency and credit system of the country to its advantage." The objectives of monetary policy in India, as have been in Bangladesh, have involved maintaining price stability and ensuring adequate flow to the productive sector of the economy. The objective of price stability has secured importance following the opening up of the economy and deregulation of the financial markets in recent times.

As regards to the conduct of monetary policy, the choice of targets, instruments and operating procedures were circumscribed to a large extent by the nature of the financial markets and institutional arrangements. It may be recalled that in recent years, the Bank Rate, Repo Rate and Cash Reserve Ratio have been used in conjunction with open market operation and other operations bearing on liquidity to meet short-term monetary policy objectives in the light of emerging domestic and external situations. The active debt management, combining private placements and distribution of securities through open market sales at convenient intervals and activating the open market operation window for Treasury bills, have helped in keeping the short-term liquidity situation reasonably comfortable during the year without causing undue pressure on security prices. It needs to be reiterated that the prime lending rates of banks for commercial credit are entirely within the purview of the banks and are not set by the Reserve Bank of India.

The Bank Rate and short-term Repo Rate announced by the Reserve Bank of India have been perceived by the markets as signals for direction in market rates of interest. The reform of the monetary and the fiscal sectors has enabled the Reserve Bank of India to expand its instruments of control. The operational target continues to be bank reserves, which are controlled by reserve requirement, affected mainly through Cash Reserve Ratio. Cash Reserve Ratio has gradually been brought down and the liquidity management in the system is carried out through open market operations.

While there has been substantial progress in achieving some of these objectives, the pace of progress has been relatively slow in certain areas. Thus, for example, considerable success has been achieved in redefining the role of the Reserve Bank in financial markets and in actively associating financial experts and intermediaries in policy formulation and its implementation. Substantial progress has also been made in the area of deregulation and providing greater autonomy to banks in operational matters. Money market is functioning reasonably satisfactorily with substantial volume of transactions, although it still continues to be dominated by a few operators. The secondary market for government securities has been strengthened with the emergence of a large number of primary dealers as active participants. Technological infrastructure in the form of Indian Financial Network has been put in place, and preparatory work for Real Time Gross Settlement System and Centralized Data Base Management have been completed. However, so far, very little progress has been made in making the secondary market for securities and bonds sufficiently liquid and accessible to individuals and small investors. Prudential and supervisory norms have been strengthened, but there is considerable scope for further improvement in risk management and internal control procedures of banks and other institutions. There is still a long way to go in making the loan recovery/settlement procedures timely and efficient. A large number of measures have been introduced to make the credit delivery system less cumbersome and hassle free, but progress is slow.

Economic reforms since 1991 have helped India achieve a large measure of macroeconomic stability and a substantial liberalization of its trade, investment and financial sectors. The Indian economy continues to perform well in most respects and long-term prospects remain optimistic, despite continuing concerns about inadequate and substandard infrastructure and budget deficits. However, growth has slowed during the past year due to falling demand, high real interest rates, political uncertainty and secondary effects from the economic crisis in other parts of Asia.

2.3 Pakistan

Pakistan became a self-governing dominion within the British Commonwealth on August 14, 1947. West Pakistan comprised the contiguous Muslim-majority districts of present-day Pakistan; East Pakistan consisted of a single province, which is now Bangladesh. Extreme poverty, underdevelopment and direct and indirect military rule in Pakistan, as well as fiscal and monetary mismanagement had produced a large foreign debt, obscured the potential of a country that had the resources and entrepreneurial skill to support rapid economic growth.

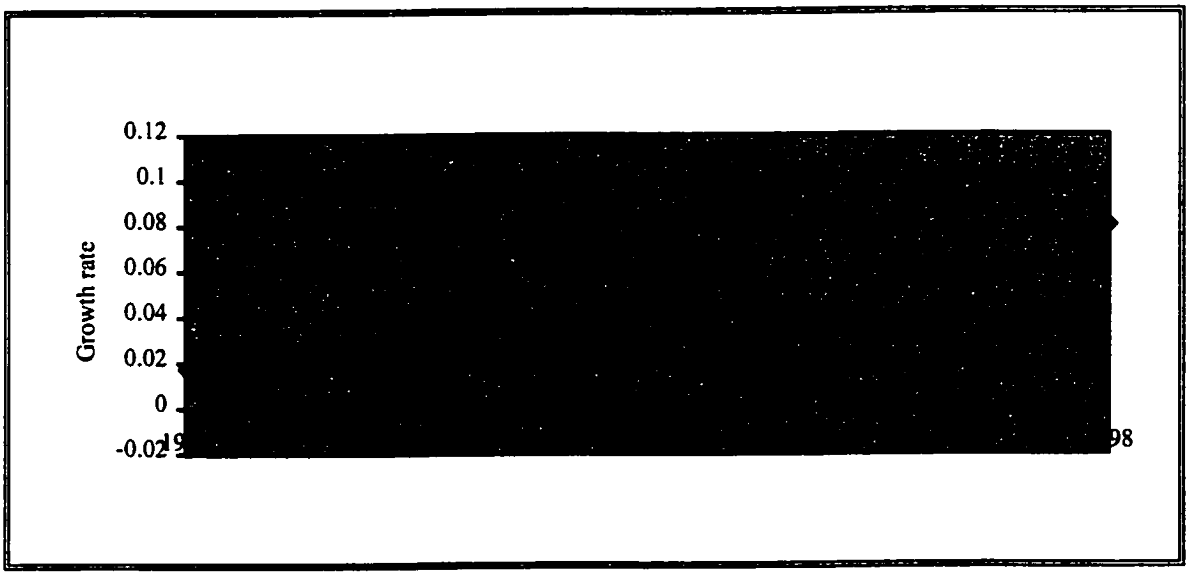
With a per capita GDP of about US$ 440, the World Bank considers Pakistan a low-income country. No more than 54% of adults are literate, and life expectancy is about 63 years. The population, currently about 138.1 million, is growing at about 2.4 percent, very close to the GDP growth rate (World Development Report, 2001). Relatively few resources have been devoted to socio-economic development and infrastructure projects. Inadequate provision of social services and high population growth has contributed to a persistence of poverty and unequal income distribution.

From independence to mid 1980s, Pakistan economy shared many characteristics of a financially repressed economy with rigidly administered interest rate, high reserve requirements, highly controlled foreign exchange, low foreign investment, and nationalization of enterprises.

Since the late 1980s, the Government of Pakistan has been pursuing a gradual strategy of deregulation, reduction of the public sector role in the economy, and opening the economy to international competition. The government has sought to reduce its direct productive or controlling role, and instead focus on creating the conditions to foster private sector investment and activity. While it has made some progress in this direction, the state remains an important player in the Pakistani economy, especially in the financial sector. One of the key challenges faced by the country is to bring the economy back on the path to sustained growth and financial stability, and reduce external vulnerability. Pakistan continues to struggle with these reforms, having mixed success, especially in reducing its budget and current account deficits. Economic reform was further set back by Pakistan's nuclear tests in May 1998 and the subsequent bilateral sanctions and suspension of new nonhumanitarian assistance from international financial institutions. The balance of payments deteriorated significantly, and the effective implementation of several structural reform measures envisaged under the program at the time of its inception was adversely affected. A review of the performance of key macro variables, financial sector reforms and conduct of monetary policy of Pakistan is presented in the following sub-sections.

GDP Growth

Figure 2.9: Annual real GDP growth rate of Pakistan

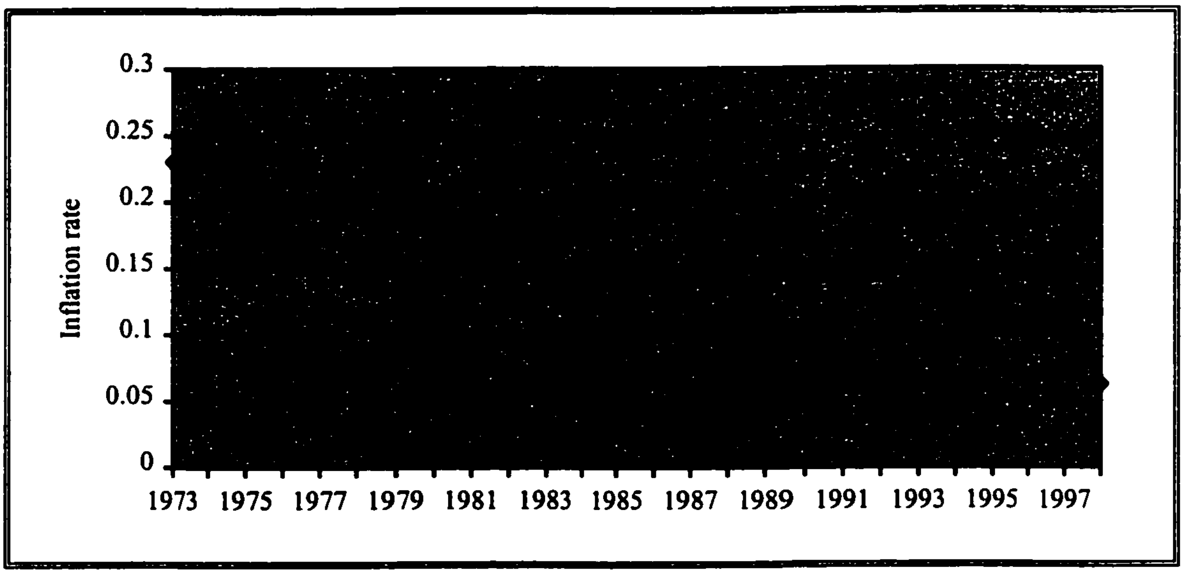


Pakistan economy averaged an impressive growth rate of 5.4 percent per annum during the period 1972-98. Annual average real GDP growth rate was 4.9 per cent in the 1970s. After growing at an average rate of over 6 per cent per year from 1981 to 1990, real GDP growth has slowed in the 1990's. Average real GDP growth from 1991 to 1998 dipped to 4.8 per cent annually. The economy is extremely vulnerable to Pakistan's external and internal shocks, such as in 1993, when devastating floods and political uncertainty combined to depress economic growth sharply and the financial crisis in Asia which hit major markets for Pakistani textile exports. Real GDP growth became negative in 1997 due to a poor cotton crop and related setbacks in the textile industry. The Pakistani economy is almost evenly divided between the commodity sector and the services sector, shares that have held constant for about a decade. Pakistan is determined to sustain real economic growth of 5 per cent or more over the medium term in order to create employment opportunities for her rapidly growing population, improve social indicators, and substantially increase per capita income.

Inflation

Pakistan experienced a double-digit annual average inflation rate of around 10% since 1972. This figure was 13.27% in the 1970s, 6.98 percent in the 1980s and 10.58% in the 1990s. Of the several factors that might be responsible for high inflation in Pakistan, some were policy related while others were outside the control of the government: i) the most important factor that caused high inflation was the rapid growth of money supply at a time when there was a sharp decline in real output; ii) excessive borrowing by government from the banking system to meet budget deficits; iii) huge military budget; iv) frequent devaluation of national currency; and v) the world wide inflation caused by the oil price shock of the 1973 also compounded inflation in Pakistan in the early 1970s. The cost of inflation in Pakistan is severe. As it erodes the value of income, fixed income people are particularly vulnerable to high inflation. High inflation also creates an uncertain environment for both savers and investors.

Figure 2.10: Annual inflation rate of Pakistan

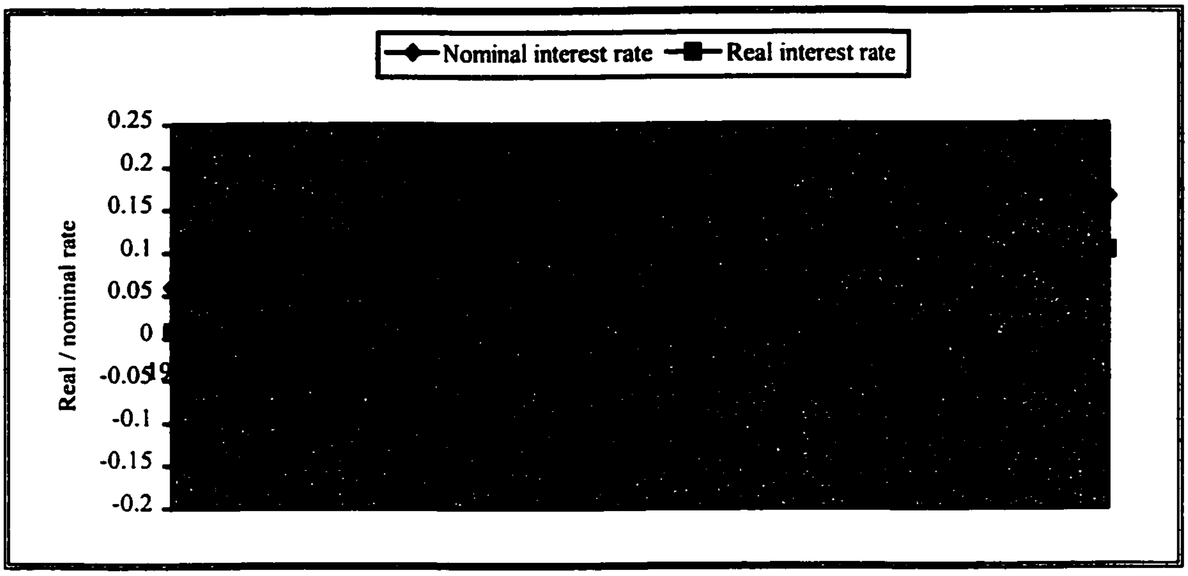


Interest rate

According to McKinnon (1973) and Shaw (1973), an indication of repressed financial market is negative real interest rate. They argued that financial repression in the form of controlled and hence often negative real interest rate reduced incentive for and hindered financial intermediation.

Liberalizing and allowing market driven positive real interest rate would channel funds from consumption, cash holding and less productive self-investment to more productive investment. Since deposit and loan rates are set in nominal terms, a high rate of inflation can produce a negative rate of return on deposits. And this is exactly what happened in Pakistan.

Figure 2.11: Nominal and real interest rates of Pakistan

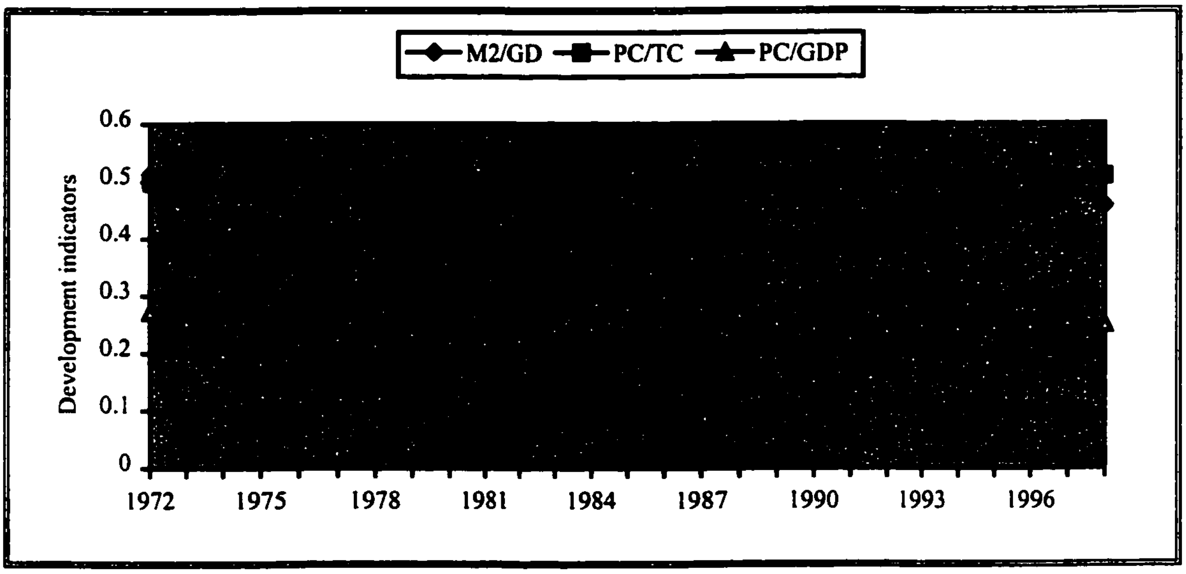


Real rate of interest remained negative for most of the period from the early 1970s, the early 1980s, and the early 1990s; figure 2.11 shows this fact. The real rate of interest started becoming positive and showed an increasing trend since mid 1980s. Although nominal rate remained static for a long time, real interest rate fluctuated because of inflation. After 1990, when liberalization measures were first taken, real interest rate increased because of a high nominal rate.

Financial development

The financial development in Pakistan since 1972 as measured by the three different indicators of financial development is shown in figure 2.12. The M2/GDP ratio was just 50% in 1972 and fell below 40% in 1974-78 period and fluctuated between 40% and 50% in the 1980s and 1990s. The figures do not show any significant increase in M2/GDP ratio in the post liberalization period.

Figure 2.12: Indicators of financial development of Pakistan



The other two ratios PC/TC and PC/GDP remained more or less constant on average (50% and 29%respectively) over the last three decades.

Financial sector, reform measures and monetary policy

Pakistan also went after a nationalization drive in the 1970s. The unplanned nationalization in financial sector on non-economic considerations along with nepotism, tolerance for inefficiency and blatant corruption resulted in structural imbalances in the economy and high degree of repression in the financial market. Absence of competition in the financial sector caused erosion of accountability mechanism and deterioration of services. In view of the above, the government of Pakistan has pursued market-based economic reform policies since the 1980s. Market-based reforms began to take hold in 1988, when the government launched an ambitious IMF-assisted Structural Adjustment Program in response to chronic and unsustainable fiscal and external account deficits. Since that time the government has removed barriers to foreign trade and investment, begun to reform the financial system, eased foreign exchange controls, and privatized dozens of state-owned enterprises. The reform measures included i) allowing private banks to enter into the market, ii) replacement of direct credit control through credit ceiling by a system of credit deposits ratios, iii) introduction of repurchase agreements (Repos) of government securities, iv) introduction of special cash deposit for all the commercial banks in addition to general statutory cash reserve to limit credit and control inflation, and v) regulation of credit through open market operations. Progress has continued to be made in the use of market-based instruments for monetary control[8].

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[8] For surveys on the process of structural adjustment, the major macroeconomic trends, and the main features of the economy's trade and financial sector see Naqvi and Sarmad (1997), Country Reports on Economic Policy and Trade Practices: Pakistan, The US state department, various issues.

The State Bank of Pakistan, henceforth referred to as the State Bank, has been managing domestic liquidity by intervening in the secondary market through open market operations. To facilitate these operations, three-month, six-month, and one-year treasury bills were issued in discount form to replace the existing six-month short-term federal bonds. Recent monetary policy has been inconsistent but aimed at encouraging growth in the context of price stability. The government of Pakistan and the State Bank are attempting structural reforms in an effort to move toward more indirect, market-based methods of monetary control along with greater autonomy for the State Bank.

Other monetary reforms have included efforts to reduce concessional and government-directed credit schemes, enhance competition in the banking sector, and improve prudential regulation and supervision. State-owned development of financial institutions, however, continue to make politically influenced lending decisions and, partly as a result, have weak balance sheets. Prudential regulations have occasionally been relaxed in an ad-hoc fashion to prop up loss-making public or private industries.

The State Bank is in the process of reforming its primary dealer system, which at present includes all banks, nonbank financial institutions, and some members of the stock exchange. Specifically, a new tier of specialized primary dealers is established with stricter obligations and certain privileges compared with the standard primary dealers, the average scope for cash reserve and liquidity requirements is gradually expanded, and the operational procedure for open market operations is refined to promote interbank market activities and reduce the short-term volatility of the interbank interest rate.

The State Bank's autonomy was considerably strengthened with the passage of new banking laws and the amendment of the State Bank. The State Bank of Pakistan Act of 1956 was amended in 1993 to give autonomy to it in implementing of a prudent monetary policy. With such an autonomy of the State Bank, there has been a significant improvement in the ways and means of monetary management. Given the projected growth rate of GDP and inflation target, the bank has developed its analytical capability to estimate a stable demand for money function to calculate a safe level of monetary growth. Open Market Operations are quite efficiently used along with other indirect instruments. Normally commercial banks and other financial institutions abide by the recommendations forwarded by the central bank. But again undue pressure from the politicians on key issues stands in the way of free functioning of the State Bank of Pakistan like any other developing country.

The government, with the assistance of the Asian Development Bank, has developed a comprehensive program to accelerate the development of capital markets in Pakistan. Its objectives are to augment mobilization of long-term financial resources and improve the efficiency of their allocation and to encourage broad-based participation of issuers and investors. To this end, the government has: (i) removed the existing tax discrimination against private corporate debt, and reduced restrictions on investments by institutional investors; (ii) strengthened market regulation and supervision by restructuring the Corporate Law Authority into an independent and autonomous Securities, Exchange and Corporate Commission of Pakistan; (iii) amended the securities and company laws; and (iv) strengthened self-regulation of stock exchanges coupled with restructuring of their governing boards. The government intends to modernize and upgrade the securities market infrastructure, enhance integration of markets through automated trading and developing electronic linkages among stock exchanges and develop centralized clearing, settlement and depository systems. In parallel, the development of the corporate debt market and the mutual fund industry is promoted, and the regulatory framework for the securities industry is strengthened.

What do we learn so far from these three cases reviewed here respecting the financial sector, reform measures and monetary policy making? We can draw some general conclusions, as they seem to apply for all the three countries.

1) Central banks have multiple objectives. Central banks not only care about both economic growth and inflation that may force them to confront difficult trade off but also care about other objectives.

2) All the three countries adopted neo-liberal prescriptions for financial reform at the beginning of 1990s. One of the salient features of reform is interest rate liberalization.

3) Political pressure on key macroeconomic management issues has limited central bank's autonomy in Bangladesh and Pakistan. But the problem is not so serious in India.

4) The bank rate announced by the central banks of the three SAARC countries has been perceived by the markets as signals for movements in market rates of interest. The reform of monetary and financial sector has enabled central banks to expand their instruments of control. A number of common trends in the modernization of operating procedures can be detected. First, the deepening of financial markets and growth of nonbank intermediation has induced central banks to increase the market orientation of their instruments. Second, a higher proportion of reserve is now supplied through open market operations. Third, the greater market orientation of central bank instruments has been associated with a preference for flexible instruments. But the bank rate is the main lever that central bank uses to conduct monetary policy. It is the rate of interest that the central bank charges on short term loans to financial institutions. It is seen as the trendsetter for other short-term interest rates.

5) There has been a certain convergence in monetary policy instruments and procedures in recent years in most of the SAARC economies. Major forces for change have been the rapid development and deepening of a variety of financial markets and instruments, diversification of financial institutions and the globalization of intermediation.

Chapter 3

Review of Earlier Empirical Studies

The literature on earlier empirical works on the three SAARC economies can be divided into three broad categories. One class is the univariate single equation models. While such a model offers simplicity, its assumptions are scarcely met in real economies. A second class is the bivariate causality models. Most of the studies on SAARC countries applied the bivariate causality model. While these models are definitely an improvement over the single equation models, they suffer from the omitted variables bias. A third class of models comprises the multivariate vector autoregressive models that incorporate key aggregate economic variables into the system. The model involves enough identifying assumptions to orthogonalize the shocks. One such assumption is the recursivity assumption. A small amount of literature has been written in the context of SAARC economies under this category. In this chapter, a brief review of selected previous studies is presented which helps identify the deficiencies of previous models and provide some guidance in formulating a more comprehensive model[9].

[9] The pioneering attempts to measure the effects of money on economic activity using Vector Autoregressions (VAR) are the studies of Sims (1980a, 1980b). These studies are among the most cited references in VAR literature. The studies question the importance of unexpected changes in money for future changes in economic activity and reject the neo-monetarist interpretation that monetary policy

3.1 Single Equation Models

Empirical investigations of the money-price and money-output relation in the SAARC countries based on a single equation model are relatively few in number. The important studies include Siddique (1975) and Taslim (1982) for Bangladesh, Srivastava and Saxena (1968) for India and Hussain (1982) for Pakistan.

The first study on price-money relationship in Bangladesh was undertaken just four years after its independence. Siddique (1975) estimated a single equation model using monthly data from January 1972 to March 1974. In Bangladesh from mid 1973 to early 1974, the price level increased at a rate, which is much higher than the increase in money supply. He tested the traditional quantity theory of money as to whether the velocity of circulation of money had changed during that period. Following quantity theory of money, the relationship between money and price is expressed as:

$$P = f\{ M, V, T \} \qquad (3\text{-}1)$$

where, P is price, M is quantity of money, V is velocity of circulation of money and T is total value of goods and services.

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shocks could explain nearly all cyclical variation in real variables in the economy. Sims findings led widespread criticism among the monetarists. But Sims claims that his (1980) findings provide an example of how even simple VARs can be used to present important evidence on theoretical issues. Other important works using VAR include Bernanke (1986), Sims (1986, 1992), Gali (1992), Gordon and Leeper (1994), Pagan and Robertson (1995), Leeper, Sims and Zha (1996), Cushman and Zha (1997), Bernanke and Mihov (1998), Robertson and Tallman (1999a, 1999b). All of these studies, however, dealt with developed countries.

Assuming T as constant, Siddique fitted the following regression equation:

$$P = b_1 + b_2M + \sum_{i=1}^{8} b_{2+i} D_i + e \qquad (3\text{-}2)$$

where, D_i is a dummy variable (1 if in quarter i; 0 otherwise) and e is the error term. For quarter 1, it is the coefficient of M and for subsequent quarters the coefficient of each D_i has to be added to the coefficient of M to compute the velocity of that quarter. He divided the whole period into two sub-periods with first sub-period consisting of the first 15 months and the second sub-period consisting of the last 12 months. He found that the velocity of money increased substantially in the second sub-period as compared to the first sub-period. He concluded that this happened only because of inflationary expectations. Erosion of confidence in the currency and consequent asset substitution was the main reason behind these inflationary expectations.

Taslim (1982) attempted to analyze the inflationary process in Bangladesh in light of the structuralist-monetarist controversy. To this end, he constructed a single equation model of inflation that captured all the essential arguments of structuralists. According to this model, actual rate of inflation (P) was a function of index of agricultural bottleneck (A^b), import bottleneck (I^b), and the annual rate of change of wage rate (W):

$$P = F(A^b, I^b, W)^{10} \qquad (3\text{-}3)$$

[10] A similar model was developed earlier by Hagger (1977).

He constructed indices of structural bottlenecks and developed tests using the structural model.

In addition, he constructed another single equation distributed lag model of inflation that captured the essential arguments of monetarists. In this model, rate of inflation was specified as a function of income growth rate (Y), current period money supply (M) and one period lagged money supply (M_{-1}).

$$P = F(Y, M, M_{-1}) \qquad (3\text{-}4)$$

Finally, he combined these two models of inflation and thereby developed a model that captured the arguments of both the structuralists and monetarists:

$$P = F(A^b, I^b, P_{-1}, M) \qquad (3\text{-}5)$$

He found that the combined model performed best and both monetarist and structuaralist factors were relevant for explaining the inflationary process in Bangladesh. He concluded that a slowing of the growth of money supply would have a moderate effect on inflation but one could not expect inflation rate to be less than the targeted growth rate of the economy in the presence of structural bottlenecks. A reasonable growth of money supply was essential for Bangladesh to grow. If the growth of money supply were completely halted, it would adversely affect economic growth.

Perhaps, the first study on money, output and prices in India was done by Srivastava and Saxena (1968). Their model was a simple single equation model. They regressed the index of wholesale prices (X_3) on real output (X_2) and quantity of money (X_1) for the period 1950-51 to 1964-65. They estimated the following regression equation:

$$X_3 = 85.2103 + 0.5066\,X_1 - 0.3758\,X_2 + e \qquad (3\text{-}6)$$

where, e is the estimated error term. They concluded on the basis of the above estimation: i) an increase in output induced a fall in prices whereas a rise in money supply induced a rise in prices and that money supply exerted a greater impact on prices relative to output; and ii) a unit rise in money supply induced a less than proportionate rise on price; this showed that there are some other factors operating on the price level.

Without going into details of the limitations of a single equation model in explaining the relationship among money, price and output, some specific drawbacks of this study invalidate its conclusions because (a) they did not provide any reference to standard errors of the regression coefficients; and (b) the value of 0.50 of the coefficient of money was not enough to prove that there were some other factors influencing the price level.

Investigation of the interrelationship among money, price and output in Pakistan is relatively recent compared to India and Bangladesh. Hussain (1982) initiated research in Pakistan by employing a single equation model; this is called the St. Louis equation[11]. This single equation model provides a straightforward

[11] Andersen-Jordan (1968), who developed the St. Louis equation, were interested in isolating statistically the impact of money on nominal income. Rather than constructing a complex econometric model like those in fashion at the time, they took a relatively simple approach to assessing alternative policies by

empirical test of related and critical policy issues—the relative impacts of monetary and fiscal impulses on nominal income. Hussain fitted the following equation:

$$Y = a_0 + a_1M + a_2F + u \qquad (3\text{-}7)$$

where, *Y* represents nominal gross national product, *M* is the money stock (M1 or the monetary base), and *F* is a measure of fiscal policy actions (total government expenditure).

Using yearly data covering the period 1949-50 to 1970-71, Hussain estimated equation (3-7) and tested three related hypotheses. By comparing the sizes of the estimated impacts of fiscal and monetary policy on GNP, Hussain accepted the hypothesis that output responded more to fiscal policy actions than to changes in the money stock. Comparison of the statistical significance of the coefficient estimates for monetary and fiscal policy actions led Hussain to accept the hypothesis that fiscal actions were more "reliable" in their impact on GNP than monetary actions. Finally, comparison of coefficient estimates on lagged monetary and fiscal policy actions led Hussain to accept the hypothesis that fiscal actions affect GNP faster than do monetary policy actions. He succinctly summed up the evidence: the response of economic activity to fiscal actions compared with that of monetary actions is larger, more predictable, and faster; see Hussain (1982, p.171).

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estimating a single empirical relation—a "reduced-form" model—between income and different measures of monetary and fiscal policy actions.

3.2 Bivariate Causality Models

While the single equation models discussed above are simple and easy to estimate, the equations are not derived explicitly from a larger model and therefore important feedback mechanism may be omitted. If the right hand side variables in the above equations are not exogenous, the equation may be part of a system of equations where the variables are interdependent. The extension of single equation approaches to models of interdependent variables, where feedback mechanism exists, went some way with the work of Sims (1972). Researchers in the 1970s began developing two-variable causality models. In the SAARC countries, however, use of bivariate causality models could be traced back to mid 1980s. Jones and Sattar (1988), Parikh and Starmer (1988) covering Bangladesh, Sharma (1984), Verma and Kumar (1994) covering India and Jones and Khilji (1988), Hussain (1991) covering Pakistan, are among the important studies.

Jones and Sattar (1988) used a dynamic form of Cambridge cash balance equation and examined the relationship among money, prices and output in Bangladesh. They studied the following equation:

$$\dot{P} = \dot{M} - \dot{Y} \qquad (3\text{-}8)$$

This equation posits a relationship between the inflation rate and money growth, after accounting for the growth of real output. With the aid of Granger test, they examined the causal link between money growth and inflation and money growth and output (Industrial production Index, IPI, was used as a proxy for output). First of all, taking money and inflation, two variables were regressed on each other with a lag length of 12, 24 or 36. Then they focused on the relationship between money and output by regressing each other with the same lag length. They reported that money impacted on real aggregate economic activity both in the short run and in the long run and vice versa. On the other hand, there was a feedback relationship between money and inflation, though this was a short run phenomenon only.

Jones and Sattar (1988) has several weaknesses: (a) they start with the Cambridge cash balance equation but their testing procedure does not involve that equation; (b) in the estimated regression equation, lagged values of one variable were regressed on another variable. This is essentially a two variable single equation distributed lag model and is seriously subject to omitted variable bias; and (c) the lag lengths were chosen arbitrarily. We are left with the uncomfortable conclusion that an arbitrary choice of lag length left to the discretion of individual researcher can significantly affect the nature of the economic conclusions derived from the test procedure.

In their article Parikh and Starmer (1988) addressed two issues: (i) to what extent is an expansion in money supply responsible for increase in inflation? (ii) is the money supply endogenous in the sense that it responds to increase in prices in a cost-push process? They used monthly data covering the period 1973.11-86.11 and estimated interrelationships on both level and rate of change of money and prices. They conducted the Wald test, the likelihood ratio test and the Lagrange multiplier test and reported a unidirectional causality running from prices to money. This observation rejected the treatment of money supply as an exogenous variable.

We observe that from 1970s to 1980s researchers paid less attention to modeling money and output/ money and price in India. But from the early 1980s, bivariate causality models became the core of money-output and money-price research in India. Using the theory of Granger and Sims, a maiden attempt was made by Sharma (1984) to investigate into the direction of causality between money and prices in India. Covering the data from 1962 to 1980, Sharma studied the following distributed lag system:

$$P(t) = \alpha + \sum_{s=-m1}^{m2} \beta(s)\ M(t\text{-}s) + \varepsilon(t) \qquad t = 1, \ldots T \tag{3-9}$$

$$M(t) = \delta + \sum_{s=-m1}^{m2} \lambda(s)\ P(t\text{-}s) + \eta(t) \qquad t = 1, \ldots, T \tag{3-10}$$

where, P is wholesale price index, M is both narrow money (M1) and broad money (M2), m_1 and m_2 are respectively lengths of lag distribution on the future and past values of the relevant independent variables, and ε (t) and η(t) are the error terms. With the null hypothesis that P does not cause M, β(s) should be equal to zero for s< 0 in the first equation; similarly, under the null hypothesis that M does not cause P, $\lambda(s)$ should be equal to zero for $s< 0$ in the second equation. He deseasonalised and stationarised the variables by applying ratio to moving average method and method of differencing[12]. He concluded that causality from M1 to P is much stronger than causality from P to M1. He also found a bi-directional causality between M2 and P. Another important finding was that these results were insensitive to lengthening of the lag profile.

Verma and Kumar (1994) attempted to study the direction of causality between money supply and prices in India using quarterly data for the period 1971-90. First, they deseasonalized the quarterly data by moving average method. Secondly, differences of the moving averages were taken to stationarise the variables. They employed Sims test to detect the direction of causality and found a unidirectional causality running from M1 to P.

Masih and Masih (1994) examined the issue of causality between money and prices in the context of the Indian economy covering annual data from 1961 to 1990. Two salient aspects of this study were: a) application of cointegration and error correction modeling to test the causality between money and price; and ii) adoption of four procedures such as Haugh-Pierce test, Granger test, modified Sims test and error correction approach to determine the direction of causality. Two bivariate models - one with M1 and the other with M3 (M1 plus time saving, and foreign currency deposits) - were experimented. Evidence from

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[12] Refer to Sharma (1984, p. 215) for details regarding how these two methods are accomplished.

causality tests suggested that money was the major cause of inflation as the monetarists maintained. Price was not the leading variable as the structuralists maintained. This study was indeed rich in terms of a theoretical survey and the application of various causality tests.

However, the above-mentioned study suffers from three shortcomings. In the first place, it captures one view of monetarism. But the important question of causality between money and output is ignored. Secondly, causal interpretations of causality models require a well-defined theoretical structure, which is lacking in this study. A third drawback is that causality tests are most often found to be sensitive to modification of lag length, sample size, and functional form. But no such sensitivity tests are conducted.

Other studies that fall in the bivariate analysis in the Indian context are Bhattaacharya and Sharma (1985), Roy and Namboodiri (1987), Singh (1989), Biswash and Saunders (1990) and Jadhav *et. al.* (1992). The studies adopted different sample periods, lag structures, definitions of variables and the frequency of data.

Bivariate causality models were estimated using Pakistani data in the late 1980s. Jones and Khilji (1988) attempted to determine whether an identifiable causal relationship exists between changes in money supply and price level in Pakistan. The sample period began in 1973 and ended in 1985. Two measures of inflation (consumer price index (CPI) and wholesale price index (WPI)) and two measures of money supply (M1 and M2) were used. First they removed deterministic seasonal and non-stationary elements by regressing on linear trend and seasonal dummies. Then they tested for causality using the following bivariate autoregressive model:

$$\begin{bmatrix} P_{i,t} \\ M_{j,t} \end{bmatrix} = \begin{bmatrix} A_a(L) & B_b(L) \\ C_c(L) & D_d(L) \end{bmatrix} \begin{bmatrix} P_{i,t} \\ M_{j,t} \end{bmatrix} + \begin{bmatrix} u_t \\ v_t \end{bmatrix} \tag{3-11}$$

(t=1....T)

(i = CPI, WPI)

(j = M1, M2)

where, $A_a(L)$, $B_b(L)$, $C_c(L)$ and $D_d(L)$ are lag polynomials of orders a, b, c, and d respectively. u and v are white noise error terms.

To capture short run and long run effects, b and c were set lag lengths of equal to 12, 24, or 36 whereas a and d were set lag length of 12. F-tests for joint significance of the lagged coefficients were employed to determine the causal direction of the variables. Their findings showed that unidirectional causality ran from both M1 and M2 to wholesale price but not to consumer price. The feedback came from consumer price index to both measures of money supply but not from wholesale price index.

Hussain (1991) applied the same bivariate causality model but tested the other proposition of the monetarists that is related to money and income. He applied Sims (1972) causality test procedure for the period 1971-72 to 1988-89. M1, M2 and monetary base, MB, were used as money variables. All of the data were expressed in logarithms and were prefiltered by using the formula (1- 1.5L X_t + $0.5625L^2)X_t$ where X represents each variable expressed in natural logarithms. This pefiltering, as Sims claimed, makes the residuals of the regression nearly white noise. The F-tests were conducted by choosing one year past value and one year future value of the regressor. The results showed that (i) a unidirectional causality ran from monetary base to GNP; (ii) a unidirectional causality ran from M2 to GNP; and (iii) a unidirectional causality ran from GNP to M1.

The results of this study are weighed down by some limitations: (a) Sims test is particularly sensitive to the lag structure but Hussain chose one period lag length without any statistical ground; and (b) the F-test that he used to determine the direction of causality is actually a t- test of a single coefficient.

Table 3.1 summarizes the findings of bivariate causality studies conducted for Bangladesh, India and Pakistan. The overall evidence on the question of causality is mixed. In some of the studies lagged values of money are important in explaining prices while in the other studies lagged values of prices are important in forecasting variations in money and output. As these studies included only two variables in the model, obviously they are subject to omitted variables bias. These causality tests disregard the possible influence of other variables on money and prices, which is a major deficiency of these studies. Some economists (Schwert 1979, for example) argue that causality tests are badly misnamed. They do not test causality but actually test incremental information. They simply reveal whether addition of some variables raises our information level about the future value of the dependent variable.

Table 3.1: Summary of bivariate causality studies

Country	Study	Sample Period	Data Frequency	Direction of Causality
Bangladesh	Jones and Sattar (1988)	1984 -75	Monthly	M1 ⇔ IPP M2 ⇔ IPP M1 ⇔ CPI (short run) M2 ⇔ CPI (short run)
	Parikh and Starmer (1988)	1973-86	Monthly	CPI ⇒ M1
India	Sharma (1984)	1962-80	Yearly	M1 ⇒ WPI WPI ⇔ M2
	Verma and Kumar (1994)	1971-90	Quarterly	M1 ⇒ CPI
	Masih and Masih (1994)	1961-90	Quarterly	M1 ⇒ WPI M3 ⇒ WPI M1 ⇒ CPI M3 ⇒ CPI
Pakistan	Jones and Khilji (1988)	1973-85	Quarterly	M1 ⇒ WPI M2 ⇒ WPI CPI ⇒ M1 CPI ⇒ M2
	Hussain (1991)	1971/72-88/89	Yearly	GNP ⇒ M1 MB ⇒ GNP M2 ⇒ GNP

⇒ Denotes unidirectional causality
⇔ Denotes bi-directional causality

3.3 Multivariate models

Lagged values of an explanatory variable capture the systematic or anticipated impact while the residuals capture the effects of unexpected contemporaneous events. None of the above-mentioned studies analyzed the dynamic interactions among the variables due to unexpected shocks in each of the variables. The pioneering study in this direction was Momen (1992). The study included ten countries including Bangladesh, India and Pakistan. Chowdhury *et.al.* (1995) conducted one important work on Bangladesh employing a multivariate model. Kamas and Joyce (1993) applied a multivariate model for India while Chishti et al. (1992) and Masih and Masih (1997) were two important studies on Pakistan.

Momen (1992) analyzed yearly data from 1958 to 1985 for ten industrial and agricultural economies including Bangladesh, India and Pakistan. The objective of this study was to assess interaction among the variables, namely, the rate of inflation (P), the rate of change in real gross domestic product (Y), the rate of change in term of trade (T), the rate of change in government expenditure (G), and rate of change in money supply (M). He constructed a reduced form vector auroregressive model where each of the five variables was regressed on past values of itself and past values of the other four variables in the system.

He employed a likelihood ratio test to determine the lag length and then estimated the reduced form VAR model. He found that the adjusted R^2 in all the equations for all the countries were very high and claimed that the explanatory power of the model was very high and that the variables in the models were correctly chosen. In addition, he conducted F-tests to determine causal relationship among the variables and concluded that in the industrial countries, causality ran from money supply to real GDP, which is in conformity with the monetarists view. But in predominantly agriculture economies, causality ran in the opposite direction. Finally, he computed 1-year, 3-year, 9-year and 15-year ahead forecast error variance decompositions of the variables due to shocks in the variables and tried to determine their endogeneity and exogeneity. He claimed that ordering of the variables could be determined by looking at the initial impact on each variable due to shock in the variable itself. He found that money supply was exogenous in industrialized economies and real GDP was exogenous in predominantly agriculture economies.

This study is subject to some serious shortcomings: (a) serious questions can be raised about the data set used. The study used data from 1958-85 for all the countries. But Bangladesh was liberated in 1971. Before 1971, it was part of Pakistan. He used the same data for both the countries up to 1971, which is faulty and definitely gives misleading conclusions for both Bangladesh and Pakistan; (b) he used the results of variance decomposition to determine the ordering of the variables. But ordering of the variables in VAR is normally ad hoc. Forecast Error Variance Decomposition (FEVD) is used to determine the relative strength of one variable in explaining all other variables in the system. Before computing FEVD, we need to order the variables only if we employ the recursive identification scheme; (c) he did not bother to orthognalize the shocks, which is very important to isolate their effects. He used the reduced form innovations to compute variance decomposition to draw different conclusions. But if reduced form errors are correlated, which is most likely, this methodology could lead to erroneous conclusions and that the estimated variance-covariance matrix of the errors reflects the seriousness of the problem. The error term in the first equation is a linear combination of structural errors. But structural shocks are independent and should not be correlated with each other. We need to orthogonalize the structural shocks to isolate the individual effects. But unfortunately, this study ignores this important issue.

To evaluate the relationship among key macro aggregates in Bangladesh over the period 1974-92, Chowdhury *et.al.* (1995) studied a VAR model of the form:

$$y_\tau = b_\tau + A(L)y_\tau + e_\tau \qquad (3\text{-}12)$$

where, y_τ is the 4×1 vector of four endogenous variables in the model, b_τ is a 4×1 vector of intercepts, A(L) is a 4×4 matrix of lag polynomials and e_τ is the 4×1 vector of innovations. Two four-variable VAR models were constructed consisting of a monetary aggregate, consumer price index, industrial production index and the exchange rate. One model used M1 as the monetary aggregate while the other used M2 as the monetary aggregate.

Firstly, they conducted an F-test for causality and found a feedback relationship between the growth rate of broad money and inflation rate though a unidirectional causality ran from inflation to M1. Secondly, they employed Choleski decomposition technique to orthogonalize the shocks. Dynamic interactions among the variables were analyzed with two summary measures: Forecast Error Variance Decompositions (FEDV) and Impulse Response Functions (IMF). One of the important findings was that the monetary aggregates (M1 or M2) can explain around 15 to 16% of the variation in output (industrial production index has been used as a proxy for output) at the end of 3rd year. On the other hand monetary aggregates, M1 or M2 can explain around 22% or 43% respectively of the variation in price at the end of 3rd year. Accordingly the real business cycle theorists view found support in their study.

While this study is an improvement over the Momen (1992), it is subject to the following shortcomings: (a) use of industrial production index as a proxy for output in a developing country like Bangladesh is difficult to rationalize; (b) though they claimed the F-tests they conducted as multivariate tests, actually they are bivariate causality tests. Because they considered lagged coefficients of a particular variable in a single equation of the system not the other equations of the model. Only a likelihood ratio test can do this job (see Enders 1995, p. 316, and Doan, 2000, p. 289); (c) only a recursive identification scheme is employed in which orderings of the variables are important. Only one ordering is exercised but no explanation is given as to why this particular ordering is chosen; (d) three-year time horizon is not sufficient to capture the dynamic properties of a model; and (e) no effort is used to separate the role of different variables in the post financial liberalization period in Bangladesh.

In India, empirical literature up to the early 1990s was silent on the impact of unexpected component of one variable on the other variables in a multivariate system. Kamas and Joyce (1993) investigated the impact of unexpected shocks in monetary variables on the domestic and foreign sectors in India and Mexico. They dealt with a five variable VAR model with income, prices, the central bank domestic credit and foreign reserve holdings, and US money. F-tests for causality, variance decompositions and impulse response functions were utilized to examine the relationship among the variables. The central bank domestic credit and foreign reserve holdings were considered as monetary policy variables. Causality tests show that neither of the monetary variables caused income in India. The results of 5-year ahead FEVD showed that only 1.1 to 3.4 per cent variation in output could be explained by domestic credit under different orderings. Contribution of foreign reserve holdings was below 1 per cent.

The above study suffers from the following shortcomings: (a) use of domestic credit and foreign reserve holdings as a monetary variable does not comply with the monetarists view; (b) high correlation between GDP and Industrial Production Index (IPI) is shown as reason for using IPI as a proxy for GDP. But IPI does not accurately represent GDP in a developing country like India; and (c) representation of only 5- year ahead forecast error variance decomposition while ignoring the other steps fails to capture the true dynamic picture. For example, contribution of monetary variables in explaining output may be higher in the short and the medium time horizon.

Monetary research on Pakistan turned to multivariate systems in the early 1990s. The first attempt to apply a vector autoregressive model to fit to Pakistani data was the study by Chishti et al. (1992). They used annual data covering the period 1960 to 1988 and estimated a VAR model which included ten macroeconomic variables: real GDP, consumer price index, terms of trade between agriculture and manufacturing sectors, unemployment rate, real investment, real value of remittances, real exports, real external resources, money stock and real government expenditure.

F-tests for causality found a unidirectional causality running from money to output. Price did not cause money but money did cause price. Impulse response analysis revealed that money produced a strong positive delayed impact on real GDP and general price level. FEVD showed that money could explain 33% of the variation in output and 40% of the variation in price at the end of the fifth year. This finding unequivocally supported the monetarists' position in Pakistan.

A major limitation of the above study is that it includes too many variables when data on the variables spans only from 1960 to 1988. The model includes ten variables with only 28 yearly observations. To save degrees of freedom lag length was truncated to only two periods, which is not sufficient to capture the dynamics of the issues involved. In addition, when too many variables are included in a VAR model, additional complications arise. The simultaneous relations among different variables and policy innovations make it difficult to correctly identify the shocks. There are several core macro variables that policy makers are most concerned about: interest rate, GDP, consumer price index (CPI), money stock, unemployment rate, and exchange rate. Addition of more variables would certainly have some costs. Either it is more infeasible to obtain precise estimation of the model as it grows larger or make judgemental adjustments to keep the size of the model manageable. They often lead to misleading policy conclusions. There is no consistent evidence that indicates that inclusion of too many variables would help the model better fit those core macro variables. A related point is that as no interest rate variable is included, it is not possible to say whether 'liquidity effect' or 'liquidity puzzle' dominates in Pakistan.

A recent important paper by Masih and Masih (1997) also contributes to this literature. They examined the issue of causality between money and prices covering quarterly data from 1970-71 to 1993-94. Two five-variable models - one with Ml and the other with M2- were exercised. The variables used were the consumer price index (CPI), index of industrial production (Y), market rate of interest (IR), spot exchange rate (ER), money supply (Ml or M2). They conducted both bivariate and multivariate tests for causality. They used augmented Dickey-Fuller tests and Phillips-Perron tests as diagnostics for the presence of nonstationarity in the data; they found evidence of a unit root in all the series. But all the variables were found to be stationary after first differencing. They tested for cointegrating relationships among the variables based on Johansen (1988) and Johanhen and Juselius (1990) method. They found that the five variables were bound together by a long run equilibrium relationship in both models.

Evidence from causality tests, variance decompositions and impulse response functions under a recursive identification scheme suggested that price was the leading variable and thus supported the structuralist view. Money was not the major cause of inflation as the monetarists maintained. This finding contradicted with Chishti et al. (1992).

The above review makes it clear that literature has not yet converged on a specific conclusions regarding the effects of different variables. Evidence gathered so far has made it difficult to conclude that money responds to economic activity, or that monetary policy is an inconsequential addendum to the process of output growth. It is not easy to diagnose how differences in statistical procedures affect these results.

From the methodological point of view, since Srivastava and Saxena (1968) documented the relationship among money, output and price, the continuing research has made important strides in SAARC countries. From the late 1960s to the early 1980s the single equation models dominated. From the early 1980s to the mid 1990s researchers paid considerable attention to the reduced form bivariate model of money and output/ money and price. Apart from the sample periods adopted, the studies varied in a number of technical details, the most important being the selection of lag structure, definition of variables and prefiltering, stationarity and frequency of data. While this reduced form evidence does not have any unambiguous structural interpretations, it nonetheless provides motivation for developing multivariate models from the early 1990s.

Chapter 4

Model and Methodology

Methodological debate in macroeconomics can be traced back to early 20th century. The progress of macroeconometrics, like any other science, very much depends on sound methodology. A sound methodology provides a set of principles to guide research in all its facets. This chapter is organized as follows. In section 4.1, we look at the evolution of macroeconometric methodological issues and attempt to place where it currently stands. Methodology adopted in the present study is discussed in section 4.2. Finally in section 4.3, a brief discussion about the data set used in the present study is presented.

4.1 A brief history of macroeconometric modeling and forecasting[13]

Macroeconometric model building originated in the nineteenth century and dealt mainly with various aspects of quantitative economics. One of the earliest and clearest views of the economy as a flow system is that of Leon Walras; it is purely theoretical in nature and is devoid of any quantitative content. According

[13] Historical facts of this section draw partially from Bodkin et. al. (1991), Christ (1994), and Diebold (1997).

to him, a competitive economy can be represented by a consistent set of equations for prices and quantities and the market would solve itself by what he called 'tatonnement' process. Later Walrasian system has been a source of inspiration to several generations of econometricians as they have attempted to find empirical counterpart of his abstract system of equations. Though current macroeconometric models are different from that of Walras abstract model, nevertheless, the notion of an economy as a system has been retained and developed.

Macroeconometric model building began with the structural linear simultaneous equations models of the Dutch and the US economies constructed by Jan Tinbergen in the 1930s and continued up to mid-1980s. There had been some early success for estimation methods of simultaneous equations system but they were not recognized and generally accepted by the economists. Marcel Lenoir (1913), Philip Wright (1915), Elmer J. Working (1927) made some early attempts to estimate simultaneous demand and supply equations. But they did not know how to deal with the problem when both demand and supply curves shift together. Philip Wright (1928) and Jan Tinbergen (1929-30) gave the correct solution to the problem of estimating linear supply and demand curves when both curves shift.

In the first half of 20th century, G.C. Evans (1934), C.F. Roos (1930), Ragnar Frisch (1933), and Michal Kalecki (1935) did some important research.

They helped lay the foundation for the construction of the early macroeconometric models. Both Kalecki and Frisch dealt with system of mixed difference-differential equations. Frisch substituted reasonable values for the structural parameters while Kalecki used rudimentary statistical data of the US for estimating the parameters of his system. Solution to both approaches yielded cycles. But Kalecki's effort can be regarded as pioneering as it appears to represent a step towards an econometric approach to business cycle problems and the subsequent development of macroeconometric models.

The most important single antecedent for the construction of macroeconometric models is J.M. Keynes's *The General Theory of Employment Interest and Money* (1936), briefly referred to as the General Theory. For many years macroeconometric models have been constructed as essentially empirical counterparts to the Keynesian system. Only in recent years have econometric models based on an alternative paradigm appeared. Keynes theory, however, was far ahead of measurement. Major developments of macroeconometric models on the world scene took place just after the Second World War. It was initiated by a team effort at the Cowles commission at the University of Chicago. The Cowles commission for research in economics created a revolution in econometric methods and practice. It was founded in Colorado Springs in 1932. The reputed journal *Econometrica* began its first publication in 1933. The commission's articles of incorporation gave its purpose as " to advance the scientific study and development ... of economic theory in its relation to mathematics and statistics." Later in 1939, the commission was moved from Colorado Springs to Chicago. Professor Jacob Marschak joined the commission as research director in 1943. Abraham Wald, Trygrave Haavelmo, Tjalling Koopmans, Simon Kuznets, Richard Stone, Raymond Goldsmith were the intellectuals assembled by him as staff at the Commission. L.R. Klein, K. Arrow, G. Debru, F. Modigliani were among the many other luminaries who joined later. In 1955, the commission was renamed as Cowles Foundation and moved from Chicago to Yale. Professor James Tobin was appointed as its research director. The Foundation had three divisions: economic theory (model specification), statistical inference (model estimation, testing and application) and model construction (data preparation and numerical calculation). Already available before the Cowles Foundation was Leon Walras general equilibrium theory and contemporary business cycle theory, especially the General Theory.

The two main programs of Cowles Foundation were an explicit formulation of a probabilistic framework and the notion of a simultaneous equations model. Cowles Foundation researchers were engaged in identification and estimation of structural system of equations and caught up with a measurement of Keynesian economic theory. A parallel development also took place in the Netherlands at the central planning bureau led by Professor Jan Tinbergen.

Three chief contributors to Cowles Foundation's theoretical econometric work were Haavelmo, Koopmans and Klein. Haavelmos' major theoretical econometric contributions are contained in three fundamental papers (1943, 1944, and 1947). He used stochastic simultaneous equations models, detected simultaneous equation bias and estimation method of just identified equation. Koopmans' pioneering contributions are contained in four important papers. The first (1949) presents the solution to the identification problem. The second (1950) defines some key concepts like exogenous and pre-determined variables. The third Koopmans *et. al.* (1950) gives the basic Cowles theorem on identification and maximum likelihood estimation of simultaneous equations system as a whole. The fourth, Koopmans and Hood (1953), presents some of the Cowles results. Lawrence Klein began his work in the mid -1940s and over the next fifteen years made a series of seminal contributions responsible for putting the entire field of macroeconometrics on a higher plane. Klein's *Keynesian Revolution* (1946) and Klein-Goldberger's *Econometric Model of the United States: 1929-1952* (1955), may be viewed as a first important step toward model construction, estimation and analysis of a demand oriented Keynesian system. The Klein-Goldberger model consisted of 15 structural equations; five identities and five tax transfer auxiliary relationship. It was estimated by limited information maximum likelihood method.

The macroeconomic system of equations approach appeared successful. The models were regularly used for forecasting and policy simulations. But there is a debate over the value of this achievement for applied work. The debate relates to the nature and implication of the simultaneous equations approach.

Structural economic forecasting, because it was based explicitly on theory, rises and falls with theory, typically with a lag. In the 1960s large Keynesian macroeconometric models seemed to be natural tools for meeting the demand for macroeconomic forecasting. By the end of 1960s there were several competiting economy wide macroeconometric models with very many equations. But a few prominent economists like Friedman, Lucas and Sims questioned the logical foundations of these large-scale macroeconometric models.

Friedman was one of the most persistent critic of the Cowles brand of econometrics not only from the point of view of econometric methodology but also of his skeptical view of Keynesian methods. Lucas (1976) issued a serious warning regarding the use of estimated econometric models to predict the effects of future changes in economic policy; this has come to be known in the literature as the "Lucas critique". One of the salient features of the Keynesian macro model is the slow adjustment of price to equate demand and supply in the market. To what extent sluggishness of price adjustment would change in response to a policy change? The Lucas critique challenged the reliability of policy advice derived from such models that could not answer such basic questions. According to Lucas (1976, p. 20) " the features which lead to success in short term forecasting are unrelated to quantitative policy evaluation, ...The major econometric models are (well) designed to perform the former task only, and.... simulations using these models can in principle provide no useful information as to the actual consequences of alternative economic policies." By the early 1980s, the Lucas critique had pushed macroeconometric modeling into disrepute with the majority of economics profession.

One of assumptions of the Cowles Foundation research work was to impose a priori restrictions on the parameters to identify the structural equations. Sims (1980a) dissented vigorously from the Cowles Foundation tradition resurrecting an old article by Liu (1960). It was incredible to regard variables as endogenous and exogenous. If individual decisions were determined by maximizing lifetime utility subject to budget constraint, each relationship would be determined by the same set of variables. So theory predicts no difference in the list of variables entering each equation although quantitative decisions may vary with the type of decision. Both are based on the view that the simultaneous interaction of economic variables is so pervasive that most structural relationships contain all, or nearly all, of the variables in the economy and, therefore in fact not identified. If so, it is pointless to try to estimate them. Liu concluded that in such cases we are forced to retreat the estimation of reduced form equations in which endogenous variables are expressed as a function of exogenous variables and predetermined variables. This would mean that we are unable to deduce the reduced form parameters that will prevail if a structural change occurs after we have estimated the old reduced form. Sims also regards the restrictions that would be needed to identify the structural equations as "incredible."

In addition to the above individual reservations regarding the structural approach, there were dissatisfactions in general from several viewpoints: i) there were dissatisfactions related to the strategy of model building; ii) there were problems related to the specification of conventional models. Model building began to be affected by the growing influence of empirical work on rational expectations. Questions were raised about the way in which the equations of the so-called econometric models were actually estimated. Most of the economic and statistical literature dealt with the problem of estimation of a simultaneous equations model; iii) there was lack of micro foundations of the Keynesian structural models. The Phillips curve provided the key linkage between real and nominal variables in Keynesian models. But this Phillips curve was derived as an empirical relationship not from a model of optimizing agents; iv) there was ad hoc treatment of price rigidity and expectations; and v) economists found the Keynesian structural models empirically inconsistent because of the simultaneous presence of inflation and unemployment in the 1970s. In the United States in the fourth quarter of 1972, unemployment rate averaged 5.4% and average inflation over the previous four quarters was 3.55. By the 3rd quarter of 1975, unemployment rate rose to 8.9% and inflation rose to 11% instead of falling [Webb, 1999].

Macroeconometric modeling has actually been regaining in reputation since the early 1980s. With the emerging discontent with Keynesian theory, economists tried to hammer out a solution of traditional structural system of equations approach in two different ways: First, by incorporating rational expectations into structural econometric models; second, by developing alternative non-structural forecasting methods.

Univariate non-structural forecasting is nothing new. It predates even the structural approach and continues to the present. The decades of 1920s and 1930s were periods of impressive intellectual development in the field of non-structural model development and forecasting. Yule (1927) and Slutsky (1937) did some pioneering work in this direction. They argued that linear stochastic difference equations provide a powerful and convenient framework for modelling and forecasting a variety of economic and financial time series. The main insight is that system dynamics can convert random inputs into serially correlated outputs.

In the 1930s, economists, mathematicians and engineers made some spectacular contributions to time series econometrics. Wold, Wiener, Kolmogorov and Kalman were among those researchers. Whittle (1983) nicely exposited the Wold-Wiener-Kolmogorov theory. Non-structural analysis and forecasting got momentum in the 1970s following the landmark publication of a book by Box and Jenkins (1976). Autoregressive Integrated Moving Average (ARIMA) time series analysis introduced by Box and Jenkins downplayed structural economic theory. The autoregressive (AR) part gives current values of variables in terms of its own past values; the integrated (I) part is needed to undo the difference operator if differences rather than levels of the variables are involved. The moving average (MA) part describes the way the current and past white noise errors are combined to express current values of variables.

As an alternative to traditional econometric system of equations in which variables were arbitrarily labelled as endogenous or exogenous, Vector Auto-Regressive (VAR) models have emerged as powerful multivariate models since the early 1980s. In a vector auroregressive model, each of a set of variables is regressed on past values of itself and past values of every other variable in the system. Cross variable linkages are incorporated because lags of all variables in each equation are included and also because of the existence of correlation among the disturbances of various equations. Those who use VAR models believe that important dynamic characteristics of the economy could be unlocked by VAR models without imposing "incredible identifying restrictions" from particular economic theory.

The VAR approach was criticized by Cooly and Leroy (1985) as 'atheoretical' which eventually led to the development of the so called "Structural Vector Autoregressive" (SVAR) model. SVAR model recovers the structural parameters from reduced form VAR model and dynamic features of the model give a more structural interpretation. While many economists today use VAR/SVAR models, many others continue to forecast with traditional macroeconometric models.

4.2 Methodology adopted in this study

This study uses Structural Vector Auto Regressive (SVAR) model that has only recently begun to be used. This section describes the general framework, considers some important issues regarding model specification and elaborates statistical and economic significance of dynamic interactions among the variables involved. For the general approach, as it is has been used in some important works, see for example Sims (1986) and Gali (1992).

The general framework

Let us consider the following SVAR model with M variables and p lags:

$\beta_{11}y_{1t} + \beta_{21}y_{2t} + \ldots. + \beta_{M1}y_{Mt} + \gamma_{11}(1)y_{1t-1} + \gamma_{21}(1)y_{2t-1} + \ldots + \gamma_{M1}(1)y_{Mt-1}$

$+\gamma_{11}(2)y_{1t-2} + \gamma_{21}(2)y_{2t-2} + \ldots + \gamma_{k1}(2)y_{Mt-2} + \ldots + \gamma_{11}(p)y_{1t-p} + \gamma_{21}(p)y_{2t-p} + \ldots$

$\ldots + \gamma_{M1}(p)y_{Mt-p} = \xi_{1t}$

... ...

...

$\beta_{1M}y_{1t} + \beta_{2M}y_{2t} + \ldots. + \beta_{MM}y_{Mt} + \gamma_{1M}(1)y_{1t-1} + \gamma_{2M}(1)y_{2t-1} + \ldots + \gamma_{kM}(1)y_{Mt-1}$

$+\gamma_{1M}(2)y_{1t-2} + \gamma_{2M}(2)y_{2t-2} + \ldots + \gamma_{pM}(2)y_{Mt-2} + \ldots + \gamma_{1M}(p)y_{1t-p} + \gamma_{2M}(p)y_{2t-p}$

$+ \ldots + \gamma_{pM}(p)y_{Mt-p} = \xi_{Mt}$

In matrix notation

$$\begin{bmatrix} y_{1t} & y_{2t} & \ldots & y_{Mt} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & .. & .. & \beta_{1M} \\ \beta_{21} & \beta_{22} & .. & .. & \beta_{2M} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \beta_{M1} & \beta_{M2} & .. & .. & \beta_{MM} \end{bmatrix} + \begin{bmatrix} y_{1t-1} & y_{2t-1} & \ldots & y_{Mt-1} \end{bmatrix}$$

$$\begin{bmatrix} \gamma_{11(1)} & \gamma_{12(1)} & .. & .. & \gamma_{1M(1)} \\ \gamma_{21(1)} & \gamma_{22(1)} & .. & .. & \gamma_{2M(1)} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \gamma_{M1(1)} & \gamma_{M2(1)} & .. & .. & \gamma_{MM(1)} \end{bmatrix} +$$

$$\begin{bmatrix} y_{1t-2} & y_{2t-2} & \dots & y_{Mt-2} \end{bmatrix} \begin{bmatrix} \gamma_{11(2)} & \gamma_{12(2)} & \dots & \gamma_{1M(2)} \\ \gamma_{21(2)} & \gamma_{22(2)} & \dots & \gamma_{2M(2)} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \gamma_{M1(2)} & \gamma_{M2(2)} & \dots & \gamma_{MM(2)} \end{bmatrix} + . \quad . \quad . \quad . +$$

$$\begin{bmatrix} y_{1t-p} & y_{2t-p} & \dots & y_{Mt-p} \end{bmatrix} \begin{bmatrix} \gamma_{11(p)} & \gamma_{12(p)} & \dots & \gamma_{1M(p)} \\ \gamma_{21(p)} & \gamma_{22(p)} & \dots & \gamma_{2M(p)} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \gamma_{M1(p)} & \gamma_{M2(p)} & \dots & \gamma_{MM(p)} \end{bmatrix} = \begin{bmatrix} \xi_{1t} & \xi_{2t} & \dots & \xi_{Mt} \end{bmatrix}$$

Or, in compact form

$$\mathbf{Y}_t'\mathbf{B} + \mathbf{Y}'_{t-1}\Gamma_1 + \mathbf{Y}'_{t-2}\Gamma_2 + \dots + \mathbf{Y}'_{t-p}\Gamma_p = \varepsilon'_t \qquad (4\text{-}1)$$

where, $\mathbf{Y}$ is an M×1 vector of variables, $\mathbf{B}$ is an M×M nonsingular matrix, Γs are M×M matrices, and ε is an M×1 vector of structural disturbances. Each column of the co-efficient matrices is the vector of coefficients in a particular equation while each row applies to a particular variable.

Assumptions about ε_t:

A1: $E(\varepsilon_t) = \mathbf{0}$

A2: $E(\varepsilon_t \varepsilon_t') = \begin{bmatrix} Var(\xi_{1t}) & 0 & \dots & 0 \\ 0 & Var(\xi_{2t}) & \dots & 0 \\ 0 & 0 & \dots & 0 \\ 0 & 0 & \dots & Var(\xi_{Mt}) \end{bmatrix} = \Omega$

The assumption (A2) arises from the belief that structural shocks originate from independent sources. The solution of the above system in VAR form:

$$\mathbf{Y}_t' = -\mathbf{Y}_{t-1}'\Gamma_1\mathbf{B}^{-1} - \mathbf{Y}_{t-2}'\Gamma_2\mathbf{B}^{-1} - \ldots - \mathbf{Y}_{t-p}'\Gamma_p\mathbf{B}^{-1} + \varepsilon_t'\mathbf{B}^{-1}$$

$$= \mathbf{Y}_{t-1}'\Pi_1 + \mathbf{Y}_{t-2}'\Pi_2 + \ldots + \mathbf{Y}_{t-p}'\Pi_p + \mathbf{e}_t' \qquad (4\text{-}2)$$

where, $-\Gamma_i\mathbf{B}^{-1} = \Pi_i \quad (i = 1 \ldots p)$

$\mathbf{e}_t' = \varepsilon_t'\mathbf{B}^{-1}$

In matrix notation:

$$\begin{bmatrix} y_{1t-1} & y_{2t-1} & \ldots & y_{Mt-1} \end{bmatrix} \begin{bmatrix} \pi_{11(1)} & \pi_{12(1)} & \ldots & \pi_{1M(1)} \\ \pi_{21(1)} & \pi_{22(1)} & \ldots & \pi_{2M(1)} \\ \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots \\ \pi_{M1(1)} & \pi_{M2(1)} & \ldots & \pi_{MM(1)} \end{bmatrix}$$

$$+ \begin{bmatrix} y_{1t-2} & y_{2t-2} & \ldots & y_{Mt-2} \end{bmatrix} \begin{bmatrix} \pi_{11(2)} & \pi_{12(2)} & \ldots & \pi_{1M(2)} \\ \pi_{21(2)} & \pi_{22(2)} & \ldots & \pi_{2M(2)} \\ \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots \\ \pi_{M1(2)} & \pi_{M2(2)} & \ldots & \pi_{MM(2)} \end{bmatrix} + \ldots$$

$$+ \begin{bmatrix} y_{1t-p} & y_{2t-p} & \ldots & y_{Mt-p} \end{bmatrix} \begin{bmatrix} \pi_{11(p)} & \pi_{12(p)} & \ldots & \pi_{M(p)} \\ \pi_{21(p)} & \pi_{22(p)} & \ldots & \pi_{2M(p)} \\ \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots \\ \pi_{M1(p)} & \pi_{M2(p)} & \ldots & \pi_{MM(p)} \end{bmatrix} = \begin{bmatrix} e_{1t} & e_{2t} & \ldots & e_{Mt} \end{bmatrix}$$

It follows from the assumptions about ε_t, that:

B1: $E(\mathbf{e}_t) = E(\mathbf{B}^{-1\prime}\varepsilon_t) = \mathbf{0}$

B2: $E(\mathbf{e}_t \mathbf{e}_t') = E(\mathbf{B}^{-1\prime}\varepsilon_t\varepsilon_t'\mathbf{B}^{-1}) = \mathbf{B}^{-1\prime}\Omega\mathbf{B}^{-1} = \Sigma$

Since reduced form errors are correlated, Σ is not a diagonal matrix. The relationship between Σ which is assumed to be known, and the unknown Ω is:

$$\mathbf{B}^{-1\prime}\Omega\mathbf{B}^{-1} = \Sigma$$

$$\Rightarrow \quad \Omega = \mathbf{B}'\Sigma\mathbf{B} \tag{4-3}$$

Identification

Given the structural form (4-1), we can deduce the reduced form (4-2) uniquely since **B** is non-singular. But given the reduced form i.e. Π_i and Σ, we cannot always deduce uniquely the structural form. If a reduced form has two or more structural forms associated with it, the structures are said to be observationally equivalent. If we can deduce a unique structural form, given the reduced form, by imposing restrictions then the model is said to identified. Let us go back to the structure:

$$\mathbf{Y}_t'\mathbf{B} + \mathbf{Y}'_{t-1}\Gamma_1 + \mathbf{Y}'_{t-2}\Gamma_2 + \ldots + \mathbf{Y}'_{t-p}\Gamma_p = \varepsilon'_t$$

Now consider an imposter

$$\mathbf{Y}'_t\mathbf{B}\mathbf{A} + \mathbf{Y}'_{t-1}\Gamma_1\mathbf{A} + \mathbf{Y}'_{t-2}\Gamma_2\mathbf{A} + \ldots + \mathbf{Y}'_{t-p}\Gamma_p\mathbf{A} = \varepsilon'_t\mathbf{A}$$

Which is obtained by post multiplying the structure by a non singular M×M matrix **A**. Reduced form of the imposter is

$$Y'_tBA = -Y'_{t-1}\Gamma_1 A - Y'_{t-2}\Gamma_2 A - \ldots\ldots - Y'_{t-p}\Gamma_p A + \varepsilon'_t A$$

$$Y'_t = -Y'_{t-1}\Gamma_1 A(BA)^{-1} - Y'_{t-2}\Gamma_2 A(BA)^{-1} - \ldots - Y'_{t-p}\Gamma_p A(BA)^{-1} + \varepsilon'_t A(BA)^{-1}$$

$$= -Y'_{t-1}\Gamma_1 B^{-1} - Y'_{t-2}\Gamma_2 B^{-1} - \ldots - Y'_{t-p}\Gamma_p B^{-1} + \varepsilon'_t B^{-1}$$

$$= Y'_{t-1}\Pi_1 + Y'_{t-2}\Pi_2 + \ldots + Y'_{t-p}\Pi_p + e'_t \quad \text{where, } -\Gamma_i B^{-1} = \Pi_i$$

So the false structure looks like the original one, statistically there is no way we can tell them apart. The structures are observationally equivalent and thus unidentified.

We can estimate the reduced form VAR model by Ordinary Least Square (OLS) since errors are uncorrelated with the regressors and each equation has the same set of explanatory variables (see Zellner, 1962). We can estimate the variance-covariance matrix Σ :

$$\hat{\Sigma} = \begin{bmatrix} \hat{\sigma}_{11} & \hat{\sigma}_{12} & \ldots & \hat{\sigma}_{1M} \\ \hat{\sigma}_{21} & \hat{\sigma}_{22} & \ldots & \sigma_{2M} \\ \ldots & \ldots & \ldots & \ldots \\ \hat{\sigma}_{M1} & \hat{\sigma}_{M2} & \ldots & \hat{\sigma}_{MM} \end{bmatrix}$$

where, $\hat{\sigma}_{ij}$ are estimated variance/covariance and each element of $\hat{\Sigma}$ is constructed as the sum:

$$\hat{\sigma}_{ij} = \frac{1}{T}\sum_{1}^{T} e_{it}e_{jt}$$

where, e_{it} and e_{jt} are the OLS residuals at time t for the equations i and j.

In order to solve this identification problem, simply count the equations and the unknowns. The unknown structural parameters consist of **B**, Γ_i and Ω where,

B is M×M matrix, which has M^2 parameters; Γ_i is M×M matrix, and that each Γ_i has M^2 parameters; since i =1.....p, the number of lags, the number of parameters in all the equations is M^2p. Ω is M × M matrix but since structural errors are assumed orthogonal, this is a diagonal matrix. So the number of parameters in Ω is M.

The known reduced form consists of Π_i and Σ where, Π_i is M×M matrix, and that each Π_i has M^2 parameters; since i =1.....p, the number of parameters in all the equations is M^2p. Σ is M × M symmetric matrix, so the total number of parameters in Σ is $(M^2 + M)/2$.

Hence, the total number of unknown structural parameters = $M^2 + M^2p + M$

Total number of known reduced form parameters = $M^2p + (M^2 + M)/2$

Excess number of parameters in the structural form

$$= \{M^2 + M^2p + M\} - \{M^2p + (M^2 + M)/2\}$$

$$= M^2 + M - M^2/2 - M/2$$

$$= M^2/2 - M/2 + M$$

$$= (M^2 - M)/2 + M$$

To identify the structural model from a reduced form VAR it is necessary to impose $(M^2 - M)/2 + M$ restrictions on the structural parameters. It is notable that traditional simultaneous equation approach requires stronger a' priori restrictions on B matrix than SVAR approach; see Leeper *et. al.*(1996) for specific details on this issue.

The Cowless Foundation philosophy was to leave the variance-covariance matrix unrestricted but to impose restrictions on the contemporaneous coefficient matrix and then recover the structural parameters. In contrast SVAR methodology imposes restrictions both on the contemporaneous coefficient matrix and the variance-covariance matrix of disturbance terms. Our main objective is to restrict the system in such a way that i) we can recover the structural shocks (the ξ_{it}s) from reduced form innovations, and ii) we can preserve the assumed error structure concerning the independence of various ξ_{it} shocks.

In each equation, each contemporaneous variable has a coefficient of one. This normalisation is a necessary scaling of the equation, which is equivalent to putting one variable on the left-hand side of an equation. So we need $(M^2 - M)/2$ restrictions to be imposed on the system. Our discussion so far, is limited to the order condition of identifying structural equation. There is also the rank condition of identification. According to Doan (2000, p.295), the simplest approach to check this condition in practice, is to look at the log likelihood value of the estimated model and the log likelihood value of an unrestricted model; for a just identified model those should be equal. The present study uses several alternative identification schemes on the structure.

Model specification

The objective of this study is to investigate how key aggregate economic variables like output, price level, interest rate and the stock of money evolve and influence each other over time. We focus mainly on the dynamic effects of monetary policy shocks on output and prices. So our model includes two policy variables, viz. money stock (m) and interest rate (r) and two non-policy variables, viz. output (y) and price (p). The reasons for including these variables are: (a) basic macroeconomic models developed in the Keynesian flavour include these variables;

(b) in an open economy monetary policy operates through interest rate and exchange rate channels. When a VAR model is applied to unravel the workings of an open economy, additional complications arise. The simultaneous relations between the monetary policy instrument and the exchange rate innovations make it difficult to correctly identify monetary policy shocks. So the list of variables does not include one channel of monetary transmission mechanism - the exchange rate. Obviously monetary shocks are transmitted to the real sector only through interest rate channel;

(c) no fiscal variables are included. Changes in expectations about future tax and spending policies can show up in the model only indirectly.

(d) considering the sample size, it is not plausible to include too many variables as it will erode degrees of freedom. So the Y-vector is

$Y' = [y, p, r, m]$ where,

y = Log of real GDP

p = Log of consumer price index

r = Nominal interest rate

m = Log of nominal broad money stock M2.

Matrix of contemporaneous coefficients B is: $\begin{bmatrix} 1 & \beta_{12} & \beta_{13} & \beta_{14} \\ \beta_{21} & 1 & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & 1 & \beta_{34} \\ \beta_{41} & \beta_{42} & \beta_{43} & 1 \end{bmatrix}$

We need $(4^2 - 4)/2 = 6$ restrictions to identify the structural system. In the following subsections we present alternative identification schemes exercised in this study.

Scheme 1

The first scheme is a recursive structure. The recursive structure is subject to controversy. The dynamic response of a shock very much depends on the ordering of the variables. In a four-variable model we obtain $4! = 24$ such orderings. The question is: which of the 24 different models that arise is most appropriate? Ordering of the variables can be determined by looking at the across-equation correlation coefficient ρ_{ij} of reduced form errors. Usually the researcher will want to test the null hypothesis: $|\rho_{ij}| > 0.2$. If it is accepted, either we have to reorder the variables or look for an alternative identifying structure.

A second approach is to provide a "semi-structural" interpretation of the model. Since selection of an appropriate model out of 24 different models is somewhat cumbersome, in this study we adopt the second approach. We pick the ordering {r, m, p and y}. We assume that there is no feedback from the economy to policy actions within the period[14]. We have two policy variables, r and m; but we want to put r first in ordering. Because putting interest rate first in ordering means that interest rate is given the maximum opportunity to influence the other variables in the system. So interest rate innovation is independent and no other variable enters into the interest rate equation. Interest rate r is followed by m, p and y respectively in ordering in such a way that m innovation is contemporaneously effected by r innovation, p innovation is contemporaneously effected by r and m innovations and y innovation is contemporaneously effected by r, m and p innovations. This structure actually imposes 6 restrictions as explained below:

Restriction 1

Money stock (m_t) has no immediate effect on interest rate (r_t) i.e. $\beta_{21} = 0$

[14] See Bernanke and Blinder (1992).

Restriction 2

Price (p_t) has no immediate effect on interest rate (r_t), i.e., $\beta_{31} = 0$

Restriction 3

Output (y_t) has no immediate effect on interest rate (r_t), i.e., $\beta_{41} = 0$

Restriction 4

Price (p_t) has no immediate effect on money stock (m_t), i.e., $\beta_{32} = 0$

Restriction 5

Output (y_t) has no immediate effect on money stock (m_t), i.e., $\beta_{42} = 0$

Restriction 6

Output (y_t) has no immediate effect on prices (p_t), i.e., $\beta_{43} = 0$

The above restrictions actually make B an upper triangular matrix.

$$\mathbf{B} = \begin{bmatrix} 1 & \beta_{12} & \beta_{13} & \beta_{14} \\ 0 & 1 & \beta_{23} & \beta_{24} \\ 0 & 0 & 1 & \beta_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

When **B** is triangular, we actually decompose Σ following Cholesky decomposition[15]. The idea of imposing restrictions on SVAR seems contrary to the spirit of Sim's argument against "incredible identifying restrictions". Unfortunately there is no simple way to circumvent the problem. Identification requires imposing some structure on the system. Triangularization provides the minimal set of assumptions that can be used to identify the model.

Scheme 2

This identification scheme is a modified version of Sims (1986). The model is actually a typical Keynesian macro model augmented with a Philips curve. It is notable that monetary innovations are allowed only in money supply and money demand equations. Money feeds back into real output via interest rate.

Restrictions 1 and 2

Output is contemporaneously influenced only by interest rate, which imposes two restrictions on the output equation. Hence,

$\beta_{21} = 0, \quad \beta_{41} = 0$

These restrictions make the equation an IS curve:

$y_t + \beta_{31} r_t = \xi_{yt}$

---

[15] Given a positive definite symmetric matrix Σ, there is one and only one decomposition into $B'B$ such that

Restrictions 3 and 4

Price is influenced only by output within the period, which imposes two restrictions on the price equation. That is

$\beta_{32} = 0, \quad \beta_{42} = 0$

and these yield an augmented Phillips curve:

$p_t + \beta_{12} y_t = \xi_{pt}$

Restrictions 5 and 6

Central bank and other banks can observe interest rate and money stock instantly but can react to other variables only after delay. Thus interest rate is determined by money supply and no other variables, which imposes two restrictions on the interest rate equation:

$\beta_{13} = 0, \quad \beta_{23} = 0$

We can call it a money supply rule:

$r_t + \beta_{43} m_t = \xi_{rt}$

We place no restrictions on the last equation, which we call as money demand equation:

$m_t + \beta_{14} y_t + \beta_{24} p_t + \beta_{34} r_t = \xi_{mt}$

The money demand equation allows money innovations to depend on output, price level, and interest rate.

B is upper triangular with positive elements on the diagonal. This is Cholesky decomposition.

Under this structure, we restrict the contemporaneous B matrix such that:

$$[y_t \quad p_t \quad r_t \quad m_t]\begin{bmatrix} 1 & \beta_{12} & 0 & \beta_{14} \\ 0 & 1 & 0 & \beta_{24} \\ \beta_{31} & 0 & 1 & \beta_{34} \\ 0 & 0 & \beta_{43} & 1 \end{bmatrix} = [\xi_{yt} \quad \xi_{pt} \quad \xi_{rt} \quad \xi_{mt}]$$

Scheme 3

This identification scheme captures some aspects of the developing countries. This differs from scheme 2 in several ways. First, it considers adverse supply shocks, which frequently occur in developing countries. Second, it imposes a symmetric restriction on the money equation. Though these restrictions are open to dispute, nonetheless it may be a good working hypothesis.

Restrictions 1, 2 and 3

All the three countries experienced sudden increase in price level particularly in the early 1970s (see Chapter 2) because of flood, drought, oil price shock and other unforeseen adverse supply shocks that developing countries face most often. Therefore, we can assume that in the developing countries price is not contemporaneously influenced by other variables in the system but by adverse supply shocks. It imposes three restrictions on the price equation[16]:

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[16] Keating (1992) used similar restrictions but this study fits these restrictions to the reality of developing economies.

$\beta_{12} = 0, \beta_{32} = 0, \ \beta_{42} = 0$

Restrictions 4 and 5

Since output and prices are not observed by the central bank immediately, it can only adjust interest rate immediately to changes in money stock. This imposes two restrictions on the interest rate equation:

$\beta_{13} = 0, \ \beta_{23} = 0$

Restriction 6

Following the tradition, it is assumed that money demand depends on real GDP, price level, and interest rate. In developing economies the capital market is very much underdeveloped and is confined to a small number of investors; people have no choice but to hold money. Nominal money holding might be proportional to nominal income. Therefore, it is assumed that y_t and p_t effect m_t with the same magnitude and same sign. By imposing a symmetric restriction on the money equation, we get the desired money demand function. That restriction is

$\beta_{14} = \beta_{24}$

Under this structure, contemporaneous relations among variables and the innovations are:

$$[y_t \quad p_t \quad r_t \quad m_t]\begin{bmatrix} 1 & 0 & 0 & \beta_{14} \\ \beta_{21} & 1 & 0 & \beta_{14} \\ \beta_{31} & 0 & 1 & \beta_{34} \\ \beta_{41} & 0 & \beta_{43} & 1 \end{bmatrix} = [\xi_{yt} \quad \xi_{pt} \quad \xi_{rt} \quad \xi_{mt}]$$

Now $\xi_{yt}, \xi_{pt}, \xi_{rt}, \xi_{mt}$ can be identified from the estimates of the reduced form equations vector $e_{yt}, e_{pt}, e_{rt}, e_{mt}$ and variance co-variance matrix Σ using the relations $\Omega = \mathbf{B}'\Sigma\mathbf{B}$ and $\varepsilon'_t = \mathbf{e}'_t\mathbf{B}$.

The above-mentioned identification schemes exercised in this study capture a wide rage of interrelationships among the variables involved based on traditional economic theory. How well these schemes capture standard theoretical predictions with regards to developing countries is an empirical issue.

Stationarity

The question of stationarity of data comes next. The answer to this question involves an assessment of the trade off between the loss of efficiency and loss of information. A SVAR model specified with levels, when time series are nonstationary, will generate estimates that may be spurious. On the other hand a SVAR model specified with differences, when series are nonstationary will generate estimates that are efficient but will ignore potential long run relationships. Sims (1980a) and Doan (2000), recommend against differencing even if the variable contains a unit root because it throws away information concerning the co-movement of variables. Fuller (1976, Theorem 8.5.1) shows that differencing produces no gain in asymptotic efficiency in an autoregression, even if it is appropriate. Following Sims and Doan, unit root tests are not conducted and the present study uses levels rather than differences of the variables involved.

Lag length

The next issue is related to the determination of appropriate lag length. To capture dynamics, it is customary to include 4 lags if the data are quarterly and to include 12 lags if the data are monthly; see for example, Sims (1986, 1992) and Christiano *et. al.* (1994). In principle there is nothing to prevent us from incorporating a large number of lags in a VAR model. But as a practical matter degrees of freedom are quickly eroded as more lags are included. If lag length is p, each of M equations contains Mp coefficients plus the intercept term. Appropriate lag length selection can be critical. To check lag length, begin with longest feasible lag length given degrees of freedom considerations. Sims (1980a, p. 17) recommends the following likelihood ratio statistic for lag length selection:

$$(T-k)\{\text{Log } |\hat{\Sigma}_r| - \log |\hat{\Sigma}_u|\}$$

where, T is the number of usable observations and k is the total number of parameters in the unrestricted system divided by the number of equations. $\hat{\Sigma}_r$ is the matrix of cross product of residuals when the model is restricted. $\hat{\Sigma}_u$ is the same matrix for the unrestricted model. By unrestricted system we mean the largest feasible lag length say, 12. By restricted system we mean a system that is restricted to a particular lag length say, 8 or 4. Number of restrictions is equal to the number parameters reduced from the unrestricted system. The test statistic follows a χ^2 distribution with degrees of freedom equal to the number of restrictions.

The likelihood ratio test is based on asymptotic theory that may not be suitable for small samples. It is applicable when one model is a restricted version of the other. Alternative test criteria developed are the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC):

$$AIC = T \log|\hat{\Sigma}| + 2k$$

$$BIC = T \log|\hat{\Sigma}| + k \log (T)$$

where, T is the number of usable observations, k is the total number of parameters estimated in all equations of the system, and $\hat{\Sigma}$ is the matrix of cross product of residuals. We select that model which has the minimum AIC or BIC value. Note that in all cases the residuals are estimated by OLS method, which are used to estimate Σ, Σ_u, and Σ_r. This study employs all the three tests to determine lag length.

Causality

One of the common uses of VAR models has been in testing the causality between the variables. A variable y_1 is said to be Granger (1969) caused by a variable y_2 if information in the past and present y_2 help improve the forecasts of variable y_1. It is commonly used to help identify and understand the pattern of cross linkages and feedback in vector auto regressions. An F-test is constructed under the null hypothesis that the coefficients on the lags of an independent variable in the equation for given dependent variable are jointly equal to zero.

The multivariate generalization of Granger Causality test has one unrestricted system containing lags of all the variables in the system and a restricted system, which exclude lags of the variable (or variables) of interest. This cross equation restriction is tested by the following likelihood ratio test (see Enders 1995, p. 316):

$$(T-k)\{\text{Log}\ |\hat{\Sigma}_r| - \log |\hat{\Sigma}_u|\}$$

where, T is the number of usable observations and k is the total number of parameters in the unrestricted system divided by the number of equations. $\hat{\Sigma}_r$ is the variance-covariance matrix of residuals of the restricted system and $\hat{\Sigma}_u$ is the variance-covariance matrix of residuals of the unrestricted system. Number of restrictions is equal to the number parameters reduced from the unrestricted system. The test statistic follows a χ^2 distribution with degrees of freedom equal to the number of restrictions.The present study employs F-test for joint significance of the lagged coefficients and multivariate test to determine the direction of causality among the variables.

Impulse response function

A system's reaction to shock in one of the variables can best be explained by a VAR model; see Sims (1980a, 1980b), Enders (1995)). Consider the equation:

$$Y_t' = Y'_{t-1}\Pi_1 + Y'_{t-2}\Pi_2 + \ldots + Y'_{t-p}\Pi_p + e'_t \quad \text{(4-2) -repeated}$$

$$\text{Or, } Y_t = \Pi'_1 Y_{t-1} + \Pi'_2 Y_{t-2} + \ldots + \Pi'_p Y_{t-p} + e_t$$

$$\Rightarrow Y_t = \Pi'_1 LY_t + \Pi'_2 L^2 Y_t + \ldots + \Pi'_p L^p Y_t + e_t \quad \text{where, L is the lag operator}$$

$$\Rightarrow Y_t = (\Pi'_1 L + \Pi'_2 L^2 + \ldots + \Pi'_p L^p)Y_t + e_t$$

$$\Rightarrow Y_t = \Pi'(L)Y_t + e_t \quad \text{where } \Pi'(L) = (\Pi'_1 L + \Pi'_2 L^2 + \ldots + \Pi'_p L^p)$$

$$\Rightarrow Y_t - \Pi'(L)Y_t = e_t$$

$$\Rightarrow Y_t = [I - \Pi'(L)]^{-1} e_t$$

$$Y_t = \Phi'(L)e_t \quad \text{where } [I - \Pi'(L)]^{-1} = \Phi'(L)$$

$$Y_t = \phi_0 e_t + \phi_1 Le_t + \phi_2 L^2 e_t + \ldots + \phi_p L^p e_t + \ldots + \ldots$$

$$Y_t = \phi_0 e_t + \phi_1 e_{t-1} + \phi_2 e_{t-2} + \ldots + \phi_p e_{t-p} + \ldots + \ldots$$

Hence, the moving average representation of equation (4-2) is:

$$Y'_t = e'_t\phi_0 + e'_{t-1}\phi_1 + e'_{t-2}\phi_2 + \ldots + e'_{t-p}\phi_p + \ldots + \ldots \quad (4\text{-}4)$$

Using the relationship between reduced form error and structural form error $\mathbf{e}_t' = \varepsilon'_t\mathbf{B}^{-1}$ we can represent $\mathbf{Y}_t$ as a linear combination of current and past structural shocks.

$$\mathbf{Y}'_t = \varepsilon'_t\mathbf{B}^{-1}\phi_0 + \varepsilon'_{t-1}\mathbf{B}^{-1}\phi_1 + \varepsilon'_{t-2}\mathbf{B}^{-1}\phi_2 + \ldots + \varepsilon'_{t-p}\mathbf{B}^{-1}\phi_p + \ldots \tag{4-5}$$

Alternatively,

$$\mathbf{Y}'_t = \varepsilon'_t\psi_0 + \varepsilon'_{t-1}\psi_1 + \varepsilon'_{t-2}\psi_2 + \ldots + \varepsilon'_{t-p}\psi_p + \ldots + \ldots \tag{4-6}$$

where, $\mathbf{B}^{-1}\phi_i = \psi_i$ $(i = 1 \ldots p)$

each ψ_i is an M×M matrix of parameters derived from the structural model. The coefficient of ψ_i can be used to generate the effect of ξ_{1t}, ξ_{2t}, ξ_{3t}.....shocks on the entire time paths of y_{1t}, y_{2t}, y_{3t}... sequences. So the response of y_1 to a unit shock in y_1 is thus given by $\psi_{11}(0)$, $\psi_{11}(1)$, $\psi_{11}(2)$, $\psi_{11}(3)$,...which is called impulse response function. We have M^2 sets of such impulse response functions.

Variance decomposition

Variance decomposition allocates each variable's forecast error variance to the individual shocks; see Enders (1995, p. 310). The forecast error can be written following the previous development as:

$$\mathbf{Y}'_t - E_{t-n}\mathbf{Y}'_t = \sum_{i=0}^{n-1} \varepsilon'_{t-i}\psi_i \tag{4-7}$$

where, $E_{t-n}\mathbf{Y}'_t$ is the expected value of $\mathbf{Y}'_t$ based on the entire information available at time t-n.

To fix ideas, let us consider the y series in $Y'_t = [y_t, p_t, r_t, m_t]$, the four-variable model described earlier. We see the n-step ahead forecast error is given by:

$$y_{t+n} - E_t\, y_{t+n} = \Psi_{11}(0)\xi_{yt+n} + \Psi_{11}(1)\xi_{yt+n-1} + \Psi_{11}(2)\xi_{yt+n-2} + \ldots + \Psi_{11}(n-1)\xi_{yt+1}$$
$$+ \Psi_{12}(0)\xi_{pt+n} + \Psi_{12}(1)\xi_{pt+n-1} + \ldots + \Psi_{12}(n-1)\xi_{pt+1} + \Psi_{13}(0)\xi_{rt+n} + \Psi_{13}(1)\xi_{rt+n-1} +$$
$$\ldots + \Psi_{13}(n-1)\xi_{rt+1} + \Psi_{14}(0)\xi_{mt+n} + \Psi_{14}(1)\xi_{mt+n-1} + \ldots + \Psi_{14}(n-1)\xi_{mt+1}$$

Variance of the n-step ahead forecast error for the y series is:

$$\sigma_y^2(n) = \mathrm{Var}\,[y_{t+n} - E_t\, y_{t+n}] = \Psi_{11}(0)^2\,\mathrm{Var}(\xi_{yt+n}) + \Psi_{11}(1)^2\,\mathrm{Var}(\xi_{yt+n-1}) + \Psi_{11}(2)^2$$
$$\mathrm{Var}(\xi_{yt+n-2}) + \ldots + \Psi_{11}(n-1)^2\,\mathrm{Var}(\xi_{yt+1}) + \Psi_{12}(0)^2\,\mathrm{Var}(\xi_{pt+n}) + \Psi_{12}(1)^2\,\mathrm{Var}(\xi_{pt+n-1})$$
$$+ \ldots + \Psi_{12}(n-1)^2\,\mathrm{Var}(\xi_{pt+1}) + \Psi_{13}(0)^2\,\mathrm{Var}(\xi_{rt+n}) + \Psi_{13}(1)^2\,\mathrm{Var}(\xi_{rt+n-1}) + \ldots +$$
$$\Psi_{13}(n-1)^2\,\mathrm{Var}(\xi_{rt+1}) + \Psi_{14}(0)^2\,\mathrm{Var}(\xi_{mt+n}) + \Psi_{14}(1)^2\,\mathrm{Var}(\xi_{mt+n-1}) + \ldots + \Psi_{14}(n-1)^2$$
$$\mathrm{Var}(\xi_{mt+1})$$

$$= \Psi_{11}(0)^2\,\sigma_y^2 + \Psi_{11}(1)^2\,\sigma_y^2 + \Psi_{11}(2)^2\,\sigma_y^2 + \ldots + \Psi_{11}(n-1)^2\,\sigma_y^2 + \Psi_{12}(0)^2\,\sigma_p^2 +$$
$$\Psi_{12}(1)^2\,\sigma_p^2 + \ldots + \Psi_{12}(n-1)^2\,\sigma_p^2 + \Psi_{13}(0)^2\,\sigma_r^2 + \Psi_{13}(1)^2\,\sigma_r^2 + \ldots + \Psi_{13}(n-1)^2$$
$$\sigma_r^2 + \Psi_{14}(0)^2\,\sigma_m^2 + \Psi_{14}(1)^2\,\sigma_m^2 + \ldots + \Psi_{14}(n-1)^2\,\sigma_m^2$$

Since all values of $\Psi_{jk}(i)^2$ are nonnegative, the variance of forecast error increases as the forecast horizon n increases. It is possible to decompose the n-step ahead forecast error variance of y series due to each one of the shocks ξ_{yt}, ξ_{pt}, ξ_{rt}, ξ_{mt}:

$$\mathrm{VDF}\,(y, y, n) = \{\Psi_{11}(0)^2\,\sigma_y^2 + \Psi_{11}(1)^2\,\sigma_y^2 + \ldots + \Psi_{11}(n-1)^2\,\sigma_y^2\} \,/\, \sigma_y^2(n)$$

$$VDF\ (y, p, n) = \{\Psi_{12}(0)^2 \sigma_p^2 + \Psi_{12}(1)^2 \sigma_p^2 + \ldots + \Psi_{12}(n-1)^2 \sigma_p^2\} / \sigma_y^2(n)$$

$$VDF\ (y, r, n) = \{\Psi_{13}(0)^2 \sigma_r^2 + \Psi_{13}(1)^2 \sigma_r^2 + \ldots + \Psi_{13}(n-1)^2 \sigma_r^2 \} / \sigma_y^2(n)$$

$$VDF\ (y, m, n) = \{\Psi_{14}(0)^2 \sigma_m^2 + \Psi_{14}(1)^2 \sigma_m^2 + \ldots + \Psi_{14}(n-1)^2 \sigma_m^2\} / \sigma_y^2(n)$$

We can derive the set of variance decomposition functions (VDF) for the variables p, r and m following a similar procedure described above.

Historical Decomposition

Historical values of set of time series can be decomposed into a base projection and accumulated effects of currents and past shocks. Historical decomposition allows us to quantify the relative importance of specific shocks to each variable. See for example, Burbidge and Harrison (1985), Fackler and McMillin (1998) and Doan (2000). Moving average representation of the SVAR model as described in equation (4-6) is:

$$Y'_t = \sum_{s=0}^{\infty} \varepsilon'_{t-s}\psi_s$$

The historical decomposition partitions the MA representation into the following two segments:

$$Y'_{t+k} = \sum_{s=0}^{k-1} \varepsilon'_{t+k-s}\psi_s + \sum_{s=k}^{\infty} \varepsilon'_{t+k-s}\psi_s \qquad (4\text{-}8)$$

The second sum is the dynamic forecast or "base projection" of Y_{t+k} conditional on information available at time t; it can also include a constant, linear time trend, etc. The first sum represents the difference between the actual series and this base projection due to innovations in the variables in periods t+1 to t+k. Thus, the gap between each data series and its base projection can be assessed in terms of the contributions of the innovations to each series in the analysis. Since sum of the forecast and the contributions of shocks account for the data, it is always possible to explain the dynamic path of any variable in the VAR model using Historical Decomposition (HD) technique.

4.3 Data

The data used in this study are taken from the IMF, *International Financial Statistics* (IFS) CD-ROM- supplemented by IMF, IFS Yearbook except for CPI in Bangladesh. Quarterly observations comprising the period 1967:Q1-1996:Q4 for India, 1972:Q1- 1997:Q2 for Pakistan and 1974:Q2-1998:Q4 for Bangladesh are used to estimate the models. Where quarterly observations are not available, figures are obtained by using Lisman and Sandee (1964) method. For details of this method, see Appendix 1.

Price (line 64): The Consumer Price Index (CPI) is used because it is a good indicator of the movement of prices (Crocket and Evans, 1980). It is the cost of acquiring a fixed basket of goods and services by the average consumer. Bangladesh CPI is obtained from Monthly Statistical Bulletin of Bangladesh, Bangladesh Bureau of Statistics and its various issues. This CPI represents cost of living of the government employees in Dhaka city. This is the only CPI available in Bangladesh that covers the whole sample period. Quarterly figures are calculated as simple averages of the corresponding monthly figures.

Interest rate (line 60): The bank rate (discount rate) is used for the nominal interest rate variable. The bank rate is the main lever that central bank uses to conduct monetary policy. It is the rate of interest that the central bank charges on short term loans to financial institutions. It is seen as the trendsetter for other short-term interest rates.

GDP (line 99b): Comprises of final expenditure on export of goods and services + import of goods and services + government spending + private consumption + gross fixed capital formation + increase/decrease in stock. Real GDP is used as a measure of aggregate economic activity. Real GDP is computed by deflating the nominal GDP by the Consumer Price Index.

Money (lines 34+35): Broad Money (M2) is used as money stock. It comprises of currency in circulation + demand deposit+ time deposit + savings deposit + foreign currency deposit of resident sector.

Since this study is interested in examining the dynamic interactions among the above-mentioned variables, the study uses a similar data set, sample period, and framework for all countries, as far as it is allowed by the availability of data.

Chapter 5

Substantive Results and Discussions

The objective of this study is to investigate the dynamic relationship among key aggregate economic variables like output, price level, interest rate and the stock of money; we focus mainly on the impact of monetary policy shocks on prices and output. Estimated results and discussions will be presented in this chapter in light of the methodology discussed in the previous chapter. In this chapter, we will present the results, compare them among the three SAARC economies, and investigate into the qualitative and quantitative differences among them. We will examine the implication of such findings on monetarist / IS-LM theory and the real business cycle theory. If the evidence from this study supports stylized predictions of those theories, economists and academicians in developing countries would then feel more comfortable to assess policy initiatives under different institutional settings.

This chapter is divided into seven sections. The specification of the VAR model as determined by lag length tests is presented in section 5.1. Section 5.2 displays the results of bivariate, multivariate and block causality tests. Analysis of variance decompositions and impulse response functions under alternative identification schemes are discussed in sections 5.3, 5.4 and 5.5. Results of the historical decomposition technique are analyzed in section 5.6. Finally, sensitivity analysis of the results is presented in section 5.7.

5.1 Lag length tests

As mentioned earlier, quarterly data from IMF International Financial Statistics are used for empirical analysis. Determination of optimal lag length is important for the proper specification of a VAR model. We used the likelihood ratio test, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) to determine the optimal lag length for each country. Tables 5.1 and 5.2 report these results.

Table 5.1: Results of likelihood ratio test for lag length

	Null Hypothesis	Log determinant of variance/covariance matrix of residuals	Chi-Squared (Degrees of freedom)	Level of significance
Bangladesh	H_0 : 8 lags against 12 lags	$\lvert\hat{\Sigma}_{12}\rvert$= -33.456 $\lvert\hat{\Sigma}_{8}\rvert$= -31.411	71.588 (64)	0.240
	H_0 : 4 lags against 8 lags	$\lvert\hat{\Sigma}_{8}\rvert$= -30.086 $\lvert\hat{\Sigma}_{4}\rvert$= -27.823	124.427 (64)	0.000
India	H_0 : 8 lags against 12 lags	$\lvert\hat{\Sigma}_{12}\rvert$= -29.541 $\lvert\hat{\Sigma}_{8}\rvert$ = -28.708	46.664 (64)	0.949
	H_0 : 4 lags against 8 lags	$\lvert\hat{\Sigma}_{8}\rvert$= -26.832 $\lvert\hat{\Sigma}_{4}\rvert$= -25.880	72.324 (64)	0.222

Pakistan	H_0 : 8 lags against 12 lags	$\lvert\hat{\Sigma}_{12}\rvert = -32.594$ $\lvert\hat{\Sigma}_{8}\rvert = -30.802$	71.706 (64)	0.237
	H_0 : 4 lags against 8 lags	$\lvert\hat{\Sigma}_{8}\rvert = -30.621$ $\lvert\hat{\Sigma}_{4}\rvert = -29.263$	81.490 (64)	0.069

Table 5.2: AIC and BIC for lag length

	Lags	AIC	BIC
Bangladesh	1	1065.1540	991.1768
	2	1067.0825	931.4575
	3	1063.4483	866.1757
	4	1042.1931	783.2727
	5	1028.5845	708.0164
	6	1000.4388	618.2231
	7	997.2859	553.4224
	8	956.3970	450.8858
India	1	1290.0928	1209.6289
	2	1316.1181	1168.6009
	3	1300.1529	1085.5824
	4	1268.1106	986.4868
Pakistan	1	1170.6398	1094.9862
	2	1181.4090	1042.7107
	3	1176.8299	975.0868
	4	1144.3347	879.5469
	5	1105.2877	777.4552
	6	1064.9477	674.0745
	7	1039.2030	585.2810
	8	1006.8923	489.9257

To check lag length, we begin with 12 lags as the longest feasible lag length given degrees of freedom considerations. Then we consider paring down lag length. We tested two null hypotheses: 8 lags against 12 lags, and 4 lags against 8 lags. Based on the significance of the Chi-square value, a lag length of 8 for Bangladesh, 4 for India and 8 for Pakistan is adopted. For India, both the hypotheses are accepted but we adopted lesser lag length to save degrees of freedom. AIC and BIC results as shown in table 5.2 supplements the likelihood ratio tests reported in table 5.1. As the data are not seasonally adjusted in all the variables in the three countries, three seasonal dummy variables in each equation for each country are included. Therefore, each variable enters each equation with 8 lags for Bangladesh and Pakistan, 4 lags for India, and three seasonal dummy variables and a constant.

5.2 Causality tests

In a VAR model the current innovations e_t is unanticipated but become a part of information for the next period. The implication of this is that lagged values of a variable jointly capture the systematic or anticipated impact of that variable while the residuals capture unexpected contemporaneous events. According to Sims (1980a, p. 20), it is especially difficult to make sense of VAR system by examining the coefficients in the regression equations themselves. The estimated coefficients on successive lags tend to oscillate and there are complicated cross-equation feedbacks. A joint F-test on the lagged coefficients, however, can provide us information about the impact of anticipated portion of the right hand side variables.

Table 5.3: F-Tests for Granger causality

	Independent Variable	Equation			
		r	m	p	y
Bangladesh	r	0.000	0.000	0.017	0.016
	m	0.667	0.000	0.009	0.498
	p	0.257	0.009	0.000	0.000
	y	0.634	0.001	0.011	0.000
India	r	0.000	0.357	0.770	0.167
	m	0.999	0.000	0.079	0.915
	p	0.022	0.223	0.000	0.001
	y	0.010	0.565	0.041	0.000
Pakistan	r	0.000	0.826	0.219	0.205
	m	0.090	0.000	0.044	0.043
	p	0.086	0.000	0.000	0.000
	y	0.139	0.040	0.156	0.000

The figures in table 5.3 are the marginal significance levels for F-test constructed under the null hypothesis that the coefficients of the independent variables row i are jointly zero in equation j given by column j, where i, j = r, m, p and y.

Let us begin with the interest rate equation. In the cases of Bangladesh and Pakistan, one of the important features is that none of the variables in the model help forecast interest rate except interest rate itself. But interest rate causes every other variable in the system. A good policy variable should be free from feedback from non-policy variables in the model. So the interest rate deserves to be a good policy variable at least from the perspective of causality test in Bangladesh and Pakistan. But the picture is not the same for India. Here interest rate gets some feedback from other non-policy variables such as price and output.

In the broad money equation, the results are almost reversed compared to interest rate. In case of India, one of the important features is that none of the variables in the model help forecast money except money itself. Money causes price in the system. So money deserves to be a good policy variable from the perspective of causality test in India. But the picture is not the same for Bangladesh and Pakistan. Here money gets some feedback from other non-policy variables such as price and output. For Bangladesh, F-tests reveal that all the variables contribute significantly to explaining m. In fact, there is controversy among economists regarding the use of monetary aggregates like M1, M2 or the monetary base as a policy variable.

Next consider the p equation. For Bangladesh r, m, p and y all do cause p. It is clear that a bi-directional causality, or feedback, exists between money and prices. Chowdhury *et. al.* (1995) reported a similar result. This bi-directional causality also exists in Pakistan. The implication of such a result is that an increase in money stock fuels prices, which in turn, leads to an increase in money stock. It supports the view of real business cycle theorists who postulate that monetary changes only affect prices; see Cooley and Hansen (1995).

Finally real GDP is not caused by money stock in both Bangladesh and India. This finding does not corroborate the monetarist (Friedman 1992, p. 48) view that money causes income. There exists a feedback between real GDP and price level. In Pakistan, however, money causes output.

Table 5.4: Multivariate Granger causality test

	Null Hypothesis	Chi-squared (degrees of freedom)	Level of Significance
Bangladesh	H_0 : r does not Granger cause m, p, y	34.395 (24)	0.077
	H_0 : m does not Granger cause r, p, y	35.501 (24)	0.061
	H_0 : p does not Granger cause r, m, y	46.403 (24)	0.003
	H_0 : y does not Granger cause r, p, m	28.748 (24)	0.229
India	H_0 : m does not Granger cause r, p, y	8.382 (12)	0.754
	H_0 : r does not Granger cause m, p, y	8.970 (12)	0.705
	H_0 : p does not Granger cause r, m, y	26.694 (12)	0.008
	H_0 : y does not Granger cause r, p, m	8.382 (12)	0.754
Pakistan	H_0 : r does not Granger cause m, p, y	21.658 (12)	0.599
	H_0 : m does not Granger cause r, p, y	23.631 (24)	0.482
	H_0 : p does not Granger cause r, m, y	58.013 (24)	0.000
	H_0 : y does not Granger cause r, p, m	28.243 (24)	0.249

Now the issue before us is to determine whether one variable, say, interest rate, Granger causes any other variable of the system. In this four-variable case with r, m, p and y, the test is whether interest rate Granger causes either m or p or y. So it restricts all lags of interest rate variable in the m, p and y equation to be equal to zero. This is the multivariate generalization of Granger causality test. Table 5.4 displays the results. Multivariate causality tests suggest that r and m do cause either output or price in Bangladesh at 6% and 7% levels of significance. So monetary policy plays a role in Bangladesh. But this is not the case in the other two countries.

Lastly, we will perform two block causality tests. We consider the two non-policy variables (y, p) as one block and the two policy variables (r, m) as another block. The test procedure is the same as multivariate tests. Instead of a single variable we put restrictions on a block of variables. Table 5.5 reports these results.

Table 5.5: Results of block causality tests

	Null Hypothesis	Chi-squared (degrees of freedom)	Level of Significance
Bangladesh	H_0 :(r, m) does not Granger cause (p, y)	45.995 (32)	0.050
	H_0 : (p,y) does not Granger cause (r, m)	27.236 (32)	0.706
India	H_0 :(r, m) does not Granger cause (p, y)	14.786 (16)	0.540
	H_0 : (p, y) does not Granger cause (r, m)	25.390 (16)	0.063
Pakistan	H_0 : (r,m) does not Granger cause (p, y)	30.601 (32)	0.537
	H_0 : (p,y) does not Granger cause (r, m)	52.689 (32)	0.012

Block causality tests for Bangladesh also indicate that non-policy variables y and p get feedback from policy variables. Interest rate and money as a block cause output and prices but output and price do not cause interest rate and money. The situation, however, is reversed for India and Pakistan.

The results presented, so far, indicate the direction of causality within the sample period. It does not provide us with the dynamic properties of the system. Sims (1980a, 1980b), therefore, suggested the use of variance decompositions and impulse response functions to capture the dynamic interaction among the variables in the post-sample period. This dynamic simulation provides important insight into economic significance of the variables in the system, as will be discussed in the next three sections.

5.3 Analysis of variance decompositions and impulse response functions under identification scheme 1

In identification scheme 1, the recursive structure, interest rate innovation is assumed to disturb all other variables in the system within the quarter while output innovation is assumed to disturb only the output within the quarter. Price equation connects money innovations and interest rate innovations with price innovations and no other innovations can influence it contemporaneously. The money supply equation allows money innovations to depend on innovations in interest rate alone. So policy variables are allowed the maximum opportunity to influence the non-policy variables under this recursive structure. The estimated relationships among the contemporaneous coefficients are listed in table 5.6.

Table 5.6: Results of contemporaneous coefficients

Bangladesh	$r_t = \xi_{rt}$ $m_t - 0.001r_t = \xi_{mt}$ (0.86) $p_t - 0.001r_t - 0.050m_t = \xi_{pt}$ (0.636) (0.438) $y_t + 0.00009r_t - 0.050m_t + 1.049p_t = \xi_{yt}$ (0.957) (0.081) (0.000)
India	$r_t = \xi_{rt}$ $m_t - 0.008r_t = \xi_{mt}$ (0.585) $p_t - 0.007r_t - 0.058m_t = \xi_{pt}$ (0.069) (0.025) $y_t + 0.007r_t - 0.011m_t + 0.381p_t = \xi_{yt}$ (0.387) (0.822) (0.040)
Pakistan	$r_t = \xi_{rt}$ $m_t - 0.002r_t = \xi_{mt}$ (0.438) $p_t - 0.003r_t - 0.088m_t = \xi_{pt}$ (0.115) (0.201) $y_t + 0.007r_t - 0.004m_t + 0.908p_t = \xi_{yt}$ (0.201) (0.792) (0.000)

Since in VAR models under recursive structure, estimated coefficients do not provide us with interpretable economic insight and hence we present the two important summary measures, namely, Forecast Error Variance Decompositions (FEVD) and Impulse Response Functions (IRF), which capture the dynamic properties of the recursive model.

Variance decompositions measure the quantitative effect that individual shocks have on all the variables in the system including the shocked variable itself. The method of decomposition is discussed in detail in Chapter 4. Though there is no hard and fast rule regarding the number of steps to be examined but it should be enough to understand the dynamic interactions among the variables. We will examine 20 quarters, which is five years worth of steps.

Table 5.7: Variance decompositions for r

	Step	Std Error	Explained by innovations in			
			r	m	p	y
Bangladesh	1	0.299932	100	0	0	0
	2	0.432697	99.573	0.327	0.1	0.001
	4	0.641759	98.704	0.722	0.282	0.291
	6	0.784682	97.731	1.545	0.362	0.362
	8	0.906399	94.74	3.029	0.328	1.903
	10	1.008881	89.939	4.773	1.079	4.209
	12	1.096788	85.073	5.633	2.412	6.882
	14	1.165292	79.951	6.205	4.482	9.362
	16	1.220664	76.017	6.362	6.429	11.193
	18	1.270557	72.402	6.564	8.777	12.257
	20	1.312921	69.237	6.601	11.211	12.952
India	1	0.252558	100	0	0	0
	2	0.359775	98.239	0.141	1.62	0.001
	4	0.49907	88.127	0.584	8.072	3.218
	6	0.593003	81.898	0.929	14.318	2.855
	8	0.663413	78.061	1.477	17.976	2.486
	10	0.711827	76.31	2.164	19.198	2.328
	12	0.742895	75.963	2.996	18.793	2.248
	14	0.763737	76.07	3.879	17.889	2.162
	16	0.780471	75.97	4.724	17.231	2.074
	18	0.795899	75.558	5.463	16.92	2.058
	20	0.810456	75.045	6.09	16.707	2.157
Pakistan	1	0.513824	100	0	0	0
	2	0.677923	99.424	0.349	0.216	0.011
	4	0.865106	97.562	0.677	1.551	0.21
	6	1.029328	96.325	0.619	2.815	0.241
	8	1.173886	93.861	3.504	2.287	0.348
	10	1.298316	89.435	7.092	2.676	0.797
	12	1.400719	84.646	10.061	4.242	1.051
	14	1.502649	78.994	12.411	7.674	0.921
	16	1.617336	72.658	14.03	12.502	0.81

	18	1.692919	68.839	15.057	15.315	0.789
	20	1.754617	65.95	15.692	17.536	0.823

The third column in the table is the standard error of forecast over various forecasting time horizons of the model when sampling error in the estimated coefficients is ignored. We see that forecast standard error rises steadily as the forecasting time horizon increases. The last four columns, namely the columns r, m, p, and y give the decompositions. In each row they add up to 100%. Table 5.7 provides the following information:

- Even 20 periods later interest rate remains the principal factor driving the interest rate in all the three countries.
- Contribution of m in explaining r is around 6% in Bangladesh and India and around 16% in Pakistan in the long run.
- For Bangladesh contribution of p is below 1% in explaining interest rate even in the 8^{th} quarter. But long run effect is moderate in all the three countries.
- Though y plays a modest role in explaining interest rate in Bangladesh, its role is reduced to almost naught in India and Pakistan in the end.

The variance decompositions for series m are provided in table 5.8, which give the following insights.

Table 5.8: Variance decompositions for m

	Step	Std Error	Explained by innovations in			
			r	m	p	y
Bangladesh	1	0.018846	0.033	99.967	0	0
	2	0.023353	4.761	85.777	0.418	9.044
	4	0.035304	6.232	77.038	2.19	14.54
	6	0.048496	3.482	72.06	4.234	20.225
	8	0.056807	4.585	63.455	7.116	24.844
	10	0.063576	5.466	58.27	8.307	27.958
	12	0.067837	5.068	53.76	10.199	30.973
	14	0.071403	5.045	51.266	11.244	32.445
	16	0.075039	6.309	48.878	12.012	32.802
	18	0.079951	8.146	47.325	11.998	32.532
	20	0.085609	9.304	46.015	12.393	32.287
India	1	0.040949	0.258	99.742	0	0
	2	0.043487	1.323	98.182	0.041	0.454
	4	0.048619	2.14	94.768	1.659	1.433
	6	0.057054	3.686	92.699	1.837	1.778
	8	0.062972	4.917	90.701	2.374	2.008
	10	0.069191	6.347	88.807	2.791	2.055
	12	0.074838	7.814	87.188	3.003	1.995
	13	0.077657	8.588	86.45	3.015	1.947
	14	0.08036	9.391	85.726	2.984	1.899
	16	0.085712	11.008	84.372	2.824	1.797
	18	0.091007	12.616	83.062	2.616	1.706
	20	0.096257	14.157	81.802	2.413	1.627
Pakistan	1	0.01581	0.637	99.363	0	0
	2	0.018336	2.313	95.05	2.253	0.384
	4	0.026098	2.584	93.706	3.363	0.347
	6	0.030284	3.973	92.174	2.889	0.964
	8	0.034409	4.794	83.342	11.006	0.858
	10	0.038841	6.536	70.298	22.081	1.086
	12	0.043406	7.656	59.197	30.711	2.437
	14	0.049002	8.539	49.317	37.624	4.52
	16	0.055037	8.891	42.241	41.641	7.227
	18	0.060774	9.469	37.568	43.892	9.071
	20	0.066139	9.846	34.35	45.844	9.96

- Interest rate has moderate explanatory power in explaining *m* across all the three countries.
- In the beginning the principal factor driving *m* is *m* itself contributing almost 100% in the 1st period in all the three countries.

- **Price is the prime mover of *m* in Pakistan at the end of time horizon.**
- **Contribution of innovations in output is remarkable and is fairly constant after 12 quarters (3 years) in Bangladesh. In India output innovation was never an important factor in explaining money. For Pakistan, the contribution is negligible initially but moderate in the end.**

The variance decompositions for series p are displayed in table 5.9. One of the views of monetarism as expressed by Friedman and Schwartz (1963) and Poole (1978) is that movements in money stock lead, are positively related to, and are the primary determinants of movements in the price level at least in the medium to long time horizon. Entries in the 5th the column of table 5.9 provide an answer to whether money stock is the principle mover of price. The more interesting information is at the longer steps, where the interactions among the variables begin to be felt.

Table 5.9: Variance decompositions for p

			Explained by innovations in			
	Step	Std Error	r	m	p	y
Bangladesh	1	0.011016	0.258	0.758	98.985	0
	2	0.014221	0.158	0.464	98.379	0.999
	4	0.018988	1.361	3.755	90.743	4.142
	6	0.023373	8.28	5.761	74.332	11.626
	8	0.025532	9.377	10.129	64.875	15.619
	10	0.027909	9.294	14.088	54.431	22.187
	12	0.030937	10.128	17.522	44.647	27.703
	14	0.034219	11.92	19.446	37.222	31.412
	16	0.037876	13.501	21.174	32.22	33.104
	18	0.041352	14.586	21.904	28.89	34.619
	20	0.045061	15.003	23.087	27.108	34.802
	1	0.011909	3.009	4.071	92.921	0
	2	0.021028	4.36	3.238	90.954	1.448
	4	0.037584	3.944	2.461	88.683	4.912

India	6	0.049592	3.53	3.656	83.725	9.089
	8	0.056299	3.179	5.406	77.321	14.094
	10	0.059771	2.895	7.848	70.729	18.528
	12	0.062038	2.69	10.415	65.815	21.08
	14	0.064038	2.537	12.788	63.023	21.651
	16	0.065729	2.411	14.938	61.399	21.252
	18	0.066997	2.34	17.031	59.932	20.696
	20	0.068028	2.388	19.131	58.284	20.196
Pakistan	1	0.010943	2.825	1.64	95.535	0
	2	0.016787	6.814	2.633	88.24	2.313
	4	0.022659	9.662	4.786	82.812	2.74
	6	0.028915	14.574	6.604	74.671	4.151
	8	0.034799	15.987	10.94	68.922	4.15
	10	0.04037	18.254	14.595	62.664	4.487
	12	0.045297	19.503	17.04	57.964	5.493
	14	0.049452	20.442	17.967	55.951	5.641
	16	0.053584	20.421	18.301	55.116	6.163
	18	0.056917	20.25	18.187	54.581	6.982
	20	0.059632	19.869	17.896	54.45	7.786

- While price innovations are the prime mover of price itself at the beginning, it loses supremacy to real GDP by the end of forecast time horizon in Bangladesh. For India and Pakistan leading role of price innovations remain intact from the beginning to end of forecast time horizon.
- Money innovation is not the prime mover of price in any of the three countries though its role is not negligible (above 15%) either, at least in the medium time horizon to long time horizon. The above analysis weakly support the monetarists view in case of developing countries like Bangladesh, India and Pakistan.
- Interest rate innovation plays a negligible role in price determination in India.

- **Output innovation plays a major role in price determination in Bangladesh while its role in India is also remarkable.**

Another important view of monetarism as expressed by Friedman and Schwartz (1963) and Poole (1978) is that changes in the quantity of money are the primary cause of business cycles because these changes cause, lead, and are positively related to changes in output at least in the short to medium time horizon. Entries of the 5th column of table 5.10 provide an answer to this view.

Table 5.10: Variance decompositions for y

	Step	Std Error	Explained by innovations in			
			r	m	p	y
Bangladesh	1	0.012456	0.231	0.002	85.343	14.423
	2	0.017277	0.273	2.753	68.696	28.278
	4	0.021491	0.494	5.462	53.915	40.13
	6	0.023609	1.604	14.502	46.026	37.868
	8	0.025367	1.443	16.509	40.134	41.913
	10	0.026901	3.66	19.13	37.478	39.733
	12	0.02953	11.729	17.774	36.838	33.659
	14	0.032402	17.411	15.743	37.263	29.583
	16	0.034305	21.8	14.507	36.531	27.162
	18	0.035371	23.98	14.145	36.144	25.731
	20	0.035806	25.204	13.961	35.501	25.334
India	1	0.023287	1.304	0.034	3.536	95.126
	2	0.032166	4.412	0.046	4.299	91.243
	4	0.043431	10.459	0.08	11.694	77.767
	6	0.049077	14.936	0.066	17.698	67.3
	8	0.051264	18.344	0.062	18.363	63.231
	10	0.052285	20.395	0.061	18.091	61.453
	12	0.053929	20.654	0.08	20.572	58.695
	14	0.05629	19.861	0.181	24.4	55.558
	16	0.058569	19.082	0.419	26.729	53.771
	18	0.060305	18.76	0.803	26.984	53.453
	20	0.061575	18.825	1.302	26.187	53.685
	1	0.010335	3.894	1.35	88.485	6.272
	2	0.014551	10.556	2.143	75.526	11.775
	4	0.019276	13.689	4.327	48.381	33.603
	6	0.021117	21.167	5.786	40.595	32.452
	8	0.022035	23.301	7.285	38.226	31.188
	10	0.023154	27.548	8.641	34.851	28.96

Pakistan	12	0.024632	31.571	9.747	33.047	25.636
	13	0.025471	33.854	9.422	31.65	25.074
	14	0.02634	35.354	9.309	30.132	25.204
	16	0.028029	37.512	9.385	27.708	25.395
	18	0.029018	39.308	9.883	25.997	24.812
	20	0.029671	40.536	10.206	24.998	24.26

- In Bangladesh money innovations contribute 14% of real GDP in the 20th quarter. The important question before the monetarists is: how big the contribution of money in explaining output. This figure is an indicator of the real effect of money in an economy. A closer look of the table reveals that in Bangladesh after four quarters it is 5.46%, after eight quarters it is 16.5% and reaches the highest level of 19.13% in the 10th quarter (two and one half years). In India, the 20-quarter ahead forecast error variance decomposition of output due to *m* innovation is only 1.3%, which is the highest in the entire forecasting time horizon. For Pakistan this figure is 1.3% to around 8% in the short to medium time horizon and 10.25% at the end of 20-quarter forecasting time horizon.
- For Bangladesh when contributions of *m* to the variance in y begin to fall, the contributions of interest rate begin to rise. This situation happens at the 10th quarter. Innovations of interest rate take almost ten quarters to have an effect but finally become one of the important movers. For India interest rate accounts for about 19% of the variation in output and stabilizes around it just after 6 quarters, i.e. one and one half of a year.

For Pakistan interest rate becomes the prime mover of output after 10 quarters, i.e. two and a half years, and it continues its domination till the end of the forecasting time horizon.

- Output innovation is the prime mover of output from the beginning to the end in India. Surprisingly prime mover of real GDP is the price from the beginning to the end in Bangladesh. But its influence gradually decreases over time. For Pakistan, contribution of output shock is fairly good at all forecasting horizons.

According to the monetarists in the 1960s and 1970s money's share of output variability should be well over 50% [Poole (1978, p.64)]. Friedman and Schwartz (1963, p. 695) suggest that this figure should be about 50%. Money's share of output variability should be larger than interest rate and such share must be caused by a positive relationship between money and output. According to Todd (1990), if a model includes both interest rate and money then money's share of output variability should be over 14%.

The finding of table 5.10 is consistent with Sims (1980b) finding that interest rate role in output determination is larger than money's role. This finding does not fit well with extreme monetarists view that money stock alone is a complete measure of the stance of monetary policy. However, it is consistent with the broader view that monetary policy is important in generating business cycles. For more information on how money affects real output and interactions of other variables in the system, we need to look at the impulse response functions depicted in figures 5.1 through 5.3 for Bangladesh, India, and Pakistan respectively.

Each column of graphs represents response of a single variable due to shocks in all the variables in the system. Response graphs in a given column all have the same scale with the maximum and minimum heights shown on any graph in the column noted at the left of each graph. The height of the graphs in a given column provides a visual measure of the relative contribution of shocks listed in the rows to explaining variance in the variable listed at the top (bottom) of the column. On the other hand, each row of graphs represents response of all the variables in the system due to shock in a single variable. The solid lines in the figures represent the impulse response functions, while the dashed lines correspond to the two standard deviation upper and lower confidence bands about the point estimates of impulse response functions[17]. Confidence intervals for impulse responses give a measure of uncertainty about the point estimates of impulses. Literature uses both formula based method and simulation method to construct this intervals. Recently some researchers define confidence intervals in terms of nominal coverage and effective coverage. They opine that the conventional Monte Carlo methods have effective coverage below the nominal coverage.

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[17] The two standard deviation bands were computed using Doan's (2000, p. 397) Monte Carlo simulations employing 2500 random draws.

Shock to interest rate (r)

First row represents the responses of interest rate itself, broad money, price and real GDP to positive one standard deviation shock in interest rate. Prediction of IS-LM theory is that when monetary policy shocks are identified with innovations in the interest rate, monetary contraction generates declining price, money and output. The outcome in case of Bangladesh is mixed. We observe that the overall response of output is very much negative and fits well with the theory. But the typical path of money stock response shows somewhat of an erratic behavior. We see initially money rises up to the 5^{th} quarter, which should not happen. In the medium term the effect is negative but finally a positive response of money is observed; and this is not consistent with theory. The response of price is positive and eventually becomes stronger. Persistent positive response of price produces puzzling dynamic effects, which economists term as the "price puzzle".

For India, the figure 5.2 shows a persistent negative effect on output as expected. Persistent positive effect on money stock is not a consistent result. Initial positive response of price produces an implausible result, once again producing the "price puzzle". For Pakistan, figure 5.3 shows a persistent negative effect on output as expected. Persistent positive effect on money stock is not a consistent result. Persistent positive response of price produces puzzling dynamic effects. Hence "price puzzle" also exists in Pakistan.

Figure 5.1: Impulse response functions of Bangladesh

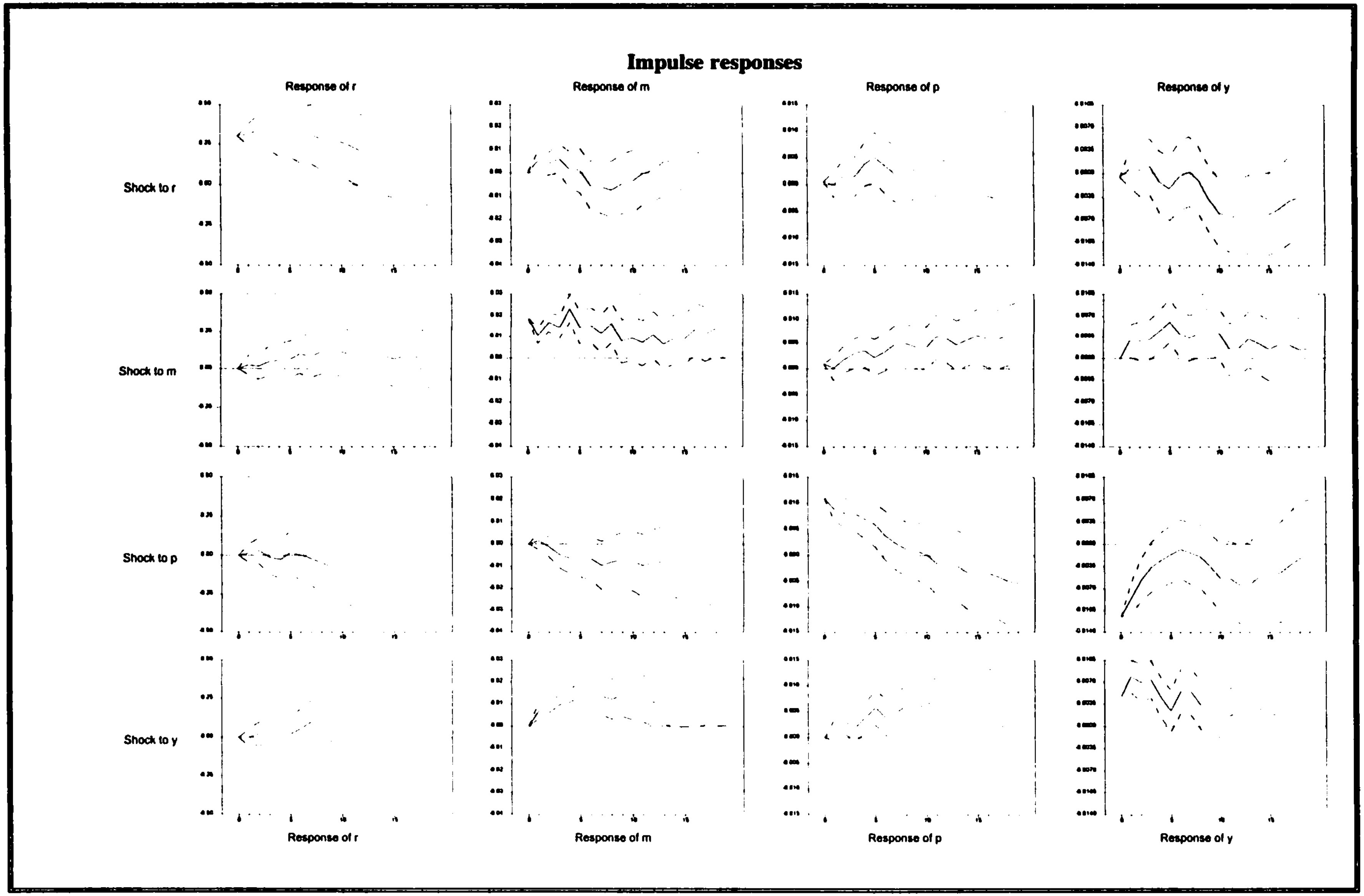


Figure 5.2: Impulse response functions of India

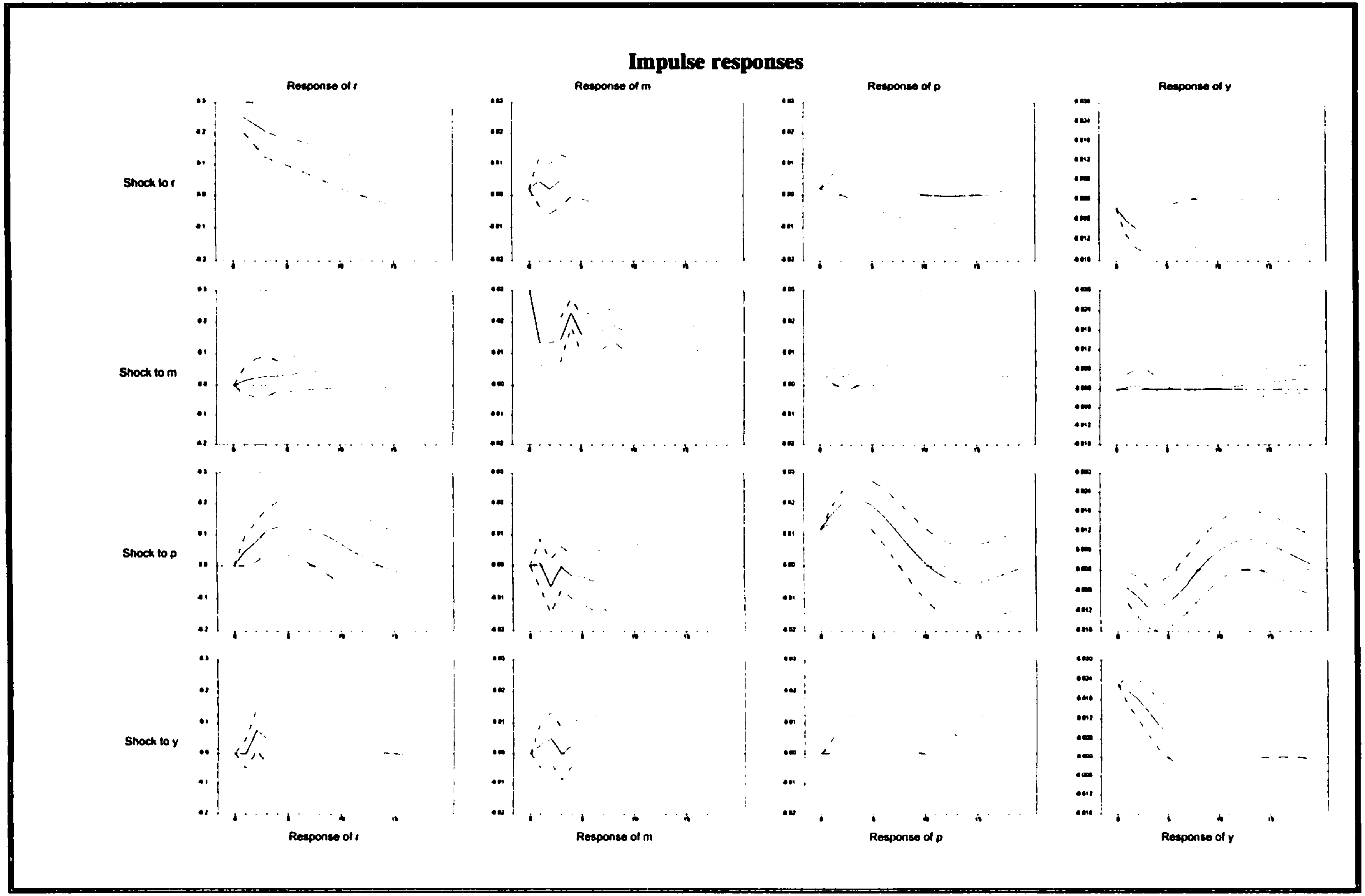
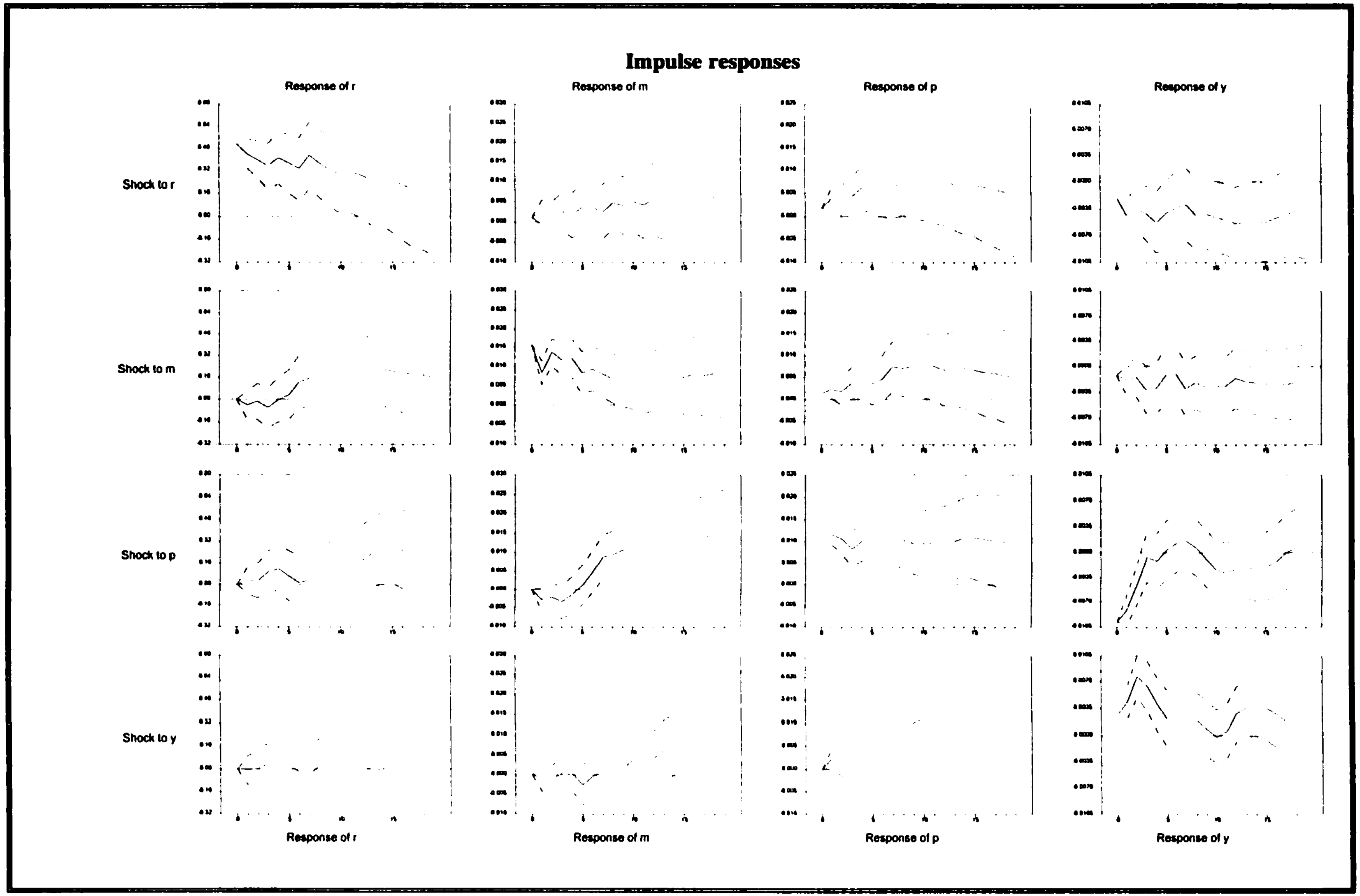


Figure 5.3: Impulse response functions of Pakistan



Shock to money (m)

Second rows of figures 5.1 through 5.3 represent the response of interest rate, broad money itself, price and real GDP to a positive one standard deviation shock in money. The IS-LM theory predicts that when monetary policy shocks are identified with innovations in money stock, such a monetary expansion leads to an increase in price, money and output but a decline in interest rate.

For both Bangladesh and India response of interest rate to money shocks show inconsistency - it is positive over the entire time span. This is termed as the "liquidity puzzle" often found even in developed countries under a recursive structure; see Gordon and Leeper (1994). But in the case of Pakistan the response does not show signs of the liquidity puzzle. Initial impact of an unanticipated expansionary monetary policy lowers the interest rate for a short period of time. Eventually, however, anticipated inflationary effect will come into force and dominate the liquidity effect as people adjust their inflation expectations to the new money growth rate. Persistence time horizon of liquidity effect is approximately four to five quarters in Pakistan.

Response of price is positive and volatile in Bangladesh. But the overall trend is positive giving a result, which is consistent with the monetarist/ IS-LM prediction. The responses of India and Pakistan also come up as per expectations. After an expansionary monetary shock, households cannot immediately adjust the quantity of cash spent on consumption to changed financial market circumstances. The financial intermediaries, which have become more liquid because of newly injected cash, have to lower the interest rate to encourage firms to borrow more. As a result real activities are stimulated and output is increased. As incomes rises, households will also adjust their consumption and saving decisions and price will eventually adjust to the new money growth rate. Output initially rises up to the 5th quarter and finally shows a declining trend in Bangladesh; but in India output hardly changes. The worst responses come from Pakistan. Negative response of output as a result of monetary expansion is very difficult to rationalize from the rational expectations monetarists' point of view.

A reasonable measure of shocks to monetary policy ought to have the property that an expansionary shock drives output up and leads to an opposite movement in interest rate. Money innovations, therefore, are not a fair candidate for interpretation as a monetarist/IS-LM policy shock in any of the three developing countries studied here.

To complete our discussion we need to discuss the bottom two rows of figures 5.1 through 5.3. A positive price shock leads to a negative and sustained decline in interest rate and money in Bangladesh. Response of output is negative as expected; such a negative impact on output is initially strong, and then becomes weaker and finally stronger again. For Pakistan, responses are largely similar to Bangladesh. For India, all the responses are well behaved. Responses of all the variables to GDP shocks are positive in all the three countries, which are reasonable.

Though the recursive structure is convenient for statistical purposes yet it is not sensible in economic terms. The disturbances can be interpreted behaviorally distinct if one believes that behavioral version of the system would have the form of Wold causal chain. It seldom represents the actual structure of an economy. If we look at table 5.6, we see that interest rate elasticity of money is zero; this is unrealistic. If the model is intended to be useful for policy decision, the "price puzzle" is indeed troublesome because it implies that monetary policy must expand the money stock in order to lower inflation. Moreover, the ordering of variables is important in a recursive structure when coefficient of correlation of residuals is large.

In summary, this section examines the behavior of key variables in response to different shocks and emphasizes the behavior of prices and output in light of Keynesian, monetarist and real business cycle perspectives. Price puzzle seems to be a universal phenomenon under the recursive identification scheme as it is observed in all the three countries. The positive response of prices in all the three countries raises serious difficulties for interpreting interest rate shocks as equivalent to monetary policy shocks. This price puzzle is an important one as it poses a clear threat to Keynesians, monetarists and real business cycle analysts.

In fact there is no business cycle theory, which says that monetary contraction is associated with prolonged inflation.

Sims' (1992) explanation of the price puzzle builds on the view that the monetary authority often has the information regarding inflationary pressures not captured in the history of the variables included in the VAR model. Acting on the basis of such knowledge, policy maker may raise interest rate in an effort to prevent inflation. Under these circumstances an econometrician would find that innovations in interest rate are followed by increases in price level and interest rate as well as a decline in output. What an econometrician cannot see is the price level that would have obtained had the policy maker not acted in a contractionary manner.

We do not see money demand and money supply shocks in this identification scheme. A rational expectation monetarist will treat innovation to money as monetary policy shocks while many other economists would rather treat interest rate as the policy variable. But in order to assess the policy effects of money, one must understand the economics of demand for money that approximates the private sector behavior and supply of money that approximates the central bank behavior. Differentiating the central bank behavior from that of the private sector behavior is the first critical step in estimating the impact of monetary policy. In the next two sections, we consider this important matter by examining alternative identification schemes to the recursive structure of the model, which has been discussed so far.

5.4 Analysis of variance decompositions and impulse response functions under identification scheme 2

Identification scheme 2 postulates that the price equation connects output innovations with price innovations and no other innovations can influence it contemporaneously. The money demand equation allows money innovations to depend on innovations in all the remaining variables in the model. The money supply equation allows money innovations to depend on innovations in interest rate alone. The output equation allows output innovations to depend on innovations in interest rate.

The estimated relationships among the contemporaneous coefficients are listed in table 5.11. P-values are given in parentheses below the coefficients. A two-step procedure is used to estimate the structural VAR model. First, the reduced form VAR, with lag structure determined by the likelihood ratio tests as described in the previous section, is estimated by OLS method. Next a sufficient number of restrictions are imposed on B and Ω to identify the parameters. Finally Broyden, Fletcher, Goldfarb, Shanno (BFGS) method estimates the model; see Press et. al. (1988) and Doan (2000, p. 213).

Table 5.11: Results of contemporaneous coefficients

Bangladesh	Output:	$y_t + 1.001r_t = \xi_{yt}$ (0.656)
	Price:	$p_t + 0.815y_t = \xi_{pt}$ (0.000)
	Money Supply:	$r_t - 1.236m_t = \xi_{rt}$ (0.873)
	Money Demand:	$m_t - 0.765y_t - 0.947p_t + 0.003r_t = \xi_{mt}$ (0.060) (0.039) (0.900)
India	Output:	$y_t + 0.009r_t = \xi_{yt}$ (0.371)
	Price:	$p_t + 0.096y_t = \xi_{pt}$ (0.039)
	Money supply:	$r_t - 4.551m_t = \xi_{rt}$ (0.090)
	Money Demand:	$m_t - 0.057y_t - 1.127p_t + 0.116r_t = \xi_{mt}$ (0.0814) (0.012) (0.125)
Pakistan	Output:	$y_t + 0.003r_t = \xi_{yt}$ (0.053)
	Price:	$p_t + 1.024y_t = \xi_{pt}$ (0.000)
	Money Supply:	$r_t - 0.082m_t = \xi_{rt}$ (0.936)
	Money Demand:	$m_t - 0.167y_t - 0.352p_t - 0.0016r_t = \xi_{mt}$ (0.770) (0.543) (0.558)

The output equation which represents the IS curve, comes up with the expected sign in all the three countries. Price equation, which represents the augmented Philips curve relation, however, gives unexpected sign. Money supply equations have reasonable interpretations in all the three countries; the coefficients are of the expected signs. The money demand equations have reasonable economic interpretations in Bangladesh and India but not in Pakistan. In Pakistan interest rate coefficient in money demand equation does not give the expected sign. But this coefficient is not significant.

Before we analyze the dynamic properties of the model, we need to give a structural interpretation of the shocks related to each one of the equations. Shocks related to price equation are termed as "aggregate supply shocks"; shocks related to output equation are identified as "IS shocks" or "aggregate demand shocks"; shocks related to interest rate equation are identified as "money supply shocks"; and shocks related to money equation are identified as "money demand shocks". In some literature shocks associated with y are labeled as supply shocks, particularly in the long run models. But here aggregate supply is normalized on the price level. Therefore it will be appropriate to call it "adverse supply shock[18]". Tables 5.12 through 5.15 display Forecast Error Variance Decompositions (FEVD) and figures 5.4 through 5.6 represent the Impulse Response Functions (IRF) of each of the variable attributable to each of the orthogonalized structural shocks.

The variance decompositions for series y are provided in the entries in table 5.12 which yield the following conclusions:

Table 5.12: Variance decompositions for y

			Explained by innovations in			
	Step	Std Error	IS	Supply	Money supply	Money demand
	1	0.012456	99.772	0	0.226	0.001
	2	0.017277	91.396	7.04	0.186	1.379
	4	0.021491	80.127	17.121	0.299	2.453
	6	0.023609	69.914	18.677	2.023	9.385
	8	0.025367	63.096	25.018	1.851	10.035

[18] The oil price shock of 1973 is an outstanding example of adverse supply shock. See Blanchard and Fischer (1989, p. 520) for details.

Bangladesh	10	0.026901	59.334	24.182	4.484	12
	12	0.02953	55.602	20.132	12.923	11.343
	14	0.032401	54.395	16.886	18.759	9.959
	16	0.034305	52.551	15.129	23.222	9.098
	18	0.035371	51.375	14.232	25.501	8.892
	20	0.035806	50.521	13.987	26.762	8.731
India	1	0.023287	98.998	0.024	0.632	0.346
	2	0.032166	95.914	0.297	3.007	0.783
	4	0.043431	85.812	5.716	7.25	1.222
	6	0.049077	76.637	11.798	9.838	1.726
	8	0.051264	72.57	13.015	11.895	2.521
	10	0.052285	70.311	12.84	13.17	3.679
	12	0.053929	66.456	15.376	13.49	4.679
	14	0.05629	61.7	19.829	13.287	5.185
	16	0.058569	58.326	23.171	13.244	5.259
	18	0.060305	56.908	24.305	13.661	5.126
	20	0.061575	56.617	23.976	14.465	4.942
Pakistan	1	0.010335	96.095	0	3.905	0
	2	0.014527	87.883	1.911	9.9	0.306
	4	0.019133	64.096	21.257	11.442	3.205
	6	0.020891	55.164	21.402	18.557	4.877
	8	0.021766	51.021	21.47	20.606	6.903
	10	0.022866	46.584	20.098	24.999	8.32
	12	0.024389	43.644	17.886	29.585	8.885
	14	0.026045	40.95	17.395	33.245	8.41
	16	0.027681	38.929	17.38	35.267	8.424
	18	0.028641	36.921	17.041	37.05	8.988
	20	0.029269	35.355	16.884	38.277	9.483

- IS shocks account for most of the variability of output in both the short run and long run, though their influence decreases over time.
- Supply shock seems to be an important source of variation in output in the medium term.
- Contributions of money supply shock of variation in output at the end of time horizon are 27%, 14% and 38% in Bangladesh, India and Pakistan respectively.

- Contributions of money demand shock at the end of forecasting time horizon are 9%, 5% and 9.5% in Bangladesh, India and Pakistan respectively.

The variance decompositions for series p are provided in table 5.13, which gives the following insights.

Table 5.13: Variance decompositions for p

	Entry	Std Error	Explained by innovations in			
			IS	Supply	Money supply	Money demand
Bangladesh	1	0.011016	84.753	15.053	0.192	0.001
	2	0.014221	79.964	19.519	0.118	0.4
	4	0.018988	68.128	29.387	1.038	1.447
	6	0.023373	50.979	39.48	7.337	2.204
	8	0.025532	43.224	43.76	8.103	4.913
	10	0.027909	36.835	48.085	7.825	7.255
	12	0.030937	32.66	49.239	8.35	9.751
	14	0.034219	30.31	48.507	9.815	11.368
	16	0.037876	29.943	45.788	11.101	13.169
	18	0.041352	30.158	43.819	12.01	14.013
	20	0.045061	31.322	40.972	12.295	15.411
India	1	0.011909	3.558	96.407	0.023	0.012
	2	0.021028	1.264	98.327	0.389	0.02
	4	0.037584	0.744	98.781	0.438	0.037
	6	0.049592	2.244	97.38	0.263	0.113
	8	0.056299	5.395	93.645	0.425	0.536
	10	0.059771	9.244	87.995	1.116	1.645
	12	0.062038	12.362	82.037	2.223	3.379
	14	0.064038	13.909	77.23	3.395	5.467
	16	0.065729	14.26	73.8	4.331	7.609
	18	0.066997	14.113	71.219	4.959	9.709
	20	0.068028	13.833	69.105	5.319	11.743
Pakistan	1	0.010942	89.945	6.4	3.655	0
	2	0.016858	77.764	13.445	8.606	0.186
	4	0.022807	72.202	14.631	11.806	1.361
	6	0.029213	63.516	16.962	17.245	2.276
	8	0.0352	59.175	16.837	18.733	5.255
	10	0.040897	53.948	16.98	21.116	7.956
	12	0.045957	49.494	18.189	22.522	9.795
	14	0.050204	47.738	18.325	23.506	10.431
	16	0.054421	46.693	19.178	23.553	10.577
	18	0.057831	45.708	20.414	23.463	10.415

	20	0.060604	45.08	21.638	23.143	10.139

- IS shock has a strong effect on price both in the short run and in the long run in Bangladesh and Pakistan. In India, its effect is moderate.
- Supply shock is the prime mover of price variation in India and Bangladesh at the end of forecasting time horizon but not in Pakistan.
- A money supply shock has a relatively small affect on price movement in India and Bangladesh but produces a sizeable affect in Pakistan.
- Money demand contributes 15%, 12% and 10% to price movement during the 20-quarter or the five-year forecast time horizon in Bangladesh, India and Pakistan respectively.

Table 5.14: Variance decompositions for r

	step	Std Error	Explained by innovations in IS	Supply	Money supply	Money demand
Bangladesh	1	0.299932	0	0.028	99.398	0.574
	2	0.432697	0.094	0.126	98.341	1.439
	4	0.641759	0.235	0.728	97.056	1.982
	6	0.784682	0.35	0.935	95.547	3.168
	8	0.906398	0.726	2.753	92.011	4.51
	10	1.00888	2.678	4.562	86.804	5.955
	12	1.096787	5.563	6.159	81.792	6.487
	14	1.165291	9.325	7.244	76.659	6.771
	16	1.220662	12.625	7.847	72.773	6.756
	20	1.312919	19.204	7.819	66.113	6.864
India	1	0.252558	0.02	2.405	63.042	34.533
	2	0.359776	0.149	6.768	59.449	33.633
	4	0.499071	1.551	19.043	50.312	29.094
	6	0.593003	1.122	27.569	45.055	26.254
	8	0.663413	0.908	32.483	41.304	25.304
	10	0.711827	0.79	34.532	38.928	25.75
	12	0.742896	0.73	34.467	37.481	27.322
	14	0.763738	0.697	33.319	36.476	29.508

	16	0.780471	0.669	31.956	35.558	31.817
	18	0.795899	0.674	30.76	34.646	33.919
	20	0.810457	0.758	29.731	33.798	35.713
Pakistan	1	0.513816	0	0	99.999	0.001
	2	0.677795	0.157	0.001	99.407	0.435
	4	0.8673	0.958	0.472	97.579	0.991
	6	1.034063	2.069	0.729	96.393	0.808
	8	1.177285	2.022	0.602	93.942	3.434
	10	1.305506	2.487	1.55	89.62	6.344
	12	1.410958	4.167	2.349	84.956	8.528
	14	1.514263	8.142	2.42	79.406	10.032
	16	1.630501	13.27	2.704	73.207	10.819
	18	1.707362	16.075	3.102	69.492	11.331
	20	1.770164	18.177	3.534	66.692	11.597

Entries in table 5.14 yield the following conclusions:

- IS shock plays a relatively moderate role in interest rate variation in Bangladesh and Pakistan but an insignificant role in India.
- Supply shock play some role in interest rate variation in Bangladesh and Pakistan but a significant role in India.
- Money supply shock takes on a leading role in explaining interest rate variation from the beginning in all the three countries.
- Money demand shock explains significantly the interest rate variation in India but not in Bangladesh and Pakistan.

Table 5.15: Variance Decompositions for m

	Step	Std Error	Explained by innovations in			
			IS	Supply	Money supply	Money demand
	1	0.018846	0.002	4.562	0.352	95.083
	2	0.023353	0.275	18.683	3.533	77.509
	4	0.035304	6.302	22.634	4.014	67.05
	6	0.048496	11.931	25.655	2.127	60.286
	8	0.056807	17.954	26.639	4.371	51.036
	10	0.063576	20.913	27.545	5.898	45.643

Bangladesh	12	0.067837	24.752	28.199	5.569	41.481
	14	0.071403	26.818	28.473	5.377	39.332
	16	0.075039	28.071	28.116	6.296	37.517
	18	0.079951	28.02	27.82	7.635	36.525
	20	0.085609	28.539	27.375	8.376	35.711
India	1	0.040949	0.037	4.417	32.129	63.417
	2	0.043487	0.336	5.158	29.627	64.879
	4	0.048619	1.719	4.754	26.543	66.984
	6	0.057054	2.035	3.854	22.707	71.405
	8	0.062972	2.334	3.232	20.167	74.267
	10	0.069191	2.418	2.735	17.821	77.025
	12	0.074838	2.364	2.412	15.899	79.325
	14	0.08036	2.242	2.245	14.213	81.3
	16	0.085712	2.098	2.233	12.752	82.917
	17	0.088373	2.027	2.273	12.09	83.61
	18	0.091007	1.96	2.331	11.474	84.235
	20	0.096257	1.837	2.468	10.361	85.334
Pakistan	1	0.015831	1.532	0.379	0.782	97.306
	2	0.018334	1.619	0.763	2.297	95.321
	4	0.026091	1.313	0.439	2.621	95.627
	6	0.030273	2.001	0.657	3.94	93.402
	8	0.034446	11.542	1.941	5.036	81.482
	10	0.038955	21.884	4.309	7.233	66.575
	12	0.043615	28.328	8.335	8.841	54.496
	14	0.049332	32.768	13.124	10.201	43.906
	16	0.055502	34.603	18.21	10.953	36.234
	18	0.061378	35.468	21.564	11.842	31.126
	20	0.066854	36.583	23.422	12.405	27.59

Entries in table 5.15 yield the following conclusions:

- Though IS shock explains almost one third of the variability in money in the long run in Bangladesh and Pakistan, its contribution in India is almost negligible.
- Long run contribution of supply shocks to money variability is remarkable in Bangladesh and Pakistan but not in India.
- Long run contribution of money supply innovation is below 12.5% in all the countries.

- Money demand innovation is the principal contributor of variability of money at least in short run. It is true of all the three countries.

In conclusion, the results discussed above reveal that IS shock is the principal source of fluctuations in output in all the three countries. The adverse supply shock is the principal source of price movement in Bangladesh and Pakistan. Role of money is relatively low or negligible under this identification scheme.

Finally, consider the impulse response functions. The typical shocks whose effects we are about to discuss are positive residuals of one standard deviation unit in each equation of the system.

The IS shocks

The dynamic effects of one standard deviation IS shock are summarized in row 1 of figures 5.4 to 5.6. An IS shock will shift the aggregate demand curve to the right. This will raise both the price level and output. An increase in price level and output will shift the money demand curve to the right and consequently an increase in interest rate and money stock[19]. Therefore, in theory it is predicted that aggregate demand shocks/ IS shocks will:

i) increase output

ii) increase price

iii) increase interest rate

iv) increase money stock

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[19] The dynamic response of different variables to a shock depends on a diversity of transmission mechanisms developed into the economy.

Figure 5.4: Impulse response functions of Bangladesh

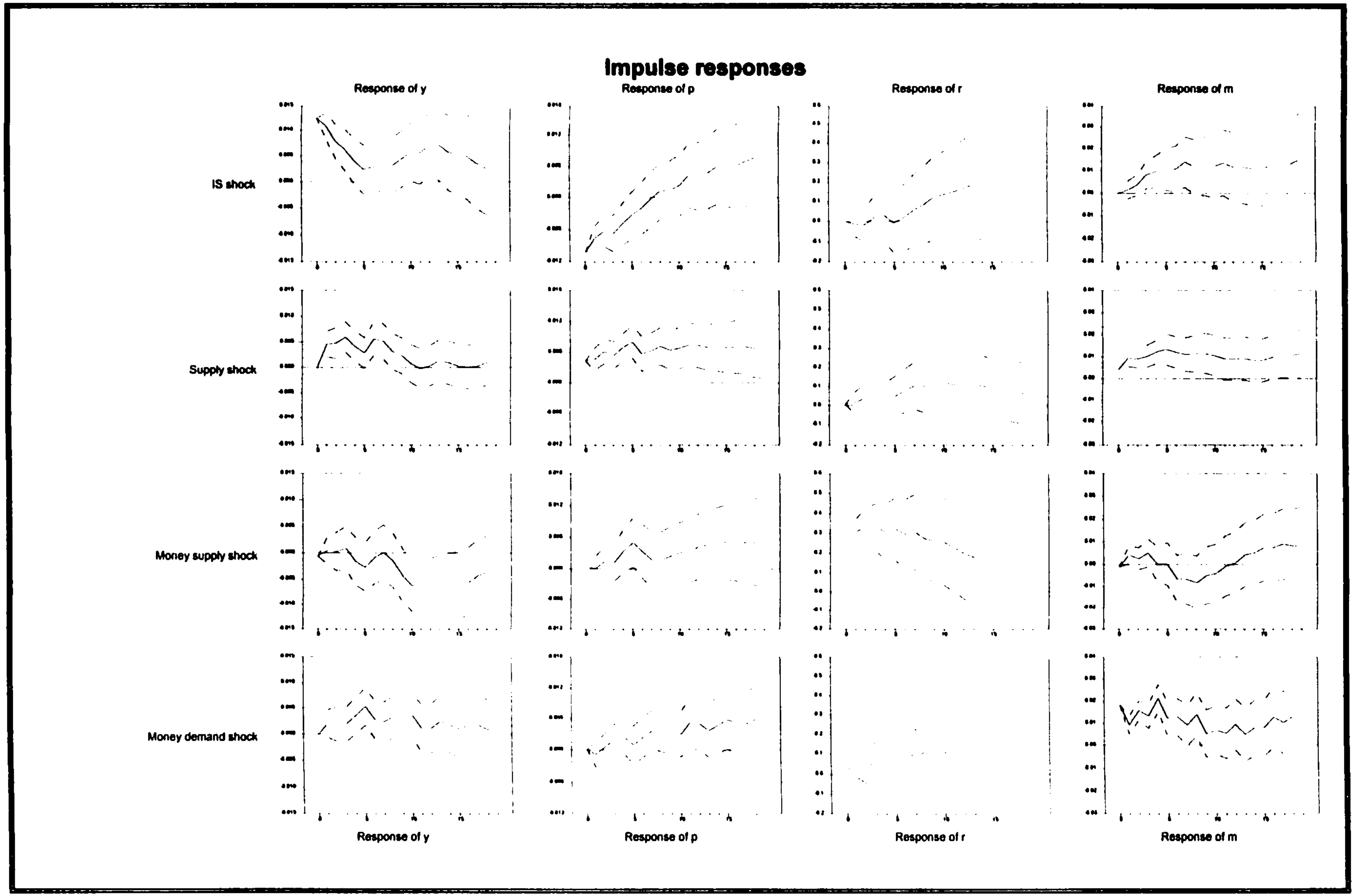


Figure 5.5: Impulse response functions of India

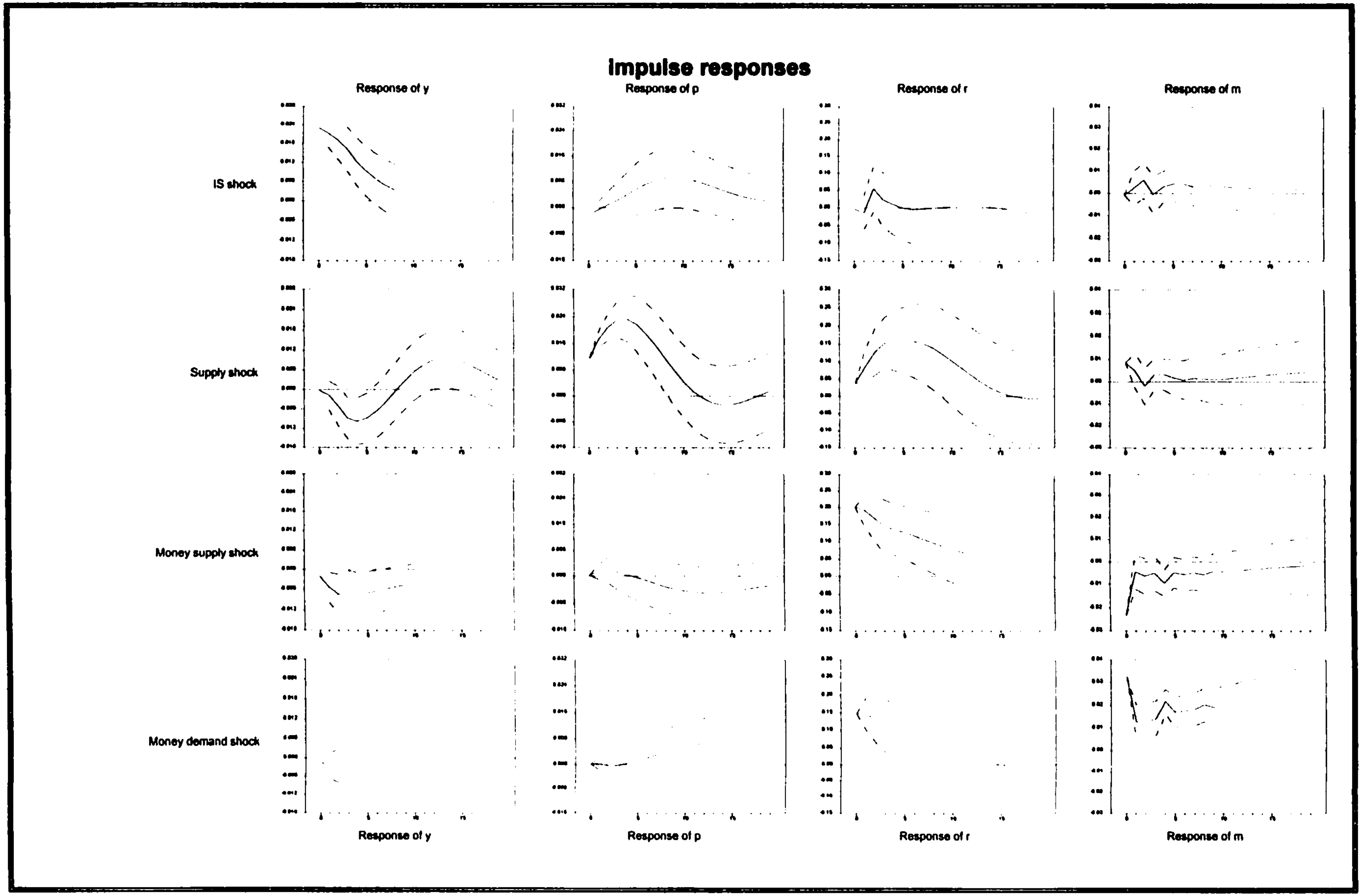
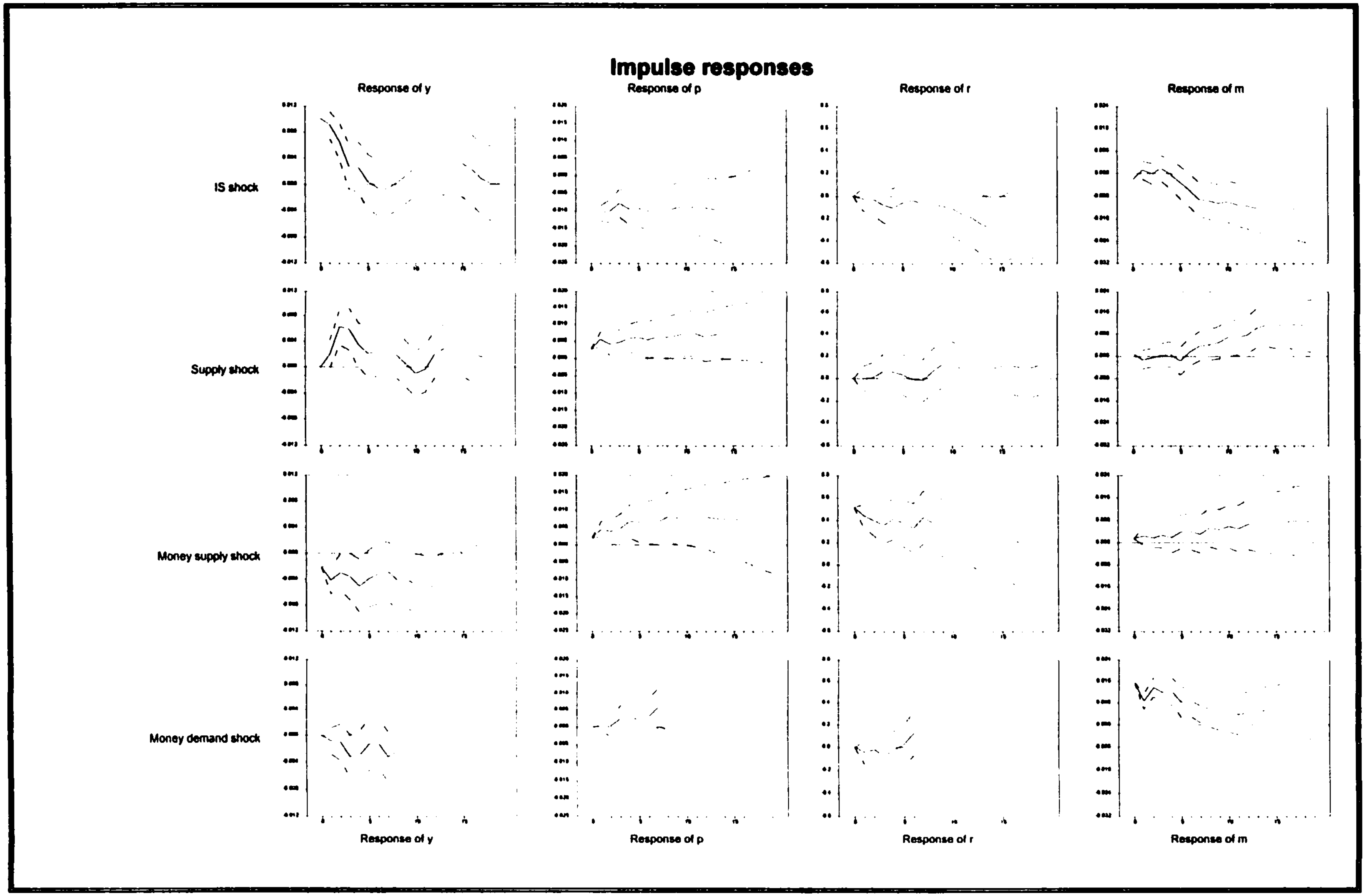


Figure 5.6: Impulse Response Functions of Pakistan



For India responses of all the variables are consistent with theory. Several characteristics deserve attention. The first feature is the strength of IS shocks initial impact on real GDP compared to other shocks. GDP rises by almost 2.4% in the quarter of the shock while the other shocks produce negative responses; see first column of figure 5.5. The second feature is the initial effect of IS shock on money demand is moderate and so is the effect on interest rate. The effect on price though initially negative, quickly recovers and reaches its peak value in the medium term.

For Pakistan, the responses do not come up as predicted by theory. The responses are not consistent in at least two cases. The IS shock raises output but money shows a declining trend. Price and interest rate also move negatively.

For Bangladesh, the IS shock has a strong positive effect on output as expected. This higher output leads to higher money demand. Higher money demand leads to higher interest rate, which is plausible. But an initial negative effect on the price level takes almost two years to be positive is not so reasonable.

The supply shocks

The dynamic effects of one standard deviation supply shock are summarized in row 2 of figures 5.4 through 5.6. Aggregate supply equation is normalized on price. An adverse supply shock, oil price shock for example, will shift the aggregate supply curve to the left. This will raise the price level and reduce output. An increase in price level will shift the money demand curve to the right, while a decrease in output will shift it to the left. If the increase in money demand due to increase in price is larger relative to decrease in money demand due to decrease in output, the net effect will be a shift in the money demand curve to the right and an increase in interest rate. On the other hand, if the increase in money demand due to increase in price is smaller relative to decrease in money demand due to decrease in output, the reverse will be true. Therefore, in theory it is predicted that adverse supply shocks will:

i) decrease output

ii) increase price

iii) increase interest rate / decrease in interest rate

iv) increase money stock / decrease in money stock

For India the results are largely consistent with theory. The initial impact on GDP is negative for up to 10 quarters. The positive effect on prices is substantial but vanishes in the 10^{th} quarter as expected. The money stock hardly changes and remains positive. But it is not inconsistent as interest rate rises due to substantial positive price effect.

For Pakistan and Bangladesh the responses are qualitatively the same. Why an adverse supply shock would lead to an initial rise in output is harder to rationalize. But the positive impact on money and interest rate satisfies the theoretical predictions. The only difference between these two countries is that the initial impact on money is stronger in Bangladesh than in Pakistan.

The money supply shocks

Money supply equation is normalized on the interest rate. The dynamic effects of one standard deviation contractionary money supply shock are summarized in row 3 of figures 5.4 to 5.6. A shift in money supply curve to the left will raise interest rate and reduce money stock. Since monetary sector affects real sector via interest rate channel, an increase in interest rate will shift aggregate demand to the left resulting in a decline of output and price. Therefore, in theory it is predicted that contractionary money supply shocks will:

i) decrease output

ii) decrease price

iii) increase interest rate

iv) decrease money stock

The rational expectations IS-LM predictions are captured well by the responses of India. The typical path of interest rate after the shock takes the form of an initial rise in interest rate followed by a gradual decline in that variable. Money stock and output decline. Low liquidity drives the price level down. The opposite response of money and interest rate suggests that "liquidity effect" dominates under this identification scheme for India.

The effects of money supply shock in Pakistan, however, depict a mixed scenario. An unexpected rise in interest rate leads to a persistent increase in money stock suggests that "liquidity puzzle" dominates in Pakistan under this identification scheme. Output declines as expected in theory. Rising price is not expected, but rising money stock accompanied by decline in output probably contributes to fuelling inflation.

The effects in Bangladesh are not impressive. Response of money is somewhat erratic. The typical path of money after the shock takes the form of an initial rise until the 5th quarter giving rise to puzzling dynamic effects. In the medium term, money shows a gradual decline suggesting that the liquidity effect dominates in that time horizon. In the long term, again the liquidity puzzle dominates. A substantial delayed negative impact on output is expected. A weak positive but persistent effect on price is not plausible.

The money demand shocks

The dynamic effects of one standard deviation money demand shock are summarized in row 4 of figures 5.4 to 5.6. A shift in money demand curve to the right will raise interest rate and money stock. Since monetary sector affects real sector via interest rate channel, an increase in interest rate will shift aggregate demand to the left resulting in a decline of output and price. So, in theory it is predicted that money demand shocks will:

i) decrease output

ii) decrease price

iii) increase interest rate

iv) increase money stock

The rational expectations IS-LM predictions are largely captured by the responses of India. Interest rate rises, money stock rises and output declines. In the case of Pakistan, initially interest rate declines but money stock rises and output declines. In the case of Bangladesh output shows a positive and volatile response, which does not fit with theory. The responses of price do not come with expectations under this identification scheme in all the three countries.

5.5 Analysis of variance decompositions and impulse response functions under identification scheme 3

Identification scheme 3 postulates that the output equation allows output innovations to depend on innovations in price, interest rate and money. Price equation is autonomous and no other innovations but price innovations can influence it contemporaneously. The money supply equation allows money innovations to depend on innovations in interest rate alone. The money demand equation allows money innovations to depend on innovations in interest rate, price and output with the latter two having symmetric effects.

The estimated relationships among the contemporaneous coefficients are listed in table 5.16. P-values are given in parentheses below the coefficients.

Table 5.16: Results of contemporaneous coefficients

Bangladesh	Output:	$y_t + 1.087p_t - 0.006r_t - 0.240m_t = \xi_{yt}$
		(0.000) (0.669) (0.408)
	Price:	$p_t = \xi_{pt}$
	Money Supply:	$r_t - 9.184m_t = \xi_{rt}$
		(0.679)
	Money Demand:	$m_t + 5.009y_t + 5.009p_t + 0.044r_t = \xi_{mt}$
		(0.589) (0.589) (0.708)
India	Output:	$y_t - 0.066p_t + 0.056r_t - 0.359m_t = \xi_{yt}$
		(0.824) (0.075) (0.089)
	Price:	$p_t = \xi_{pt}$
	Money supply:	$r_t - 5.087m_t = \xi_{rt}$
		(0.139)
	Money Demand:	$m_t - 1.903y_t - 1.903p_t + 0.113r_t = \xi_{mt}$
		(0.048) (0.048) (0.209)
Pakistan	Output:	$y_t + 0.880p_t + 0.002r_t + 0.052m_t = \xi_{yt}$
		(0.000) (0.074) (0.300)
	Price:	$p_t = \xi_{pt}$
	Money Supply:	$r_t - 38.718m_t = \xi_{rt}$
		(0.263)
	Money Demand:	$m_t - 5.375y_t - 5.375p_t + 0.032r_t = \xi_{mt}$
		(0.201) (0.201) (0.349)

The estimated coefficients of the money supply equations have reasonable economic interpretations in all the three countries. The coefficients are of the expected signs. The sign of the *m* coefficient is particularly interesting because it indicates how the bank rate responds to a change in the monetary aggregate. Suppose there is an increase in the monetary aggregate. If the central bank believes that such an increase will lead to a rise in future inflation, it will tend to increase the bank rate in order to offset the rising money stock. The relationship between interest rate and monetary aggregate is therefore expected to be positive in this policy reaction function. Interest rate semi-elasticity[20] of money supply in Bangladesh, India and Pakistan are 9.18, 5.08 and 37.81 respectively. But unfortunately none of the coefficients is significant. In the money demand function the relationship between output and money demand is expected to be positive. Because when consumer income rises, the demand for goods and services will rise which, in turn, increase their demand for money so that they can actually purchase more goods and services. This coefficient will give income elasticity of money demand. Since consumer is willing to hold less money when cost of holding money (interest rate) increases, the relationship between interest rate and money demand is negative. This means that money demand equations have reasonable interpretations in Pakistan and India. For Bangladesh interest rate coefficient in money demand equation does not give the expected sign. Income elasticity of money demand in Bangladesh, India and Pakistan are elastic, which is true of all developing countries. Interest rate semi-elasticity of money demand in Bangladesh, India and Pakistan are 0.044, 0.113 and 0.032 respectively. The IS equations can also be given good economic interpretations particularly in India and Pakistan.

Structural interpretations of the shocks are the same as described in scheme 2. Tables 5.17 through 5.20 display FEVD of each of the variable attributable to

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[20] Interest rate semi-elasticity of money supply is defined as the ratio of change in log of money supply to change in interest rate.

each of the orthogonalized structural shocks. The variance decompositions for series y are provided in table 5.17, which give the following insights:

Table 5.17: Variance decompositions for y

	Step	Std Error	Explained by innovations in			
			IS	Supply	Money Supply	Money Demand
Bangladesh	1	0.012456	5.933	85.004	0.153	8.911
	2	0.017277	7.257	66.687	0.328	25.728
	4	0.021491	8.955	51.417	0.493	39.135
	6	0.023609	7.809	43.505	6.803	41.883
	8	0.025367	8.065	37.815	7.05	47.07
	10	0.026901	7.304	35.146	11.698	45.852
	12	0.02953	6.693	35.056	19.774	38.478
	14	0.032401	6.925	36.024	24.631	32.421
	16	0.034305	7.155	35.648	28.195	29.002
	18	0.035371	6.936	35.387	30.378	27.299
	20	0.035806	7.064	34.793	31.493	26.65
India	1	0.023287	51.835	4.193	0.557	43.415
	2	0.032166	47.079	5.468	2.77	44.683
	4	0.043431	37.843	14.55	6.69	40.917
	6	0.049077	31.493	22.119	9.023	37.364
	8	0.051264	28.981	23.436	10.889	36.693
	10	0.052285	27.879	22.774	12.05	37.297
	12	0.053929	26.211	24.11	12.36	37.32
	14	0.05629	24.19	26.818	12.213	36.779
	16	0.058569	22.88	28.477	12.235	36.408
	18	0.060305	22.542	28.449	12.703	36.306
	20	0.061575	22.761	27.559	13.545	36.135
Pakistan	1	0.010335	4.28	93.599	0.074	2.047
	2	0.014551	4.939	84.181	0.701	10.179
	4	0.019276	13.485	55.627	0.673	30.215
	6	0.021117	11.347	47.574	1.255	39.824
	8	0.022035	10.505	43.901	1.523	44.071
	10	0.023154	10.071	40.432	1.567	47.93
	12	0.024632	10.52	40.148	1.617	47.715
	14	0.02634	9.289	37.88	2.409	50.423
	16	0.028029	8.359	35.956	2.566	53.119
	18	0.029018	7.862	34.173	2.571	55.394
	20	0.029671	7.616	32.687	2.582	57.115

- Supply shock explains most of the output variability not only in the short run but also in the long run in Bangladesh. This part is consistent with real business cycle theories. Money demand shock explains most of the output variability in the long run in Pakistan and India.

- In Bangladesh IS shock is never an important source of output movement and its contribution is fairly constant around 7% across the range. In India, however, it is the major source of output variability in the first two quarters.
- Money supply shock has a negligible effect on output in the short run but one of the major sources in output variability in the long run in Bangladesh. This result is consistent with the monetarist theories. For Pakistan it is very low and such a result is consistent with real business cycle theories.
- For Bangladesh money demand shock is the prime mover of output in the medium term. For India, money demand is the dominant force across all time horizons. For Pakistan the long run effect is even stronger.

The following conclusions emerge from the results displayed in table 5.18, which provides variance decompositions for series p:

Table 5.18: Variance decompositions for p

			Explained by innovations in			
	Entry	Std Error	IS	Supply	Money Supply	Money Demand
	1	0.011016	0	100	0	0
	2	0.014221	1.196	98.733	0	0.071
	4	0.018988	1.124	93.181	0.072	5.623
	6	0.023373	1.317	78.072	2.42	18.19
	8	0.025532	1.128	68.892	2.377	27.603

Bangladesh	10	0.027909	1.276	58.048	2.082	38.593
	12	0.030937	1.257	47.378	1.756	49.61
	14	0.034219	1.126	39.043	1.733	58.098
	16	0.037876	0.945	32.971	1.686	64.398
	18	0.014352	0.816	28.848	1.701	68.635
	20	0.045061	0.697	26.219	1.549	71.536
India	1	0.011909	0	100	0	0
	2	0.021028	0.954	98.303	0.241	0.502
	4	0.037584	2.531	94.766	0.284	2.419
	6	0.049592	5.828	90.612	0.19	3.37
	8	0.056299	10.517	84.913	0.462	4.108
	10	0.059771	15.904	78.538	1.303	4.256
	12	0.062038	20.385	73.014	2.571	4.03
	14	0.064038	23.156	69.091	3.892	3.861
	15	0.064936	23.999	67.625	4.466	3.91
	16	0.065729	24.619	66.358	4.96	4.063
	18	0.066997	25.526	64.158	5.705	4.611
	20	0.068028	26.28	62.249	6.168	5.303
Pakistan	1	0.010943	0	100	0	0
	2	0.016787	3.676	96.12	0.108	0.095
	4	0.022659	5.784	93.004	0.149	1.063
	6	0.028915	9.988	87.455	0.165	2.393
	8	0.034799	11.773	83.406	0.543	4.278
	10	0.04037	14.407	78.432	0.657	6.504
	12	0.045297	17.413	74.354	0.773	7.46
	14	0.049452	18.329	72.806	0.745	8.119
	16	0.053584	19.205	72.143	0.744	7.908
	20	0.059632	21.001	71.335	0.685	6.979

- IS shock explains almost nothing of price variability either in the short run or in the long run in Bangladesh and explains moderate amount of price variability in the long run in India and Pakistan.
- Supply shocks account for over 90% of price variability in the short run in all the three countries. Its leading role continues to the end of the 20th quarter in India and Pakistan.

- The contribution of money supply shocks to variability in price is almost negligible for Bangladesh and Pakistan and better than that of money demand in the case of India in the latter quarters.
- Innovations in money demand take almost five quarters to have an effect and quickly become the prime mover in Bangladesh. For India and Pakistan the effects are relatively very low.

Variance decompositions for interest rate series as displayed in table 5.19 reveal the following:

Table 5.19: Variance Decompositions for r

			Explained by innovations in			
	Entry	Std Error	IS	Supply	Money Supply	Money Demand
Bangladesh	1	0.299933	10.855	0.258	74.621	14.267
	2	0.432698	12.425	0.654	70.815	16.106
	4	0.641759	11.33	0.842	67.882	19.945
	6	0.784683	12.137	0.808	64.289	22.765
	8	0.906399	11.085	0.667	59.219	29.029
	10	1.00888	9.794	0.885	53.57	35.751
	12	1.096787	8.459	1.672	49.14	40.729
	14	1.165291	7.5	3.223	45.214	44.062
	16	1.220662	6.845	4.79	42.448	45.917
	18	1.270555	6.319	6.76	39.942	46.98
	20	1.312919	5.919	8.896	37.889	47.296
India	1	0.252558	16.589	3.009	57.498	22.903
	2	0.359775	15.946	7.814	53.95	22.29
	4	0.49907	22.143	18.277	45.327	14.253
	6	0.593003	20.547	26.911	40.4	12.143
	8	0.663413	19.499	32.082	36.855	11.564
	10	0.711827	19.558	34.21	34.577	11.656
	12	0.742895	20.31	34.163	33.159	12.368
	14	0.763737	21.201	33.041	32.162	13.596
	16	0.780471	21.799	31.702	31.269	15.23
	18	0.795899	21.99	30.497	30.399	17.114
	20	0.810456	21.885	29.438	29.595	19.081
	1	0.513825	14.488	2.825	36.735	45.952
	2	0.677924	12.968	3.776	40.436	42.82
	4	0.865108	13.29	6.363	41.799	38.548

Pakistan	6	1.029331	14.193	9.198	38.463	38.145
	8	1.173889	14.202	8.773	31.301	45.724
	10	1.298319	17.524	10.162	25.904	46.41
	12	1.400722	18.993	13.072	22.27	45.665
	14	1.502652	18.058	18.037	19.393	44.512
	16	1.617339	16.886	24.316	16.768	42.03
	18	1.692922	16.472	27.908	15.359	40.262
	20	1.75462	16.24	30.664	14.338	38.758

- IS shocks play a fair role in interest rate variation in India and Pakistan and become smaller and smaller over time. But its effect is small in Bangladesh.
- Supply shocks take almost 12 quarters to have even a negligible effect in Bangladesh. Around 30% of interest rate variability is explained by the supply shock in India and Pakistan during the last period, i.e. the 20th quarter.
- Money supply shocks obviously take the leading role in explaining interest rate variation at the beginning in all the three countries.
- Money demand shocks take a leading role in interest rate variability in the end in Bangladesh and Pakistan, and a fairly good role in India.

Table 5.20: Variance decompositions for m

			Explained by innovations in			
	Entry	Std Error	IS	Supply	Money Supply	Money Demand
Bangladesh	1	0.018846	32.589	0.774	23.805	42.833
	2	0.023353	22.178	1.826	15.672	60.324
	4	0.035304	13.557	1.656	9.327	75.459
	6	0.048496	8.812	2.438	10.944	77.807
	8	0.056807	7.311	5.006	16.328	71.356
	10	0.063576	7.159	6.097	19.51	67.234
	12	0.067837	7.346	7.842	18.595	66.217

	14	0.071403	6.823	8.638	17.079	67.46
	16	0.075039	6.186	9.128	15.599	69.087
	18	0.07995	5.585	8.893	13.891	71.631
	20	0.085609	4.974	9.006	12.153	73.867
India	1	0.040949	24.385	4.423	37.526	33.666
	2	0.043487	27.3	4.935	34.816	32.949
	4	0.048619	30.997	4.824	31.44	32.739
	6	0.057054	35.96	3.754	27.306	32.98
	7	0.059981	37.84	3.396	25.929	32.835
	8	0.062972	39.032	3.109	24.525	33.334
	10	0.069191	41.321	2.593	21.933	34.152
	12	0.074838	42.754	2.256	19.786	35.205
	14	0.08036	43.754	2.066	17.88	36.301
	16	0.085712	44.447	2.031	16.206	37.315
	18	0.091007	44.99	2.106	14.723	38.18
	20	0.096257	45.434	2.224	13.416	38.926
Pakistan	1	0.01581	10.208	1.99	55.424	32.378
	2	0.018336	9.739	1.902	49.261	39.098
	4	0.026098	10.897	1.206	46.85	41.046
	6	0.030284	10.521	1.984	44.312	43.183
	8	0.034409	9.995	13.904	38.168	37.933
	10	0.038841	9.935	28.075	30.521	31.469
	12	0.043406	11.218	38.522	24.614	25.646
	14	0.049002	13.265	46.856	19.467	20.412
	16	0.055037	16.164	51.822	15.717	16.297
	18	0.060774	18.456	54.873	13.111	13.56
	20	0.066139	19.598	57.442	11.288	11.672

Variance decompositions for money as displayed in table 5.20 reveal the following:

- For Bangladesh though IS shock explains almost one third of variability in money in the first quarter, yet its influences fades away as time marches on. For India this figure gradually increases and stabilizes around 45% in the end. The effects are moderate for Pakistan and show an increasing trend from the 12th quarter onwards.

- Contribution of supply shocks to money variability is never above 10% in Bangladesh and India. But for Pakistan the supply shock accounts for 57% of money variability at the end of 20-quarters i.e. the end of the 5^{th} year.
- Money supply innovation's short run effect is greater than its long run effect in all the countries.
- Money demand innovations are the principal contributor of variability of money in Bangladesh while in the other two countries its effects are substantial, though relatively smaller.

In conclusion, the results discussed above seem fit well with the traditional Keynesian view of business cycle fluctuations in India. Such a view tend to perceive money demand, money supply or IS shocks as the principal source of fluctuations in output when we constrain the supply factors such as technological shift and population growth. In contrast with that view, the estimates for Bangladesh suggest that supply shock, which is normalized with price, is the most important source of output variability.

Finally, we examine the impulse response functions. The typical shocks whose effects we are about to discuss are positive residuals of one standard deviation unit in each equation of the system.

Figure 5.7: Impulse response functions of Bangladesh

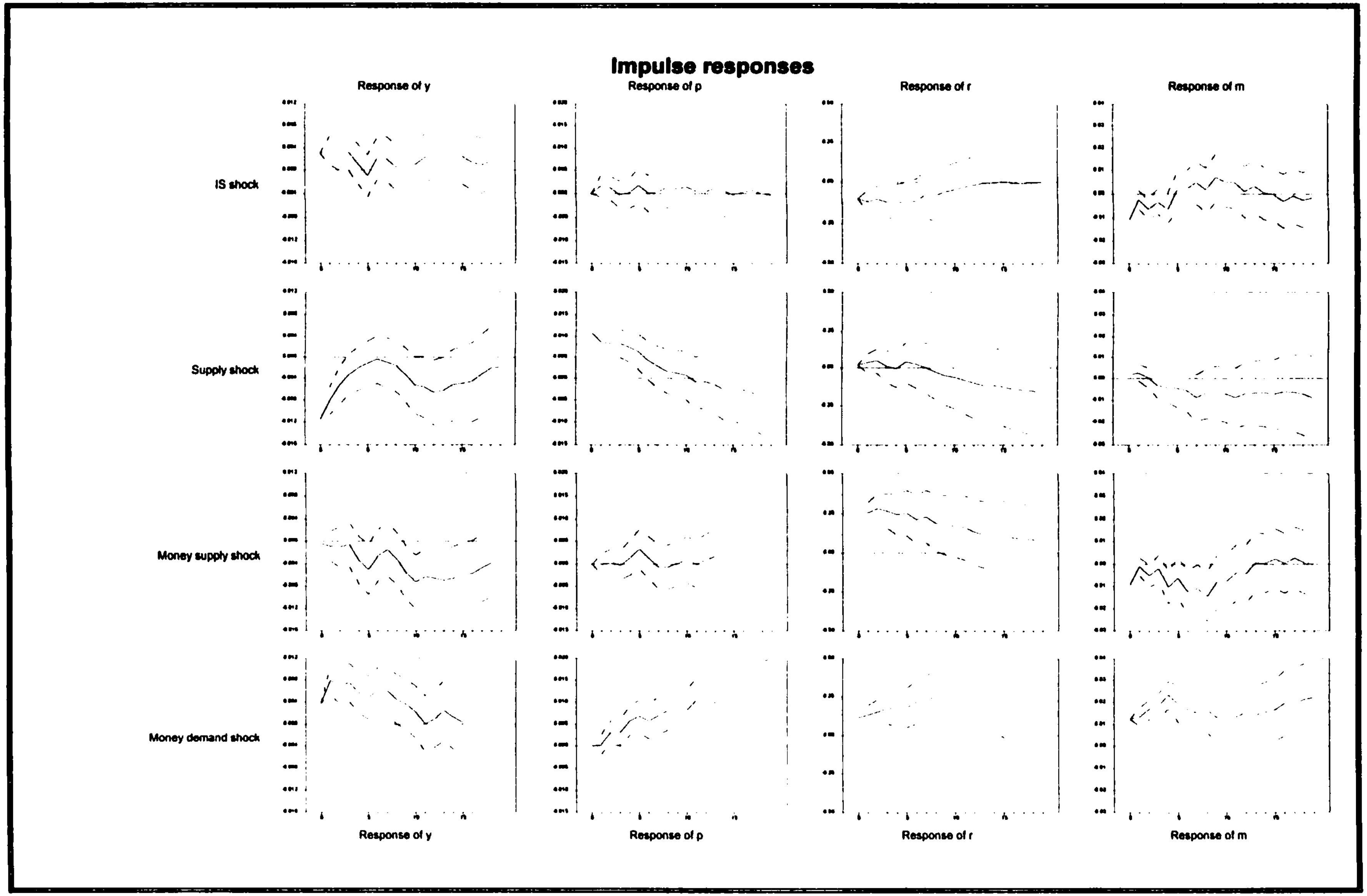


Figure 5.8: Impulse response functions of India

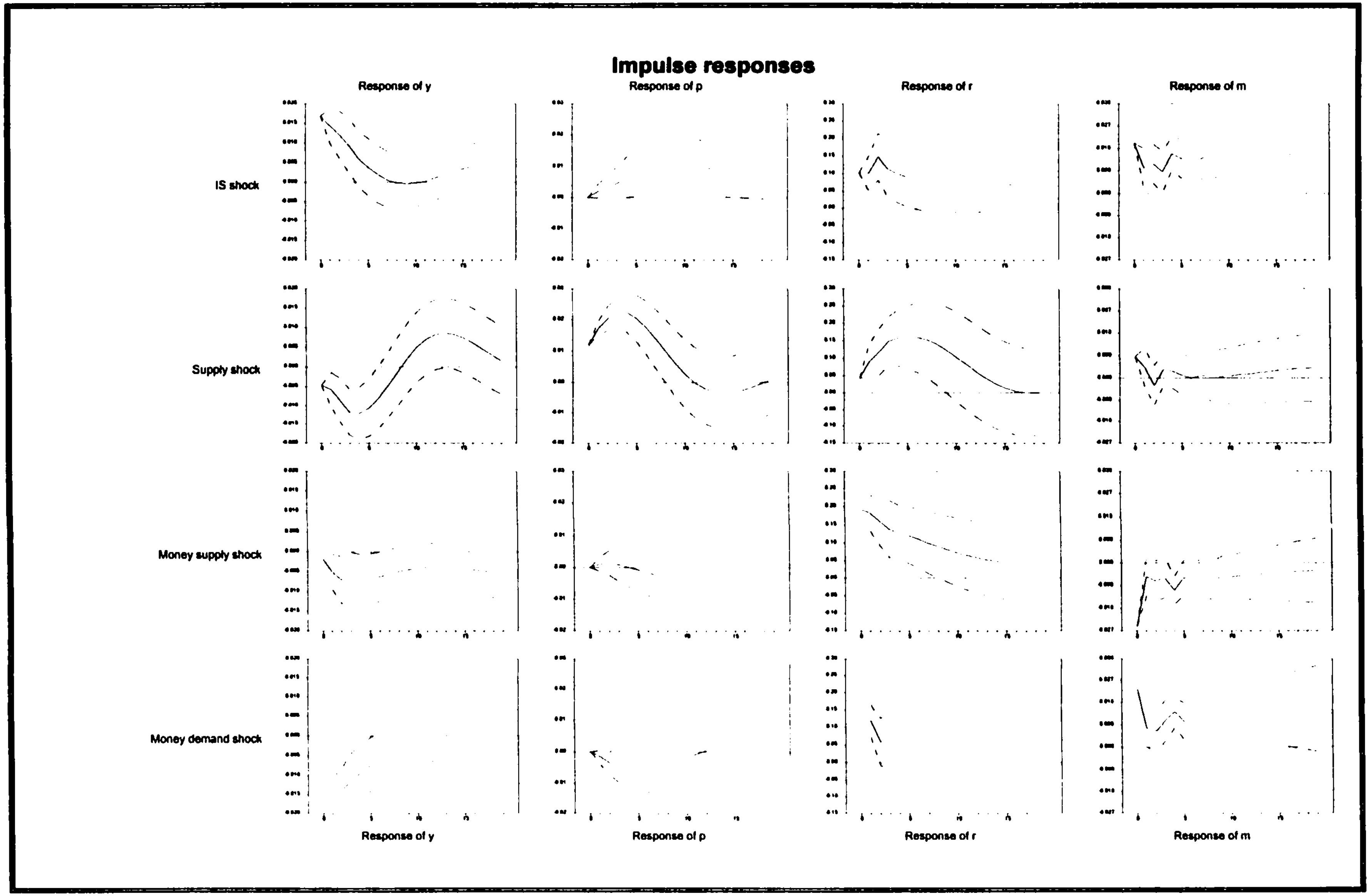
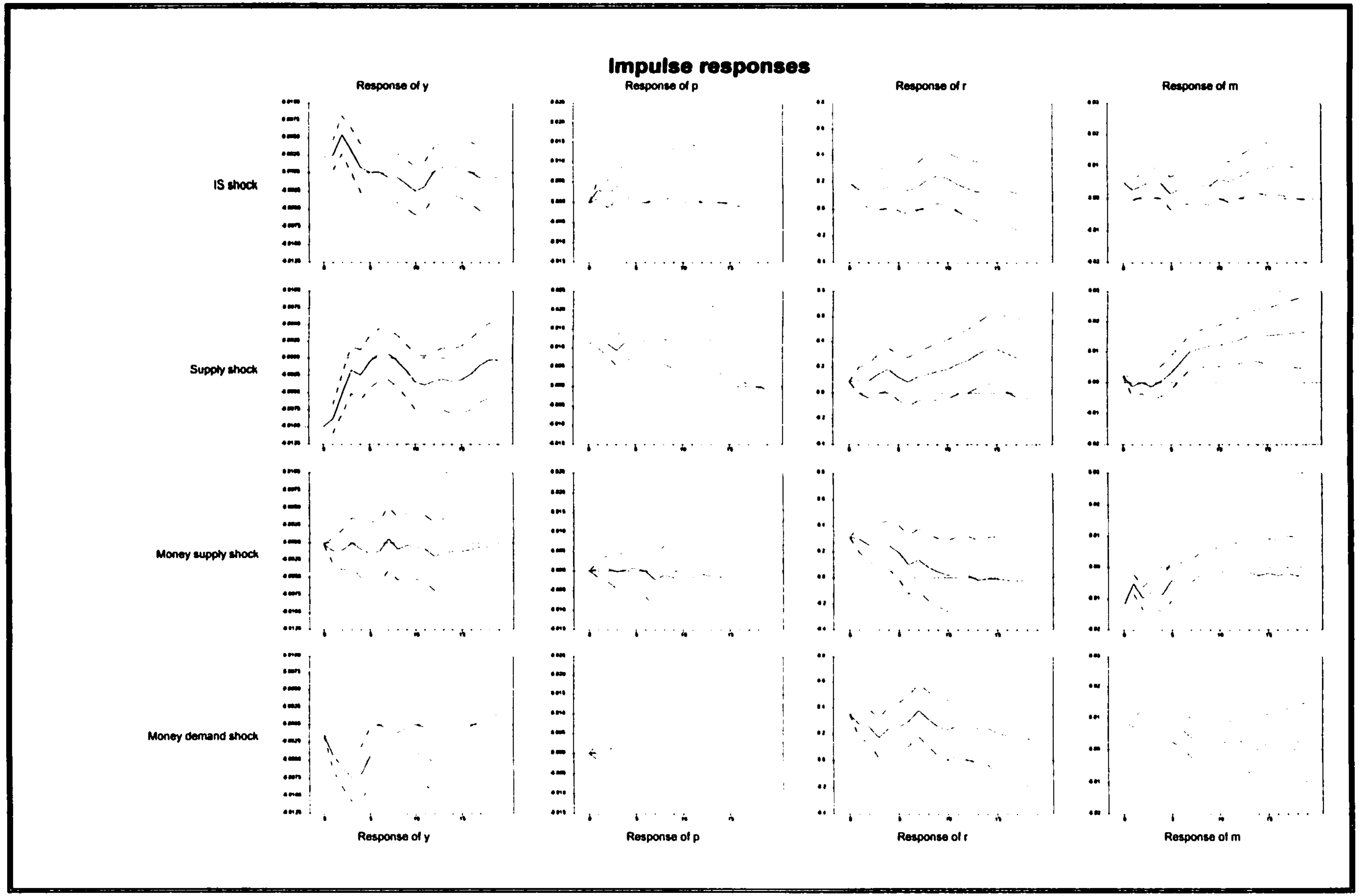


Figure 5.9: Impulse response functions of Pakistan



The IS shocks

The dynamic effects of one standard deviation IS shocks are summarized in row 1 of figures 5.7 through 5.9. For India, responses of all the variables are consistent with theory. However, several aspects deserve attention. The first aspect is the strength of IS shocks and their initial impact on real GDP compared to other shocks. GDP rises by almost 1.5% in the quarter of the shock while the other shocks produce negative responses (see the first column of figure 5.8). But the effect on GDP is less persistent. The second aspect is the substantial permanent effect on price, nominal interest rate and the money stock.

For Pakistan the responses are qualitatively the same as those for India. But for Bangladesh the responses are not consistent at least in two cases. The IS shock raises output and a very weak positive effect on price level. The shock has an initial negative but gradual declining impact on interest rate and a mixed affect (negative effect in the short time horizon, positive effect in the medium time horizon and again negative effect in the long time horizon) on money stock.

The supply shocks

The dynamic effects of one standard deviation supply shocks are summarized in row 2 of figures 5.7 through 5.9. Aggregate supply equation is normalized on the price level.

For India the results are largely consistent with theory. The initial impact on GDP is negative for up to 10 quarters. The positive effect on prices is substantial but vanishes during the 10^{th} quarter as expected. Interest rate rises and the money stock is positive though weak, but it is not inconsistent due to substantial positive movement of price.

For Pakistan the responses are qualitatively the same as those for India except for the effect on money is relatively strong in the latter quarters. For Bangladesh, the responses are also consistent. Supply shock has a negative effect on output and a positive effect on price; these effects are as expected. The substantial decline in output probably outweighs the increase in price and consequently interest rate shows a declining trend and money stock also declines.

The money supply shocks

Money supply equation is normalized on the interest rate. The dynamic effects of one standard deviation contractionary money supply shocks are summarized in row 3 of figures 5.7 through 5.9.

The rational expectations IS-LM predictions are captured well by the responses of India and Pakistan. The typical path of interest rate after the shock takes the form of an initial rise in interest rate followed by a gradual decline in that variable. Money stock and output decline. Low liquidity initially drives the output level down by about 5 basic points in India. The effects in Pakistan are, however, very weak. The response of price suggests that "price effect" dominates under this identification scheme. This is worth stressing, since in many countries evidence shows a positive impact on price. In Bangladesh, this shock has a positive effect on interest rate, a substantial negative impact on output, and a negative effect on money stock. These effects are as expected. The effect on price is weakly positive, but such an effect is not expected.

The opposite response of money and interest rate suggests that "liquidity effect" dominates under this identification scheme across all the three countries. This is also worth stressing, since in many countries evidence shows a positive correlation between money and interest rate responses. This statistical fact has been interpreted as evidence against the standard monetary transmission mechanism.

The money demand shocks

The dynamic effects of one standard deviation money demand shocks are summarized in row 4 of figures 5.7 through 5.9. As we would expect, money demand shock will produce responses, which are qualitatively the mirror image of responses derived from money supply. But since interest rate increases in both the cases, the effects of such shocks on real sector are similar. The rational expectations IS-LM predictions are captured well by the responses of India. For

Bangladesh and Pakistan the estimated price responses do not quite do that job here.

From the above discussion we see that responses are largely consistent with theory in Bangladesh and Pakistan, and strikingly consistent with theory in India. This scheme does not give rise to either the "price puzzle" or the "liquidity puzzle" in India. This scheme also does not give rise to the "liquidity puzzle" in Bangladesh, India and Pakistan. This suggests that these puzzles may be the result of contemporaneous identification strategy.

We summarize the results of the impulse responses for all the three identification schemes regarding their implications to the IS-LM theory as shown in table 5.21. It is clear from table 5.21 that identification scheme 3 produces theoretically plausible responses in most of the cases.

Table 5.21: Number of theoretically plausible responses under the three alternative identification schemes

Country	Scheme	Total responses	Theoretically plausible responses	Percentage of plausible responses
Bangladesh	1	16	12	75%
	2	16	11	68.75%
	3	16	13	81.25%
India	1	16	13	81.25%
	2	16	15	93.75%
	3	16	16	100%
Pakistan	1	16	12	75%
	2	16	9	56.25%
	3	16	15	93.75%

In summary, the previous three sections reveal that contribution of monetary policy to price and output movement depends on the contemporaneous identification strategy. Variance decompositions do not suggest a monocausal explanation of cyclical fluctuations. Neither the real business cycle view that focuses primarily on aggregate supply shock nor an extreme monetary view that focuses on monetary action is supported by variance decomposition. Results of variance decompositions under identification scheme 1 reveal that money's contribution in price variation is larger than output variation in all the three countries. Under identification scheme 3, supply shock is the principal source of variation in output in Bangladesh and India. Therefore, money can contribute more towards stabilizing price than stimulating real aggregate economic activity. It supports the view of real business cycle theorists. On the other hand, results of variance decompositions under identification scheme 2 seem to fit well with the traditional Keynesian view of business cycle fluctuations. Such a view tend to perceive money demand, money supply or IS shocks as the principal source of fluctuations in output. The differences in the results for the three countries may be due, in part, to their degree of openness, the policy goals of the respective governments, level of financial development (as discussed in chapter 2) and the structural conditions of the three economies.

From the visual evidences of impulse response functions, we observe that while adoption of one identification scheme produces puzzling dynamic effects, adoption of another scheme might help solve this problem. But one important finding common to all the three countries is that contractionary monetary policy has a negative impact on output. This is true of all the identification schemes adopted. The results of forecast error variance decompositions and impulse response functions discussed so far do not capture the relative importance of different variables in the post-financial liberalization period, which occurred in all the three countries during the early 90s. This issue is taken up in the next section.

5.6 Historical Decompositions

As all the three countries adopted neo-liberal prescriptions for financial reform at the beginning of 1990s, historical decompositions capture the character of the post liberalization period beginning from the first quarter of 1991. Taking the VAR estimates as given, we decompose the actual movement of the price level and real GDP into the following:

(a) the expected path or base projection, given information known in the 4th quarter of 1990. So "t" is set to the 4th quarter of 1990; and

(b) the unexpected movement attributable to shocks in interest rate, money, price level and real GDP.

Since identification scheme 3 produces theoretically consistent results in most of the cases, we use this structure to orthogonalize the shocks. Tables 5.22

through 5.27 and figures 5.10 through 5.15 display the results. It should be noted that the last four columns of each table give the sum of forecasted values plus effects of respective shocks. This addition makes the corresponding graphs more meaningful. The last two rows of each table represent: i) Root Mean Squared Errors (RMSE) of base projection, and base projection plus contribution of innovation to each variable; and ii) ratio of Root Mean Squared Errors (RMSE) of base projection plus contribution of innovation to each variable to Mean Squared Errors (RMSE) of base projection. These statistics are important because they help us rank the variables in explaining output and price in the post liberalization period. While considering the figures, we will focus on three types of visual evidence:

i) how well the base projection is able to track the general pattern of actual movement in price and output;

ii) how well innovation to a particular variable closes the gap between the base projection and the actual observation; and

iii) how far innovation to a particular variable helps reproduce the turning points in various sub periods.

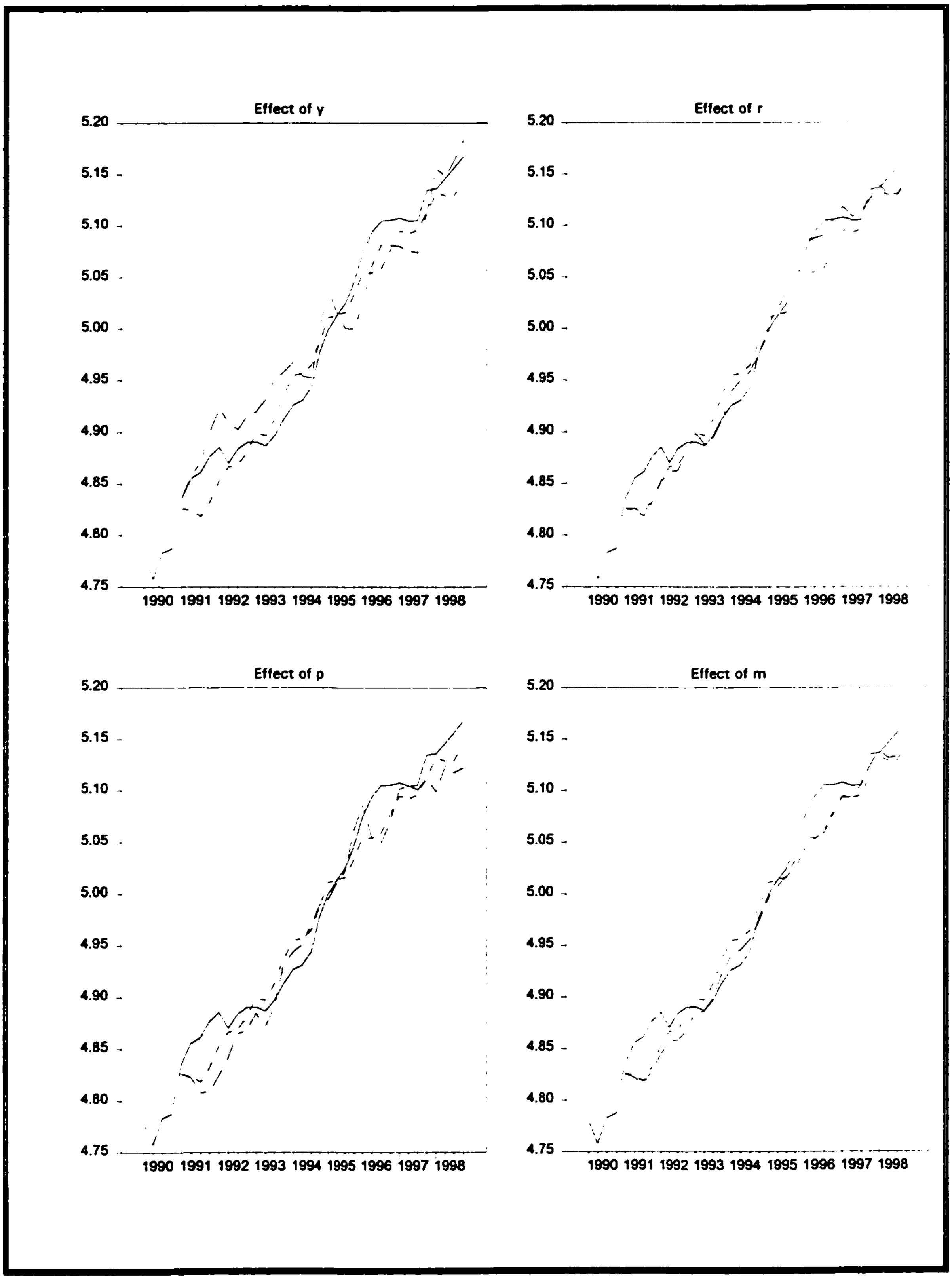
Table 5.22: Historical decomposition of output of Bangladesh

Entry	Actual	Base projection	Base projection plus accumulated effects of shocks in			
			y	p	r	m
1991:01	4.83541	4.825813	4.83541	4.825813	4.825813	4.825813
1991:02	4.85537	4.824064	4.857719	4.822362	4.825745	4.821737
1991:03	4.861307	4.818166	4.871611	4.807776	4.820414	4.816004
1991:04	4.876566	4.832156	4.900062	4.809538	4.835544	4.827891

1992:01	4.885302	4.85267	4.923144	4.824164	4.851665	4.84434
1992:02	4.870048	4.866488	4.909147	4.841727	4.861962	4.856677
1992:03	4.883747	4.868247	4.902528	4.864938	4.862805	4.858217
1992:04	4.890008	4.880811	4.916054	4.867961	4.880921	4.867505
1993:01	4.890355	4.899028	4.91999	4.884711	4.899071	4.883666
1993:02	4.886526	4.896624	4.931103	4.871483	4.88785	4.885961
1993:03	4.896722	4.912487	4.951325	4.889935	4.894761	4.898163
1993:04	4.912766	4.936791	4.958402	4.930848	4.912051	4.92184
1994:01	4.926471	4.955133	4.967947	4.943769	4.940273	4.939881
1994:02	4.930885	4.956585	4.954017	4.950788	4.950481	4.945353
1994:03	4.943306	4.96463	4.952668	4.970408	4.958663	4.955456
1994:04	4.977053	4.987363	5.000932	4.989405	4.97538	4.973426
1995:01	4.999361	5.011052	5.037254	4.994444	5.00446	4.996357
1995:02	5.012887	5.013284	5.01566	5.010078	5.019699	5.007301
1995:03	5.024961	5.01658	5.000379	5.02147	5.035591	5.017261
1995:04	5.045688	5.033543	5.0005	5.060858	5.059809	5.025149
1996:01	5.074519	5.054384	5.024304	5.086064	5.083839	5.043465
1996:02	5.093962	5.054583	5.060918	5.055927	5.087636	5.05323
1996:03	5.105042	5.058994	5.08196	5.049964	5.090758	5.05934
1996:04	5.105571	5.077057	5.081344	5.069026	5.106647	5.079724
1997:01	5.107864	5.094906	5.079697	5.101495	5.117759	5.093629
1997:02	5.104322	5.092644	5.075631	5.105181	5.108178	5.093263
1997:03	5.105476	5.09609	5.073947	5.10069	5.113852	5.105258
1997:04	5.134869	5.113915	5.115077	5.111341	5.125856	5.124339
1998:01	5.135937	5.132069	5.155744	5.099069	5.138715	5.138615
1998:02	5.146589	5.128761	5.147503	5.1249	5.129243	5.131225
1998:03	5.156285	5.12942	5.163278	5.117327	5.130632	5.133308
1998:04	5.168048	5.144676	5.184111	5.12271	5.146122	5.149134
Root Mean Squared Error (RMSE)		0.023069	0.029592	0.029779	0.017108	0.022917
RMSE of base projection plus effect of shock / RMSE of base projection			1.28276	1.290867	0.741601	0.993411

In the figures 5.10 through 5.15, the solid line represents the actual value, the small dashed line represents the expected path or baseline projection and the long dashed line represents the baseline projection plus the effects of shock.

Figure 5.10: Historical decomposition of output of Bangladesh



According to figure 5.10, we can divide the gap between actual output in Bangladesh and its baseline projection over the period 1991:1 to 1998:4 into three sub-periods: from 1991:1 to 1992:4 actual output is higher than projected output, from 1993:1 to 1995:1 actual output is lower than projected output and finally from 1995:2 onwards actual output is higher than projected output making the gap positive again.

Although output shock reproduces the turning points of output movement reasonably well, its performance in closing the gap between the base projection and actual observation is poor. In the first and second sub-period, the output shock actually pulls the output above the actual path. On the other hand, in the last sub-period output shock pulls the output below the expected path. The overall performance of output shock in closing the gap is reflected in the RMSE ratio, which is 1.28.

The price shock also plays virtually no role in closing the gap between the actual and projected output as seen from the left hand figure in the lower panel. In the first and last sub-period, the price shock actually pulls the output below the expected path. On the other hand, in the second sub-period price shock moderately helps close the gap. The overall performance of output shock in closing the gap is reflected in the RMSE ratio, which is 1.29.

The interest rate shock accounts for a remarkable portion of the unexpected run-up in the output. In the upper right panel of figure 5.10, at the beginning interest rate shock explains almost nothing of unexpected variation in output. But the line giving the path of the output that is obtained due to shock in interest rate is close to the path of the actually observed values from mid 1992. The lowest value of RMSE ratio, 0.74, among all the four ratios captures the fact and the interest rate shock also explains the turning points very well.

Finally, the money shock plays a good role in the second sub-period and a moderate role in the last sub period. But it can not explain some of the turning points. RMSE ratio for money shock is 0.99. A ranking of the variables in terms of relative importance in explaining output movement based on historical decomposition is {r, m, y and p}.

Figure 5.11 and table 5.23 document the effect of shocks to all the variables on the path of the price in the VAR system. Figure 5.11 shows the gap between the actual movement of price and its baseline projection is very close which leaves unexpected shocks with little to explain. We see that it is initially narrow, then the two lines are submerged in the year 1994 and finally the gap gets slightly larger.

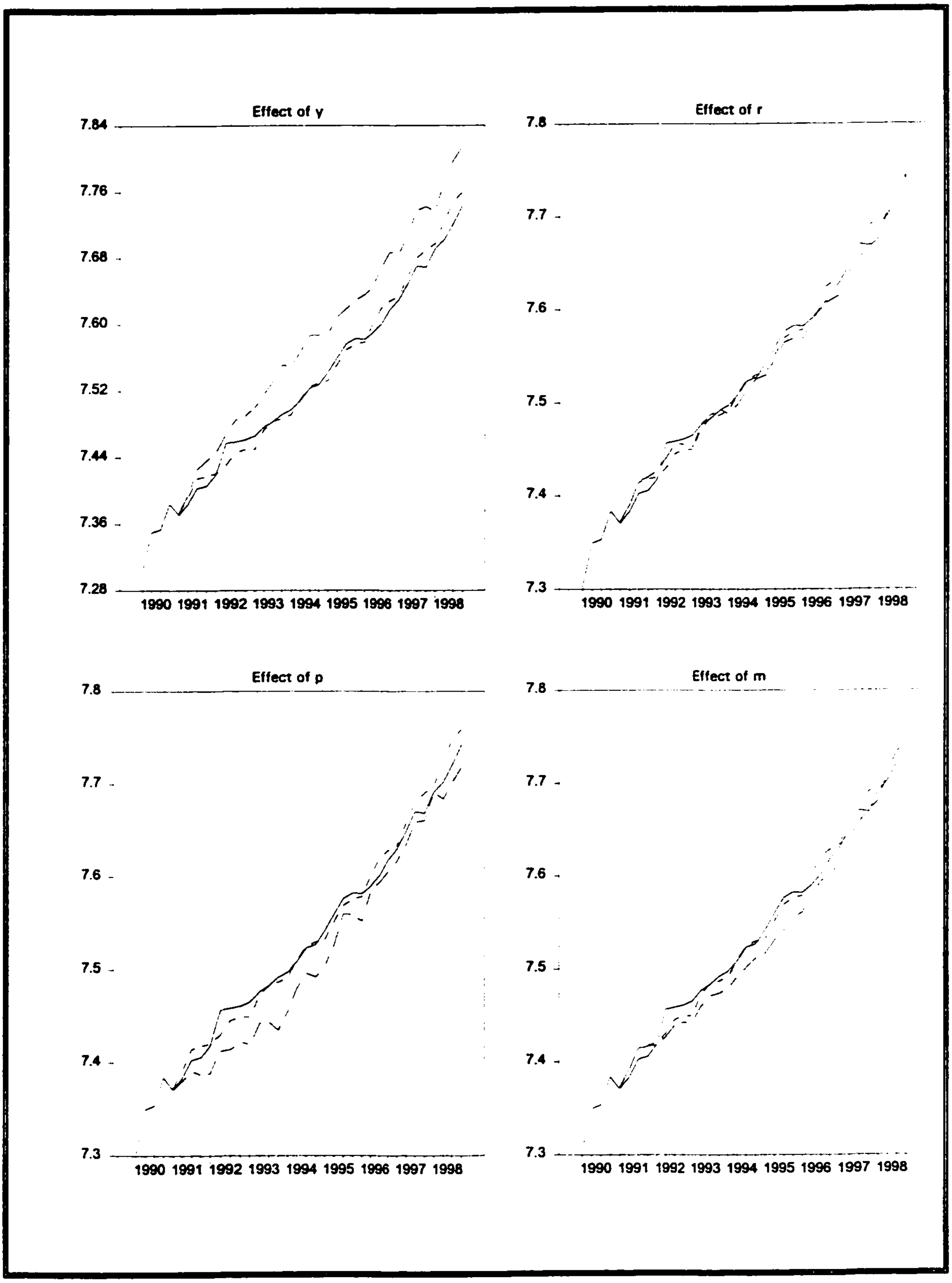
Table 5.23: Historical decomposition of price of Bangladesh

Entry	Actual	Base projection	Base projection plus accumulated effects of shocks in			
			y	p	r	m
1991:01	7.37086	7.372614	7.372614	7.37086	7.372614	7.372614
1991:02	7.383157	7.390613	7.393497	7.379765	7.390068	7.391668
1991:03	7.402452	7.414305	7.42577	7.39017	7.415737	7.413689
1991:04	7.405897	7.417866	7.436147	7.386374	7.420365	7.41661
1992:01	7.418379	7.420183	7.444914	7.388654	7.427331	7.418029
1992:02	7.456645	7.430232	7.467871	7.412026	7.440648	7.426797

1992:03	7.458567	7.445502	7.484885	7.414011	7.456729	7.439449
1992:04	7.46087	7.449537	7.489577	7.422397	7.454827	7.442682
1993:01	7.465272	7.779415	7.499868	7.418922	7.452297	7.442433
1993:02	7.476659	7.472907	7.515782	7.442404	7.477349	7.459845
1993:03	7.482868	7.483089	7.530856	7.443615	7.48665	7.471015
1993:04	7.491645	7.48668	7.550763	7.43497	7.492453	7.473501
1994:01	7.49739	7.49139	7.549247	7.454644	7.488315	7.479357
1994:02	7.508787	7.509695	7.567538	7.480101	7.498552	7.491679
1994:03	7.523481	7.525041	7.587279	7.496134	7.513428	7.501763
1994:04	7.527256	7.529941	7.587214	7.492142	7.52579	7.511932
1995:01	7.541858	7.531919	7.587895	7.503799	7.52942	7.516501
1995:02	7.559731	7.551681	7.608836	7.526869	7.547968	7.531101
1995:03	7.57661	7.569453	7.619036	7.559988	7.564503	7.541442
1995:04	7.582569	7.575923	7.629024	7.558793	7.569087	7.553435
1996:01	7.58172	7.578623	7.635711	7.55213	7.568532	7.561215
1996:02	7.590008	7.601113	7.645315	7.585009	7.585902	7.577122
1996:03	7.601232	7.620573	7.669806	7.594041	7.604521	7.594582
1996:04	7.617922	7.628168	7.687003	7.605426	7.609451	7.600547
1997:01	7.629811	7.633913	7.6859	7.616959	7.615639	7.613049
1997:02	7.649216	7.658508	7.707213	7.635343	7.641984	7.640199
1997:03	7.670116	7.680075	7.737479	7.6593	7.655688	7.657874
1997:04	7.668561	7.690168	7.742369	7.660476	7.666474	7.669745
1998:01	7.691502	7.697587	7.736191	7.69098	7.67624	7.680851
1998:02	7.701951	7.723952	7.771872	7.6838	7.707803	7.710331
1998:03	7.720311	7.747676	7.796862	7.701422	7.732018	7.733037
1998:04	7.742979	7.759492	7.81458	7.718246	7.745224	7.743405
Root Mean Squared Error (RMSE)		0.056788	0.051402	0.028452	0.009773	0.017538
RMSE of base projection plus effect of shock / RMSE of base projection			0.905156	0.501021	0.172096	0.308833

Although output shock reproduces the turning points of price movement reasonably well, its performance in closing the gap is the worst among all the four variables. The output shock actually pulls up the price above the expected path. This trend grows as we move forward. The overall performance of output shock in closing the gap is reflected in the RMSE ratio, which is 0.90.

Figure 5.11: Historical decomposition of price of Bangladesh



The price shock itself also plays virtually no role in closing the gap between the actual and the projected prices as seen from the left hand figure of the lower panel. In this case the picture is just the opposite of what we have seen in the case of the effect of output shock. The price shock actually pulls down the price below both the expected and actual paths. Moreover, the turning points are not captured well. The overall performance of price shock in closing the gap is reflected in the RMSE ratio, which is 0.50.

The interest rate shock again accounts for a remarkable portion of the unexpected run-up in the output as the lowest value of RMSE ratio, 0.17, captures the fact. In the upper right panel of figure 5.11, the line giving the path of the price that is obtained due to shock in interest rate is close to the actually observed path. The interest rate shock also explains the turning points very well.

Finally, the money shock plays no impressive role of the unexpected run-up of price. It also cannot explain some of the turning points. RMSE ratio for money shock is 0.30. A ranking of the variables in terms of relative importance in explaining price movement based upon historical decomposition is {r, m, p and y}.

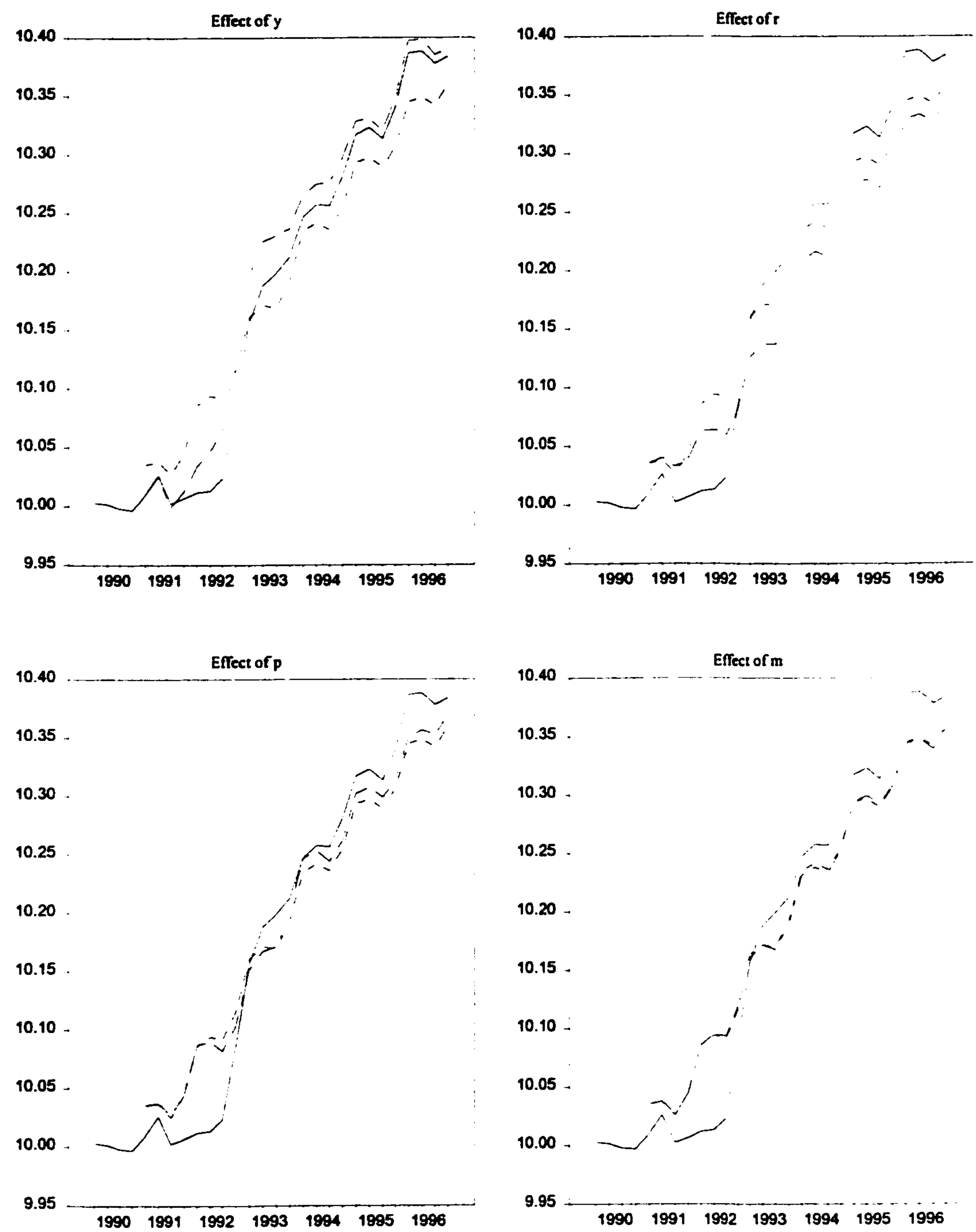
Figures 5.12, 5.13 and Tables 5.24, 5.25 represent historical decomposition of output and price during the period of financial liberalization of India. The last two rows of tables 5.24 and 5.25 give the summary measures.

Table 5.24: Historical decomposition of output of India

Entry	Actual	Base projection	Base projection plus accumulated effects of shocks in			
			y	p	r	m
1991:01	10.00972	10.03545	10.00972	10.03545	10.03545	10.03545
1991:02	10.02634	10.03816	10.02565	10.03719	10.04028	10.03769
1991:03	10.00244	10.02685	9.999525	10.02496	10.03247	10.02604
1991:04	10.00674	10.04526	10.01279	10.04446	10.04005	10.04523
1992:01	10.01195	10.08587	10.03376	10.08694	10.06245	10.08641
1992:02	10.01347	10.09403	10.04708	10.08976	10.06394	10.09478
1992:03	10.02367	10.09163	10.06378	10.08202	10.05948	10.09329
1992:04	10.08527	10.11554	10.12911	10.10291	10.08127	10.11862
1993:01	10.15615	10.16073	10.1969	10.15145	10.12646	10.16353
1993:02	10.18791	10.17125	10.22576	10.16717	10.13712	10.1716
1993:03	10.19936	10.16945	10.23176	10.17163	10.13694	10.16738
1993:04	10.21278	10.19219	10.23725	10.19963	10.16303	10.18943
1994:01	10.24714	10.23476	10.26563	10.24645	10.20778	10.23155
1994:02	10.25748	10.24179	10.27513	10.25344	10.21638	10.23791
1994:03	10.25673	10.23604	10.27609	10.24426	10.21189	10.23262
1994:04	10.2813	10.25475	10.29763	10.262	10.23287	10.25306
1995:01	10.31729	10.29362	10.32852	10.30224	10.27365	10.29374
1995:02	10.32331	10.29756	10.33084	10.3078	10.2779	10.29943
1995:03	10.31383	10.28948	10.32042	10.29933	10.27061	10.29191
1995:04	10.33988	10.30671	10.34834	10.31407	10.28984	10.30775
1996:01	10.38698	10.34492	10.39756	10.35077	10.32948	10.34393
1996:02	10.38818	10.34894	10.39828	10.3565	10.33317	10.34707
1996:03	10.37797	10.34156	10.38544	10.35247	10.32569	10.33904
1996:04	10.38389	10.35989	10.3905	10.36985	10.34638	10.35683
Root Mean Squared Error (RMSE)		0.036313	0.022201	0.031829	0.043541	0.03723
RMSE of base projection plus effect of shock / RMSE of base projection			0.611384	0.876516	1.199056	1.025258

According to figure 5.12, we can divide the gap between actual output in India and its baseline projection over the period 1991:1 to 1996:4 into two sub periods: from 1991:1 to 1993:2 when the actual output is lower than the projected output, from 1993:3 to 1996:4 when the actual output is higher than the projected output.

Figure 5.12: Historical decomposition of output of India



Upper right hand chart shows the contribution of output shock in the movement of output along with the base projection and actual value. In the first sub period, the real GDP shock explains a fair amount of unexpected movement in output. If we look at the second sub period, we see initially that the output shock pulls up output above the actual path. In the end of the period output shock has a good explanatory power. RMSE ratio for this shock is 0.61, which is the lowest among the four recorded for output.

The price shock plays a modest role in closing the gap between the actual and projected outputs as seen from the left hand chart of the lower panel. In the first sub-period, the price shock virtually plays no role. In the second sub-period price shock, however, helps close the gap between the actual and projected path to some extent. Some turning points are captured well. The overall performance of price shock in closing the gap as described by RMSE ratio is 0.87.

The interest rate shock accounts for nothing of the unexpected run-up in the output. In the upper right panel of figure 5.12, from the beginning to the end, interest rate shock explains nothing of unexpected variation in output. Rather it helps widen the gap. The highest value of RMSE ratio, 1.19, is recorded for output.

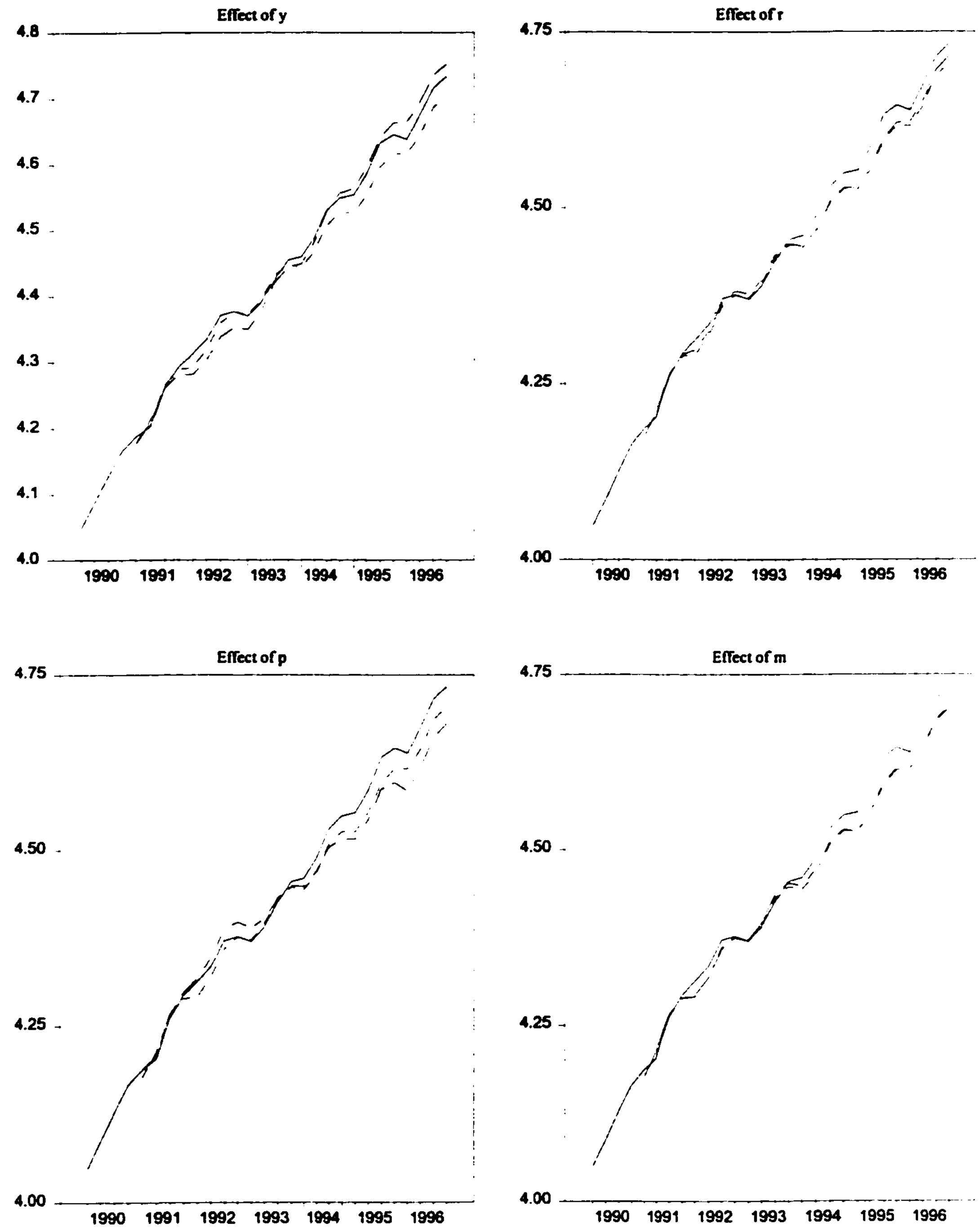
Money shock plays no role in any of the sub-periods. RMSE ratio for money shock is 1.02. A ranking of the variables in terms of relative importance in explaining output movement in India based upon historical decomposition is {y, p, m and r}.

Table 5.25: Historical decomposition of price of India

Entry	Actual	Base projection	Base projection plus accumulated effects of shocks in			
			y	p	r	m
1991:01	4.187076	4.176424	4.176424	4.187076	4.176424	4.176424
1991:02	4.203498	4.21339	4.210524	4.206799	4.212722	4.213624
1991:03	4.261975	4.264161	4.260041	4.266926	4.262759	4.264734
1991:04	4.293605	4.289332	4.282468	4.297966	4.291868	4.289298
1992:01	4.312811	4.291676	4.281061	4.318009	4.298087	4.29068
1992:02	4.334411	4.319117	4.302671	4.34611	4.324993	4.317989
1992:03	4.370839	4.359652	4.338209	4.388448	4.364903	4.358237
1992:04	4.37626	4.376053	4.351948	4.396952	4.381455	4.374064
1993:01	4.369448	4.371494	4.349063	4.388347	4.376491	4.370027
1993:02	4.389871	4.394133	4.375912	4.402401	4.398546	4.395411
1993:03	4.425685	4.431744	4.420364	4.429172	4.435223	4.436159
1993:04	4.455161	4.447174	4.444849	4.449766	4.449592	4.452475
1994:01	4.46026	4.443328	4.449301	4.447673	4.445265	4.448004
1994:02	4.488749	4.467918	4.481405	4.469448	4.469525	4.472123
1994:03	4.530662	4.508265	4.529921	4.503999	4.509826	4.511709
1994:04	4.549235	4.526827	4.556781	4.516285	4.528188	4.528463
1995:01	4.553772	4.526123	4.56315	4.515443	4.527909	4.525638
1995:02	4.585376	4.553536	4.595212	4.543159	4.556355	4.551258
1995:03	4.633077	4.596156	4.64108	4.587499	4.599938	4.593028
1995:04	4.645736	4.616318	4.662947	4.596667	4.620892	4.614185
1996:01	4.638315	4.616494	4.664422	4.585117	4.622389	4.615867
1996:02	4.67451	4.644098	4.693072	4.618453	4.651858	4.643421
1996:03	4.715279	4.686316	4.734731	4.659793	4.69562	4.684084
1996:04	4.733651	4.705621	4.752145	4.681032	4.715701	4.701637
Root Mean Squared Error (RMSE)		0.02033	0.017356	0.027039	0.017066	0.02097
RMSE of base projection plus effect of shock / RMSE of base projection			0.853723	1.329991	0.839448	1.031471

According to figure 5.13, the gap between actual price in India and its baseline projection over the period 1991:1 to 1996:4 is very close; the difference between the actual and the projected value is even almost zero in some periods.

Figure 5.13: Historical decomposition of price of India



Upper left hand chart shows the contribution of output shock to the movement of price along with its baseline projection and the actual value. Initially the real GDP shock has no role in unexpected movement in price. Gradually it contributes a moderate amount. But in the end it pulls up price above the actual path. RMSE ratio for this shock is 0.85.

The price shock plays absolutely no role in closing the gap between the actual and projected prices as seen from the left hand chart of the lower panel. The overall performance of price shock in closing the gap in terms of RMSE ratio is 1.32.

The interest rate shock accounts for a small amount of the unexpected run-up in the price. In the upper right panel of figure 5.13, from the beginning to the end interest rate shock explains almost nothing of unexpected variation in price. Overall performance of price shock in closing the gap in terms of RMSE ratio is 0.83. RMSE ratio for money shock is 1.03. A ranking of the variables in terms of relative importance in explaining price movement in India based upon historical decomposition is {r, y, m and p}.

The results of historical decomposition of output and price in Pakistan are presented in figures 5.14 and 5.15 and are summarized in tables 5.26 and 5.27.

Table 5.26: Historical decomposition of output of Pakistan

Entry	Actual	Base projection	Base projection plus accumulated effects of shocks in			
			y	p	r	m
1991:01	8.239394	8.255774	8.239394	8.255774	8.255774	8.255774
1991:02	8.248043	8.271046	8.234114	8.282541	8.273444	8.271082

1991:03	8.272094	8.27832	8.229014	8.320498	8.280001	8.277542
1991:04	8.29967	8.302204	8.251305	8.347486	8.305481	8.30201
1992:01	8.331171	8.329587	8.315052	8.343304	8.333838	8.327738
1992:02	8.343886	8.336751	8.328435	8.348052	8.340863	8.336789
1992:03	8.346691	8.335528	8.316049	8.361306	8.338032	8.337888
1992:04	8.352794	8.336533	8.326004	8.361863	8.339555	8.33497
1993:01	8.35502	8.346347	8.338637	8.361714	8.35339	8.340321
1993:02	8.343606	8.351643	8.361822	8.334594	8.359774	8.342344
1993:03	8.342108	8.355297	8.370767	8.326865	8.366659	8.343709
1993:04	8.36255	8.372414	8.36018	8.371328	8.389095	8.35919
1994:01	8.384956	8.397378	8.346439	8.422508	8.417816	8.390329
1994:02	8.385869	8.409087	8.361941	8.435128	8.413561	8.402499
1994:03	8.395589	8.410772	8.370077	8.432845	8.423304	8.401678
1994:04	8.406068	8.429728	8.407975	8.435314	8.436645	8.415317
1995:01	8.427547	8.456371	8.440052	8.459626	8.4518	8.445182
1995:02	8.458796	8.463253	8.437209	8.492996	8.464715	8.453635
1995:03	8.462388	8.454702	8.416294	8.502146	8.459178	8.448874
1995:04	8.474559	8.462881	8.457639	8.477107	8.47238	8.456075
1996:01	8.489435	8.481431	8.502178	8.471203	8.483058	8.477288
1996:02	8.502805	8.487572	8.510746	8.480125	8.491494	8.483158
1996:03	8.504537	8.485642	8.509892	8.486084	8.487146	8.478342
1996:04	8.494908	8.502777	8.496369	8.50656	8.503076	8.497233
1997:01	8.47824	8.527378	8.485055	8.540209	8.514415	8.520695
1997:02	8.477868	8.53744	8.465754	8.566589	8.526736	8.531108
1997:03	8.499075	8.537253	8.468297	8.585052	8.525995	8.53149
1997:04	8.522981	8.554517	8.491557	8.61175	8.533506	8.54972
Root Mean Squared Error (RMSE)		0.021841	0.023979	0.040159	0.020793	0.01931
RMSE of base projection plus effect of shock / RMSE of base projection			1.097891	1.838706	0.952032	0.884143

According to figure 5.14, we can divide the gap between actual output in Pakistan and its baseline projection over the period 1991:1 to 1997:4 into as many as five sub-periods: actual output is lower than projected output from 1991:1-1992:2, 1993:3-1995:3 and 1996:4-1997:4; actual output is higher than projected output from 1992:3-1993:2 and 1995:4-1996:3.

Figure 5.14: Historical decomposition of output of Pakistan

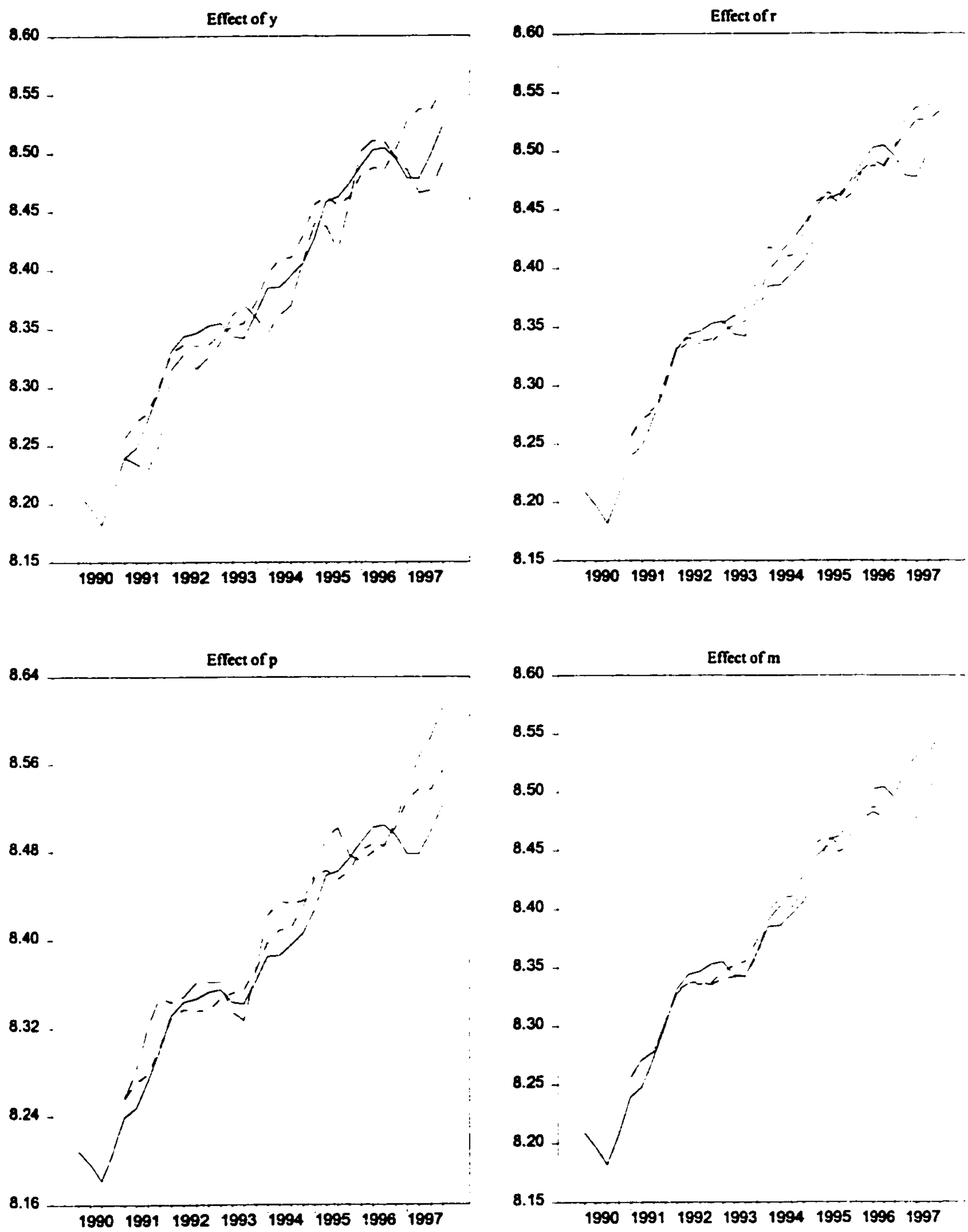


Figure 5.14 indicates that most of the movement in output above the baseline forecast represents a response to an unexpected increase in money stock.

The output shock and price shock account for virtually nothing of the unexpected movement in the output in the post liberalization period. Interestingly, the price shock actually pulls up the output above the expected path with the real GDP shock pulling down the output below the actual path. Interest rate shock plays a very moderate role in the beginning and in the end in explaining unexpected movement in output. A ranking of the variables in terms of relative importance in explaining output movement in Pakistan based upon historical decomposition is { m, r, p and y}.

Table 5.27: Historical decomposition of price of Pakistan

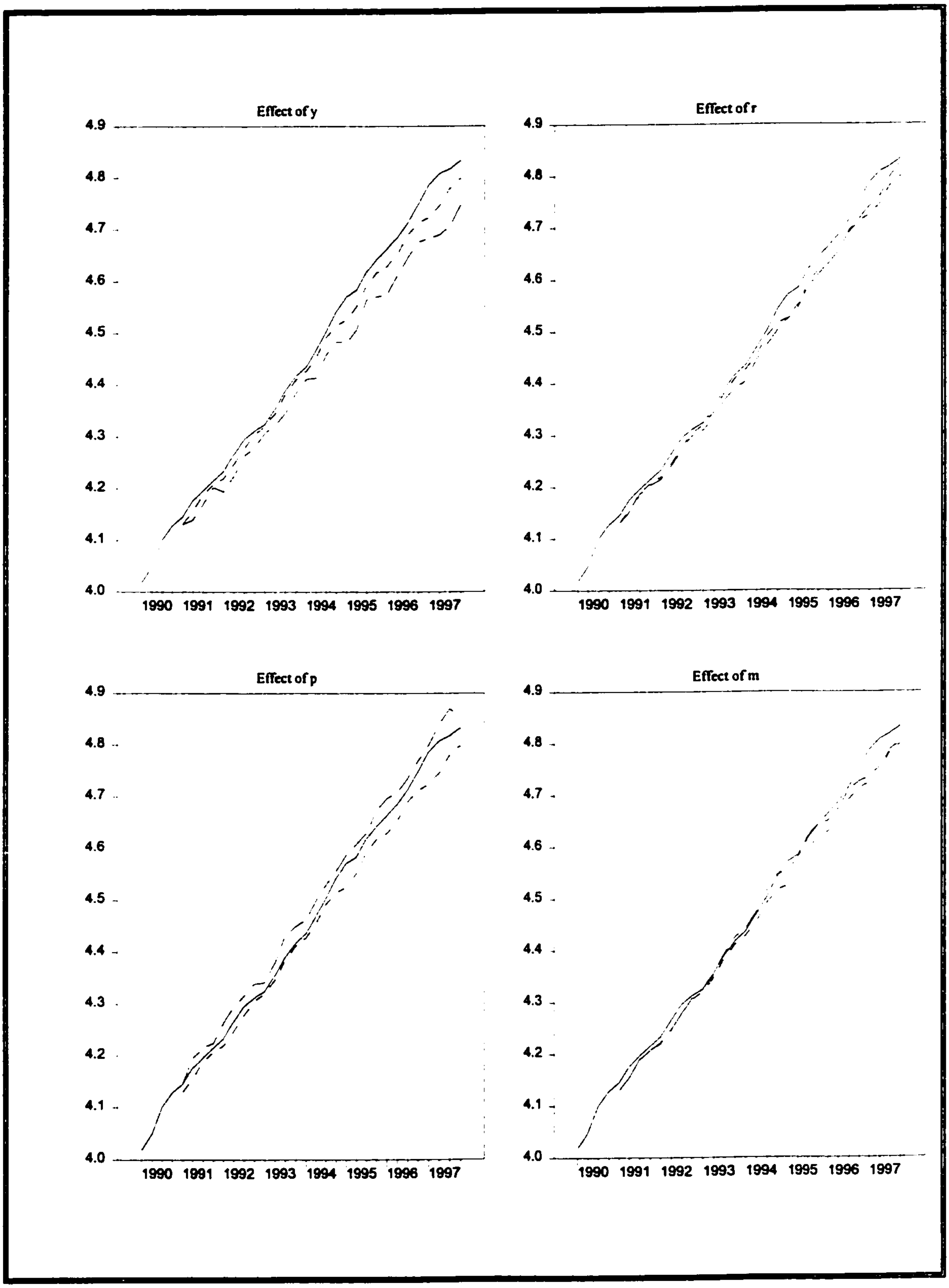
Entry	Actual	Base projection	Base projection plus accumulated effects of shocks in			
			y	p	r	m
1991:01	4.145513	4.130051	4.130051	4.145513	4.130051	4.130051
1991:02	4.176846	4.15559	4.139433	4.195526	4.153098	4.155557
1991:03	4.19645	4.18864	4.169591	4.216747	4.186665	4.189367
1991:04	4.215677	4.207377	4.202412	4.224453	4.203836	4.207108
1992:01	4.233382	4.219568	4.193083	4.262881	4.214861	4.22126
1992:02	4.265633	4.246403	4.223646	4.292633	4.241521	4.247042
1992:03	4.295788	4.277871	4.263388	4.315355	4.274094	4.276564
1992:04	4.311738	4.303871	4.27944	4.338559	4.299209	4.306143
1993:01	4.324398	4.319725	4.306977	4.340993	4.310634	4.324969
1993:02	4.354527	4.345023	4.323997	4.378806	4.334529	4.352265
1993:03	4.389995	4.381835	4.345454	4.430673	4.368083	4.391289
1993:04	4.417273	4.410693	4.384015	4.448972	4.391411	4.424955
1994:01	4.43616	4.427863	4.411982	4.462406	4.404069	4.441293
1994:02	4.469465	4.453897	4.414165	4.499386	4.445468	4.472136
1994:03	4.502916	4.492042	4.458736	4.528741	4.475498	4.516067
1994:04	4.543401	4.515455	4.48413	4.556746	4.50275	4.546139
1995:01	4.571717	4.526801	4.483634	4.587906	4.525459	4.55512
1995:02	4.584355	4.552385	4.507082	4.608685	4.546165	4.579578
1995:03	4.620059	4.593158	4.566216	4.6302	4.586277	4.616841

1995:04	4.643044	4.617919	4.571014	4.674493	4.608832	4.642461
1996:01	4.663911	4.629627	4.575308	4.696846	4.630177	4.65046
1996:02	4.686013	4.653368	4.612344	4.708747	4.652898	4.672126
1996:03	4.714383	4.690577	4.647928	4.736053	4.692969	4.709163
1996:04	4.749184	4.712502	4.675985	4.768963	4.716177	4.725565
1997:01	4.786158	4.723726	4.682928	4.799304	4.74018	4.734923
1997:02	4.808111	4.746057	4.690208	4.840517	4.760932	4.754625
1997:03	4.81794	4.780543	4.705888	4.870138	4.796651	4.786891
1997:04	4.833659	4.799067	4.748049	4.852967	4.826315	4.803529
Root Mean Squared Error (RMSE)		0.028087	0.061801	0.02551	0.028585	0.01947
RMSE of base projection plus effect of shock / RMSE of base projection			2.200349	0.908268	1.017735	0.693223

According to figure 5.15, the gap between actual price in Pakistan and its baseline projection is always positive over the entire period from1991:1 to 1997:4. From figure 5.15, we note that the base projection plus *m* shock generates a series that is consistently closer to the actual series than baseline projection alone. So *m* plays the most important role in unexpected movement in price in Pakistan. The other three shocks play a very little role in explaining price.

The output shock is pulling down price below the expected path while price shock is pushing up price above actual path. Interest rate shock on the other hand, is very close to the expected path and therefore contributes almost nothing. A ranking of the variables in terms of relative importance in explaining price movement in Pakistan based upon historical decomposition is { m, p, r and y}.

Figure 5.15: Historical decomposition of price of Pakistan



In summary, this section discusses the behavior of key variables in response to different shocks and emphasizes the behavior of prices and output in light of the historical decomposition technique in the post financial liberalization era. Analyses of historical decomposition show that monetary policy plays a leading role in determining price in all the three countries after they adopted neo-liberal prescriptions for financial reform in the beginning of 1990s. Interest rate plays a major role in output determination in both Bangladesh and Pakistan while it does not play any role in India even in the post liberalization period.

5.7 Sensitivity Analysis

Some economists consider the VAR evidence on business cycle dynamics rather controversial. They consider the results from estimated VARs are not robust. The results may change substantially due to a simple modification of the model. Stephen King (1983), David Runkle (1987) and David Spencer (1989) are among them. They speculated that the sensitivity of VAR evidence could be widespread. But Sims (1987, 1989) rejected that speculation and stood by the usefulness of VAR model.

According to Runkle (1987, p. 437), the confidence interval for the variance decompositions and impulse response functions are often so large that little useful inference can be based on them. According to Spencer (1989) these estimates frequently vary around 30%, and occasionally around 40%. Sims

(1989) rebuted this allegation by arguing that VARs are not the same type of model where the model under consideration is more or less stable and testing at a fixed significance level facilitates communications. The number of parameters estimated in a VAR model is much larger and most of the coefficients are not significantly different from zero when tested at the 5% level. These insignificant coefficients are not set to 0. Moreover, qualitative pattern of the VAR results are quite robust. Blanchard (1987) described the large confidence interval as God's will and added that one should not expect miracles. Considering all these tangles, this study takes a naive approach to determine whether a particular identification scheme or a particular series is sensitive. In this section, we reexamine the VAR results reported in the previous sections using a set of apparently innocent arbitrary modifications of the VAR model. By innocent modification we mean there is no strong economic or statistical arguments behind those modifications. We consider those results as robust, which are at least qualitatively insensitive to those modifications. A result is qualitatively insensitive if i) impulse responses are almost similar to those of sections 5.3, 5.4 and 5.5 under alternative modifications; and ii) historical decomposition gives the same ranking of the variables as described in section 5.6 under alternative modifications. We apply the following two modifications:

1. Different lag length: Since economic theory does not pin down the specific lag length for VAR, varying lag length is appropriate for testing

sensitivity of a model provided that the modified lag length is not implausible on statistical grounds. We add one more lag to the original lag length for each one of the three SAARC countries and test for sensitivity.

2. Different sample period: We reduce the sample period by four quarters for each country.

Sims has objected to the use of linear trend even though they are statistically significant. Sims (1987) argued that because the responses of both money and output to surprise movement in interest rates are low frequency phenomena, adding a low frequency variable with no clear economic interpretation, such as linear trend just adds uncertainty to the estimation of long run effects. This is why this study does not use linear trend as a modification.

First of all we examined the behavior of impulse response functions under alternative identification schemes when lag length and sample size are modified and compared the direction and overall profile of these functions with the responses derived in sections 5.3, 5.4 and 5.5. We found that all the responses of Bangladesh and India are similar under all the three identification schemes when sample size is modified. For Pakistan, one response in scheme 2 and one response in scheme 3 were found to be somewhat sensitive.

When lag length is modified, we found three responses (1 for India and 2 for Pakistan) were sensitive under identification scheme 1, three responses (1 for India and 2 for Pakistan) were found to be sensitive under identification scheme 2, and again three responses (one for each country) were sensitive under identification scheme 3[21].

Interestingly almost all the results of the historical decompositions are robust. Tables 5.28 and 5.29 show the RMSE of historical decomposition of output and price under lag length modification and sample size modification.

For Bangladesh, a ranking of the variables in terms of relative importance in explaining output movement based upon historical decomposition is {r, m, y and p} when both lag length and sample size are modified. This ranking is exactly the same as the ranking cited in section 5.6. A ranking of the variables in terms of relative importance in explaining price movement based upon historical decomposition is {r, m, p and y} under alternative modifications. This ranking is also exactly the same as the ranking cited in section 5.6. Thus we can conclude that the results of the historical decomposition are robust for Bangladesh.

For India, a ranking of the variables in terms of relative importance in explaining output movement based upon historical decomposition is {y, p, m, r} when both lag length and sample size are modified. This ranking is exactly the same as the ranking cited in section 5.6. Thus this result of the historical decomposition is robust for India. But ranking of the variables in terms of relative importance in explaining price movement based upon historical decomposition is {y, r, m, p} when lag length is modified. A ranking of the

[21] The responses are not reported here but are available from the author on request.

variables in terms of relative importance in explaining price movement based upon historical decomposition is {y, m, r, p} when sample size is modified. So this part of the result is not robust.

Table 5.28: RMSE of historical decomposition of output under alternative modifications of VAR model

	Nature of modification	RMSE of Forecast	RMSE of Forecast plus accumulated effects of shocks in			
			y	p	r	m
Bangladesh	Lag length	0.022446	0.027539	0.031205	0.017866	0.022451
	Sample size	0.023356	0.030429	0.032193	0.018291	0.021592
India	Lag length	0.033288	0.01787	0.031118	0.037196	0.033474
	Sample size	0.035746	0.0233	0.029451	0.045814	0.035101
Pakistan	Lag length	0.017764	0.028831	0.033068	0.017405	0.015355
	Sample size	0.021252	0.021025	0.037066	0.019729	0.01894

Table 5.29: RMSE of historical decomposition of price under alternative modifications of VAR model

	Nature of modification	RMSE of Forecast	RMSE of Forecast plus accumulated effects of shocks in			
			y	p	r	m
Bangladesh	Lag length	0.008664	0.037683	0.022803	0.010665	0.019309
	Sample size	0.01128	0.045414	0.019227	0.008368	0.010092
India	Lag length	0.016007	0.012049	0.019929	0.013207	0.01758
	Sample size	0.020465	0.01628	0.032755	0.019185	0.018851
Pakistan	Lag length	0.021957	0.047649	0.017843	0.029894	0.015167
	Sample size	0.024166	0.052335	0.019076	0.024064	0.017596

For Pakistan, a ranking of the variables in terms of relative importance in explaining output movement based upon historical decomposition is {m, r, y and p} when both lag length and sample size are modified. This ranking is exactly the same as the ranking cited in section 5.6. A ranking of the variables in terms of relative importance in explaining price movement based upon historical decomposition is {m, p, r and y} under alternative modifications. This ranking is exactly the same as the ranking cited in section 5.6. So we can conclude that the results of the historical decomposition are robust for Pakistan.

Thus we observe that sensitivity of VAR results can be appraised not only for the recursive identification scheme but also to the nonrecursive identification schemes. But most of the results are robust. Very few estimates of one variable's role in the determination of another are not robust. So this study finds support for Sims on the robustness of the results of a model most often compared to his critics.

Chapter 6

Summary and Policy Considerations

The main purpose of this study has been to investigate the dynamic interactions among key aggregate macro variables in three South Asian Association for Regional Cooperation countries, namely, Bangladesh, India, and Pakistan. A related purpose has been to examine how well the dynamic properties of the estimated models of the three developing countries match with the theoretical predictions of IS-LM model. It should be noted that the IS-LM model has a substantial influence on policy makers and academicians. Another objective has been to determine the role of key variables in the post financial liberalization era of the three countries. These are accomplished in three different ways: i) by conducting bivariate, multivariate and block causality tests; ii) by estimating variance decompositions and impulse response functions under the recursive and the non-recursive identification schemes; and iii) by applying historical decomposition technique. The serious problem in conducting empirical study on developing countries like Bangladesh, India and Pakistan is the quality and availability of data. For that reason, one must be careful in drawing important conclusions and use the results for implementing policy measures.

Causality tests suggest that interest rate, though controversial in developing countries, deserves to be a good policy variable in Bangladesh and Pakistan while money deserves to be a good policy variable in India. A bi-directional causality exists between money and prices in Bangladesh and Pakistan. The policy implication of such a result is that an increase in money stock fuels prices in Bangladesh and Pakistan, which in turn leads to an increase in money stock. It supports the view of real business cycle theorists who postulate that monetary changes only affect prices.

Multivariate causality tests suggest that interest rate and money do cause output in Bangladesh at the 6% and 7% levels of significance. So monetary policy plays a role in output determination in Bangladesh. But this is not the case in other the two countries. Block causality tests for Bangladesh also indicate that non-policy variables do get feedback from policy variables. Interest rate and money as a block cause output and price but output and price do not cause interest rate and money. The situation, however, is reversed for India and Pakistan. We can succinctly sum up the evidence from causality tests: The role of monetary policy is less ambiguous in Bangladesh compared to Pakistan and India.

Recursive identification scheme puts interest rate first in order to allow it the maximum opportunity to influence the other variables in the system. Results of the variance decompositions under recursive identification scheme suggest that money innovation is not the prime mover of price in any of the countries either in the short to medium time horizon or in the medium to long time horizon. The role of interest rate in output determination is larger than money's role in all the three countries. This finding does not fit well with the extreme monetarists view, viz., that money stock alone is a complete measure of the stance of monetary policy. However, it is consistent with the broader view that monetary policy is important in generating business cycles. Impulse response functions indicate that the "price puzzle" seems to be a universal phenomenon under the recursive identification scheme as it has been observed in all the three countries. If the model is intended to be useful for policy decision, the "price puzzle" is indeed troublesome because it implies that monetary policy must expand the money stock in order to lower inflation. We do not see money demand and money supply shocks in this identification scheme. A rational expectation monetarist will treat innovation to money as monetary policy shocks while many other economists would rather treat interest rate as a policy variable. Identification schemes 2 and 3 overcome this drawback.

Identification scheme 2 suggests that price equation connects output innovations with price innovations and no other innovations can influence it contemporaneously. The money demand equation allows money innovations to depend on innovations in all the remaining variables in the model. The money supply equation allows money innovations to depend on innovations in interest rate alone. The output equation allows output innovations to depend on innovations in interest rate. Money stock feeds back into real output via the interest rate channel.

Under the identification scheme 2, variance decompositions reveal that contributions of money supply shock to variation in output at the end of 20-quarter forecast time horizon are 27%, 14% and 38% in Bangladesh, India and Pakistan respectively. Contributions of money demand shock to variation in output at the end of 20-quarter forecast time horizon are 9%, 5% and 9.5% in Bangladesh, India and Pakistan respectively. A money supply shock has a smaller affect on price movement in India and Bangladesh but a relatively larger affect in Pakistan. Money demand contributes 15%, 12% and 10% of price movement in the 20-quarter forecast time horizon in Bangladesh, India and Pakistan respectively. IS shock is the principal source of fluctuations in output in all the three countries and is also the principal source of price movement in Bangladesh and Pakistan. Role of money in output determination is either low or almost negligible under this identification scheme. The response of price suggests that "price puzzle" dominates under this identification scheme in all the three countries. So this model is not much useful for policy prescriptions.

Identification scheme 3 postulates that the output equation allows output innovations to depend on innovations in price, interest rate and money. Price equation is autonomous and no other innovations but price innovations can influence it contemporaneously. The money supply equation allows money innovations to depend on innovations in interest rate alone. The money demand equation allows money innovations to depend on innovations in interest rate, price and output with the latter two having symmetric effects.

For Bangladesh supply shock explains most of the output variability not only in the short run but also in the long run. For India, money demand is the dominant force across all horizons in output movement while for Pakistan the long run effect of money demand on output is stronger. The contribution of money supply shock to price movement is negligible in Bangladesh. Innovations in money demand take five quarters to have an effect but quickly become the prime mover of price in Bangladesh. For India and Pakistan the effects are very low. The results seem fit well in the case India and Pakistan to traditional Keynesian view of business cycle fluctuations. Such a view tends to perceive money demand, money supply or IS shocks as the principal source of fluctuations in output when we constrain the supply factors such as technological shift and population growth. In contrast with that view, the estimates for Bangladesh suggest that supply shock, which is normalized with price, is the most important source of output variability.

We find that identification scheme 3 produces the impulse responses, which are largely consistent with theory in Bangladesh and Pakistan, and strikingly consistent with theory in India. This scheme does not give rise either to the "price puzzle" or the "liquidity puzzle" in India. This suggests that these puzzles may result from the identification strategy. So the policy maker should give expected importance to this scheme while considering policy prescriptions.

Several broad pictures emerge from a synopsis of the three identification schemes discussed:

(1) Variance decompositions do not suggest a monocausal explanation of cyclical fluctuations. Neither the real business cycle view that focuses primarily on aggregate supply shock nor an extreme monetary view that focuses on monetary action is supported by variance decomposition.

(2) Within the economy, technical considerations like adoption of identification strategy might help solve puzzling dynamic effects. Contribution of monetary policy in price and output movement depends on the identification strategy. While adoption of certain identification schemes, schemes 1 & 2 in the present study, produce puzzling dynamic effects, adoption of another scheme, scheme 3, might help solve this problem.

(3) Contractionary monetary policy has a negative impact on output in all the three countries. This is true for all the identification schemes adopted. This finding has a significant policy implication. The policy maker should be aware of the potential consequences of a restrictive policy while one of the main objectives of central bank is to achieve economic growth. Such a

policy can be adopted only if long run benefits of monetary contraction overwhelmingly outweigh cost of output loss.

(4) Among the three countries studied, economy-specific factors are important in explaining the differences in the results. The differences in the results for the three countries may be due, in part, to their degree of openness, the policy goals of the respective governments, levels of financial development and the structural conditions.

Historical Decomposition discusses the behavior of key variables in response to different shocks and emphasizes the behavior of prices and output in the post financial liberalization period. Analysis of historical decompositions show that monetary policy plays a leading role in determining price in all the three countries after they have adopted neo-liberal prescriptions for financial reform at the beginning of 1990s. Interest rate plays a major role in output determination in both Bangladesh and Pakistan while it plays no role in output determination in India even in the post liberalization period. Therefore, Indian economy, which is relatively less open and more controlled compared to the other two economies should be more market leaning.

Sensitivity analysis demonstrates that VAR results are not only sensitive to recursive identification scheme but also to the non-recursive identification schemes. But most of the results are robust. Accordingly, this study finds most support to Sims side. Almost all the results of historical decompositions are, however, robust.

The four variable simple VAR models we developed in this study may suffer from a number of shortcomings. Therefore, some venues for future research may be considered. They are as follows:

(1) This study uses quarterly time series data, which may mask some important dynamic aspects of the short run behavior of output and prices. An analysis based on monthly data should certainly be more enriching. But availability of monthly data for these countries would continue to be a major stumbling block at least in the foreseeable future. An important driving force of future research in time series analysis is the advance in high-volume data acquisition. Examples are: transaction-by-transaction data common to financial markets or communications networks, and in e-commerce on the internet. These data will be available in future and must be processed properly and efficiently. But the special features of the data, such as large sample sizes, heavy tails, unequally spaced observations, and mixtures of multivariate discrete and continuous variables, can easily render existing methods inadequate. Analyses of these types of data will certainly influence the directions of future research.

(2) This study uses a common framework to examine the effects of monetary policy among the three countries. The models have been estimated

independently for all the three countries. We have three different equations for predicting the same variable. Perhaps this has to be looked into in future research by using suitable panel data methods.

(3) This study can be extended on measuring two specific linkages that could transmit a crisis or shock from one country to another. The first linkage is bilateral-trade flows. Bilateral-trade flows are important determinants of a country's vulnerability to a shock, but that direct trade flows can only explain a small portion of the effects of shocks. The second linkage: how a shock to one country can also have multiplier effects through its impact on output and growth in other economies. The idea of including an export share weighted average of real GDP growth as a route for linkage among these countries would be worth pursuing.

(4) The identification schemes used in this study are open to dispute. Perhaps the chances of models yielding better results are greater if other identification schemes are adopted.

Appendix 1

Lisman and Sandee Method

Lisman and Sandee (1964) developed a simple procedure to obtain fairly good quarterly figures from given annual figures. The purpose of this appendix is to describe this method.

For each year t, the value of the quarterly figure is derived as a weighted average of the totals of the years t-1, t and t+1.

Beginning with the annual totals X_t (t=1,....,n) for each year, they divided them into four equal quarterly figures,

$$x_t = \tfrac{1}{4} X_t$$

Denote the quarterly figures to be computed by y_{t1}, y_{t2}, y_{t3}, and y_{t4}. It follows that

$$\sum_{i=1}^{4} y_{ti} \equiv 4x_t = X_t$$

Assuming the quarterly figures y_{ti} to be weighted sums of x_{t-1}, x_t and x_{t+1}, a system of equation could be constructed as:

$$\begin{bmatrix} y_{t1} \\ y_{t2} \\ y_{t3} \\ y_{t4} \end{bmatrix} = \begin{bmatrix} a & e & d \\ b & f & c \\ c & f & b \\ d & e & a \end{bmatrix} \begin{bmatrix} x_{t-1} \\ x_t \\ x_{t+1} \end{bmatrix}$$

The objective is to determine the coefficients. There are 6 unknowns, viz. a, b , c, d, e, and f instead of 12 so that a logical symmetry is maintained. We require 6 equations from which these coefficients can be derived. Since $\sum_{i=1}^{4} y_{ti} \equiv 4x_t$ must be satisfied, we impose

$a + b + c + d = 0$

If $x_{t-1} = x_t = x_{t+1}$, then $y_{ti} = x_t$ and it follows that

$a + e + d = 1$

$b + f + c = 1$

Lisman and Sandee assumed that if annual values x_t increase or decrease by a constant amount *p* per annum, the quarterly figure must increase or decrease by a constant amount ¼ *p* per quarter (a figure was used), so that $y_{ti} - y_{ti-1} = ¼ p$. After some mathematical manipulation they derived two more equations:

$a - b + c - d = 1/4$

$(b - c) = 1/8$

Thus they derived 5 independent equations under various assumptions. They expressed all six unknown parameters in terms of a new known parameter α. They introduced quite a reasonable condition in the case of an alternating series of x_t as it is assumed that the trend would be sinusoid (several figures were used in support of it). Finally they solved the system by giving $\alpha = -1.656$ and calculated the coefficients.

The result is:

$$\begin{bmatrix} y_{t1} \\ y_{t2} \\ y_{t3} \\ y_{t4} \end{bmatrix} = \begin{bmatrix} 0.291 & 0.793 & -0.084 \\ -0.014 & 1.207 & -0.166 \\ -0.166 & 1.207 & -0.041 \\ -0.084 & 0.793 & 0.291 \end{bmatrix} \begin{bmatrix} x_{t-1} \\ x_{t} \\ x_{t+1} \end{bmatrix}$$

They claimed that the solution has the advantage of simplicity, plausibility and practical usefulness.

The above described method of Lisman and Sandee was used to obtain quarterly GDP figures from annual figures in the case of Bangladesh, India, and Pakistan.

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