

Monetary Transmission Mechanism in Sri Lanka: A Comprehensive Assessment with New Evidence

Anil Perera^{1/}

Abstract

This study provides a comprehensive assessment of the transmission of monetary policy in Sri Lanka starting from changes to central bank policy to the response of final target variables-output and prices. As such, the study provides estimates for interest rate pass-through and suggests that pass-through is yet to achieve the completeness except for prime lending rates. Based on the empirical estimates obtained employing both unrestricted and structural vector auto regressions, this study observes that monetary policy in Sri Lanka is quite effective to influence the target variables of the central bank. It also suggests that monetary policy changes affect target variables through different intermediate transmission channels such as bank credit, exchange rates as well as asset prices. These results provide important policy implications for the Central Bank of Sri Lanka in the conduct of monetary policy and assessing its effectiveness.

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1. Introduction

The consensus view is that price stability, which is one of the prime objectives of modern central banking, is achieved by appropriate monetary policy supported by other macroeconomic stabilisation policies. To that end, as argued by Mishkin (1995), monetary policy remains at the centre of macroeconomic policy making. The role of monetary policy and its success can be justified by the improved macroeconomic performance over the past few decades, especially in advanced countries. In particular, inflation and inflation volatility in advanced countries have fallen significantly, while output volatility has either fallen or risen only marginally (Cecchetti, Flores-Lagunes, and Krause, 2006).^{2/} Monetary policy remains the driving force behind this improved performance, which is also supported by reductions in the variability of supply shocks and changes in the structure in economies including financial systems (Cecchetti *et al.*, 2006).

Macroeconomic stability achieved in emerging market economies is clearly evident in the behaviour of macroeconomic variables such as inflation, growth of real output and current account deficits (Montiel and Servén, 2006).^{3/} Although there is no consensus on the role of monetary policy in the emerging market economies compared to exchange rate policy and fiscal policy in macroeconomic management, it appears that monetary policy plays a credible role in terms of economic stabilisation and welfare in emerging market economies (Cook, 2004; Devereux, Lane, and Xu, 2006).^{4/}

It is evident that macroeconomic aggregates are less volatile in the Sri Lankan economy during the post-1980s than in the preceding decades. According to Table 1, on average, real output variability (as measured by the standard deviation of real GDP growth) has declined from 2.1 per cent during 1950–1980 to around 1.9 per cent during 1981–2012. Despite the somewhat reversed trend during 2001–2012 (2.6 per cent) probably due to the impact of volatile domestic and external environment, broadly a declining trend is observed particularly in the 1990s recording the lowest figure of around 1.0 per cent. Volatility in prices (as measured by the standard deviation of the GDP deflator) has also declined considerably from 7.6 per cent during 1950–1980 to around 4.3 per cent during

2/ According to World Development Indicators (WDI) of the World Bank, global inflation has declined from 17.28 per cent in 1980 to 3.67 per cent in 2012. Also during the same period, advanced country inflation has declined from 12.89 per cent to 2.44 per cent.

3/ Inflation in emerging market economies has significantly moderated from 28.29 per cent to 5.32 per cent during 1980-2012.

4/ For example, Cooper (1992) examines the challenges, *i.e.*, costs of relying on monetary policy to combat sustained increases in price levels in emerging market economies. Little, Cooper, Corden and Rajapatirana (1993) also show that how monetary policy becomes largely an adjunct of fiscal policy and of the commitment to an exchange rate in these countries, and hence monetary policy plays a rather subsidiary role.

Table 1: Macroeconomic Performance in Sri Lanka (1950–2012)

This table presents various indicators of macroeconomic performance in Sri Lanka for the period 1950–2012. Each column presents the average for the decade.

Item	1950–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2012
GDP Growth (%)	3.1	4.7	3.9	4.3	5.2	5.3
Per Capita GDP at Market Prices (US dollars)	140.0*	149.6	231.9	362.5	706.7	1,300.2
CPI Inflation (%)	0.7	2.2	6.9	12.8	11.3	10.9
GDP Deflator (%)	2.9	1.5	11.0	11.5	10.2	9.8
Budget Deficit (% of GDP)	-2.9	-6.0	-7.1	-11.3	-7.9	-8.1
Current Account Balance (% of GDP)	-0.4	-2.8	-2.0	-7.7	-4.8	-3.4
Interest Rate, 91-day Treasury bill Rate (%)	1.2	3.1	6.2	13.6	15.9	12.0
Exchange Rate (US dollar/Rupee)	4.8	5.0	8.6	25.8	52.3	100.9
Reserve Money Growth (%)	4.3	6.6	15.4	17.9	14.4	11.4
Broad Money (M ₂) Growth - M ₂ (%)	5.1	6.9	18.8	17.9	16.8	15.1
All Share Price Index	–	–	–	–	727.5	1,786.6
GDP Growth Volatility	2.0	2.0	2.1	1.5	1.0	2.6
CPI Inflation Volatility	1.3	2.7	4.3	6.7	4.7	5.4
GDP Deflator Volatility	2.2	3.5	7.9	6.1	4.0	3.8
Interest Rate (91-day Treasury bill Rate) Volatility	0.7	0.5	2.0	2.8	3.3	4.9
Exchange Rate Volatility	0.0	0.5	3.8	6.0	10.0	11.5
Reserve Money Growth Volatility	13.6	5.4	14.2	9.3	8.8	6.5
Broad Money (M ₂) Growth Volatility	9.4	4.1	13.4	7.7	4.7	3.4
Share Price Index Return Volatility	–	–	–	–	48.6	45.2

Notes: * denotes GDP per capita in 1959.

Volatility is measured by the standard deviation

Source: Updated and modified by the author based on Perera and Liyanage (2012).

1981–2012. Also monetary volatility has reduced significantly in the post-1980 period. Such macroeconomic improvement could be due to the effectiveness of monetary policy.

In particular, as the Sri Lankan economy had adopted a range of economic and financial sector reforms since the 1980s with acceleration in the 1990s, transmission of monetary policy and its effectiveness may have improved considerably. On the other hand, similar to many advanced countries and emerging market economies focusing more on price stability [for example, see Boivin, Kiley and Mishkin (2010)], monetary policy in Sri

Lanka appears more responsive to inflationary pressures with a view to create a conducive environment for sustainable economic growth.^{5/}

However, despite its importance, the role of monetary policy and its transmission have not been examined extensively in the Sri Lankan context. For example, existing literature on interest rate pass-through is very limited for Sri Lanka. Amongst the available studies, Amarasekara (2005) examines interest rate pass-through and Aazim and Cooray (2012) examine monetary policy and yield curve dynamics. However, these studies do not focus on the transmission of the impact of interest rates into final policy variables and hence are limited to early stage of monetary transmission. Whether and to what extent monetary policy will be able to transmit its impact through different channels will depend crucially on the impact of policy rate innovations on market interest rates, and hence it deserves a closer examination (Égert and Jamilov, 2014). This study contributes to the ever growing literature on the interest-rate pass-through by evaluating its empirical importance for an emerging market economy, Sri Lanka. In relation to the transmission to final target variables, Jayamaha (1995) examines monetary transmission in Sri Lanka, but the study is limited to the early years of deregulation. Amarasekara (2008) also examines the effects of interest rate, money growth and the movements in nominal exchange rate on real GDP growth and inflation in Sri Lanka, and the results are broadly in line with the established empirical findings, especially when the interest rate is considered the monetary policy variable. Both studies of Amarasekara (2005; 2008) provide a comprehensive analysis on monetary transmission in Sri Lanka, but the sample is restricted to 2004. As there are considerable developments in the monetary policy conduct since 2004, it would be imperative to provide new empirical evidence for both interest rate pass-through and monetary transmission within the context of a single study. As such, this study serves this purpose by providing a comprehensive assessment of the monetary transmission mechanism in Sri Lanka.

The remainder of the paper is structured as follows: Section 2 briefly discusses the developments of monetary policy conduct in Sri Lanka. Section 3 provides relevant theoretical underpinnings and Section 4 presents a discussion on the data and methodology of the study. Section 5 presents empirical estimates and related discussion, Section 6 is devoted to summary and conclusions.

5/ Communications of the Central Bank of Sri Lanka (CBSL) indicate that its primary responsibility is to fight inflation while securing financial system stability (Central Bank of Sri Lanka, 2011; 2012).

2. Financial and Monetary Policy in Sri Lanka: A Brief Snapshot of Historical Developments

Since the establishment of the Central Bank in 1950 under the Monetary Law Act, (No. 58 of 1949), monetary policy in Sri Lanka has evolved to achieve both the economic stabilisation objective and the development objective (Central Bank of Sri Lanka, 1998). Since inception, the Central Bank has exercised multiple objectives such as stabilisation of domestic monetary values, preservation of the stability of the exchange rate, promotion of a high level of production, employment and real income and encouragement and promotion of development of productive resources. Hence, the Central Bank was required to align its monetary policy to achieve these two broad objectives. The Monetary Law Act also provided the Central Bank with an array of instruments to implement monetary policy and the main instruments include operations in foreign exchange (external reserve management, changes in the exchange rate and exchange control regulations), credit operations with banking institutions (refinance facilities and other credit to commercial banks and other financial institutions and lender of last resort facilities), reserve requirements on commercial bank deposits, quantitative restrictions on credit, interest rate management, open market operations and the use of moral suasion. Amongst different monetary policy tools, open market operations were particularly used in the 1950s and in the post 1985 period. At the same time, the Bank Rate and the Statutory Reserve Requirement (SRR) have been used extensively. However the Bank Rate has not been used after the mid-1980s. Direct controls have served as the more important monetary policy tools in the closed economy era of the 1960s and 1970s (Central Bank of Sri Lanka, 1998). In line with such practices, two major issues can be identified in regards to implementing monetary policy in Sri Lanka, *i.e.* the relatively underdeveloped nature of financial markets and the lack of congruence between fiscal policy and monetary policy (Central Bank of Sri Lanka, 1998). In fact, the financial system has been regulated for a long period of time displaying specific characteristics such as interest rate controls, directed lending, inefficient banking system, capital controls, institutional deficiencies, *etc.* (Cooray, 2000; Paudel and Jayanthakumaran, 2009). On the other hand, from the 1950s to the 1990s, fiscal policy has been expansionary, compelling monetary policy to be contractionary to dampen inflationary pressures emanating from high fiscal deficits (Central Bank of Sri Lanka, 1998).

The Sri Lankan economy has embarked on a wide range of liberalisation policies since 1977. The policy reform package contained various measures and strategies such as trade liberalisation, exchange rate realignment, financial sector reforms, *etc.* (Cuthbertson and Athukorala, 1990). Particularly, the financial sector reforms package included several measures such as changes to interest rate policy, lifting entry barriers in the banking sector, phasing-out interest rate subsidy schemes, encouraging market-driven financial products,

and strengthening the regulatory framework, *etc.* (Athukorala and Rajapatirana, 1993; Perera, 2014). More importantly, interest rates have been deregulated since the early 1980s (Athukorala and Rajapatirana, 1993) and stock market liberalisation was a significant event of the reform agenda (Alles, 2008; Perera and Wickramanayake, 2012). During the period of economic liberalisation, coordination was developed among monetary policy, fiscal policy and exchange rate policy (Central Bank of Sri Lanka, 1998). In 2001, Sri Lanka marked a significant step by moving towards a free-floating exchange rate system and subsequently modifying the monetary policy framework while placing greater emphasis on market based monetary policy instruments (Central Bank of Sri Lanka, 2005).

In response to the changing economic environment, the Monetary Law Act was also amended in 2002 to streamline central bank objectives and to focus on two key objectives: economic and price stability and financial system stability (Central Bank of Sri Lanka, 2005). Monetary management in Sri Lanka relies on a monetary targeting framework and under this framework, the final target, price stability, is to be achieved by influencing the changes in broad money supply which is linked to reserve money (operating target) through a multiplier. Currently, to achieve monetary targets and thereby final objectives, the monetary policy framework predominantly relies on indirect monetary instruments such as open market operations and interest rates management (Central Bank of Sri Lanka, 2011).

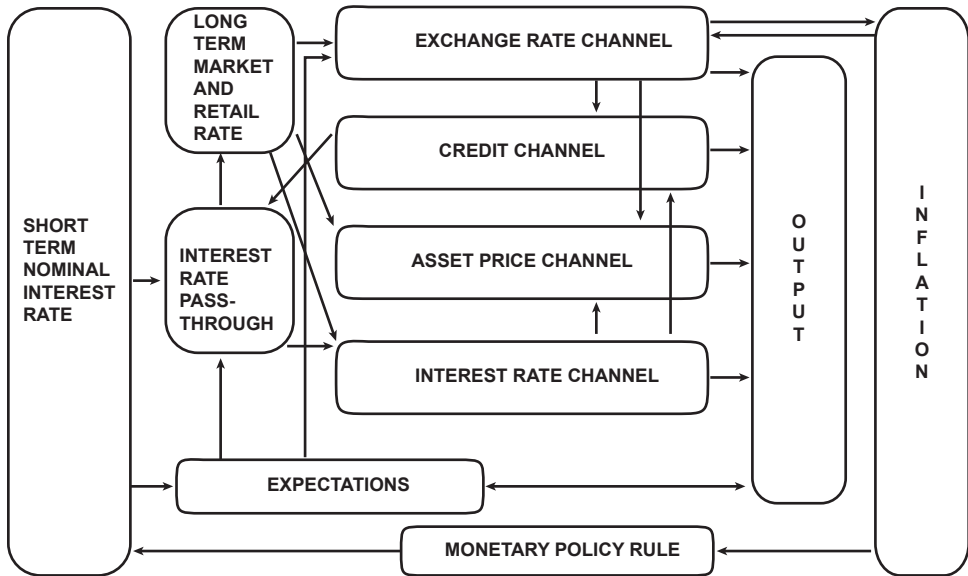
As a continuation to the modifications to the monetary policy framework, at the beginning of 2011, the CBSL adopted a more dynamic dual approach to its monetary policy analysis. Accordingly, a broader and more in-depth analysis of economic developments is carried out parallel to the analysis of monetary developments. This approach is expected to supplement the existing monetary targeting framework and strengthen the control over demand driven inflationary pressures (Central Bank of Sri Lanka, 2010).

3. Theoretical Underpinnings of Monetary Transmission Mechanism

3.1 Transmission from Monetary Policy Changes to Market Interest Rates

The monetary transmission mechanism (MTM hereafter) illustrates how policy-induced changes in monetary policy instruments of a central bank (the nominal money stock or the short-term nominal interest rate) influence real variables such as aggregate output and employment and the key nominal variable: inflation (Mishkin, 1995; Taylor, 1995). MTM begins with a change to central bank policy and then proceeds *via* different active channels such as interest rates, exchange rates, asset prices, credit as well as expectations (Mishkin, 1995; Woodford, 2003).

Figure 1: Interest Rate Pass-Through and Monetary Transmission Mechanism



Source: Adopted from Égert and MacDonald (2009).

In the process of transmission, interest rate pass-through (IRPT hereafter) becomes an important and essential element. Figure 1 provides a schematic overview of different channels of MTM and the ways they are interrelated and it mainly suggests that IRPT is the first and foremost step of the entire MTM. The process of IRPT can be decomposed into two stages (De Bondt, 2005). The first stage describes how changes in central bank monetary policy rates are transmitted to short- and long-term market rates while the second stage measures how changes in the market rates influence retail interest rates (lending and deposit rates).^{6/} The ‘cost of funds approach’ described by De Bondt (2005) is considered the best way to describe this second stage (Égert *et al.*, 2007). Accordingly, based on the idea of price setting by banks, *i.e.* mark-up pricing model of Rousseas (1985), De Bondt

^{6/} The first stage is largely influenced by the stability of the yield curve and hence the connection between short- and long-term interest rates is basically established by the term structure of interest rates (De Bondt, 2005). If the term structure (yield curve) remains stable over time, pass-through from policy rates to market interest rates is said to be proportionate. The slope and the dynamics of term structure is well explained employing a combination of standard prepositions like liquidity preference and market segmentation theories and also based on the expectations theory of yield curve (De Bondt, 2005; Égert, Crespo-Cuaresma, and Reininger, 2007).

(2005) explains the connection between money market and retail interest rates. According to this model, the price set by a financial institution, *i.e.*, retail interest rate i^B equals to marginal cost of funding approximated by a comparable market interest rate i^M and a constant mark-up α as shown in the following specification (De Bondt, 2005):

$$i^B = \alpha + \beta.i^M \quad (1)$$

In this Eq. (1), β represents the pass-through parameter (degree of long run IRPT) and it depends on the demand elasticity of loans and deposits with respect to retail interest rates. If the demand for loans and deposits is not fully elastic, parameter β is expected to be less than unity. In other words, β is equal to 1 in the case of a complete pass-through, *i.e.* ‘completeness hypothesis’ holds (De Graeve, De Jonghe, and Vennet, 2007). It is argued that speedy and complete IRPT leads to strengthen the entire MTM and thus affects price stability (De Bondt, 2005). To that end, a complete and faster IRPT implies that monetary policy is quite effective. In contrast, an incomplete and slower (disproportionate) IRPT suggests that monetary policy is less effective requiring long lags in influencing aggregate demand.^{7/}

A complete IRPT may not be observed due to several reasons such as menu costs, high switching costs, imperfect competition, and asymmetric information (Chong, Liu, and Shrestha, 2006). The menu costs hypothesis suggests that financial firms are reluctant to re-quote the prices of their products if changes in those prices are deemed to be very small and/or temporary in nature. The switching costs hypothesis argues that uninformed customers are less likely to switch financial products and/or institutions in search of the best price (or yield) when there are (perceived or real) high switching costs (Chong *et al.*, 2006). According to the imperfect competition hypothesis, interest rates are likely to adjust more slowly in uncompetitive markets (Hannan and Berger, 1991).^{8/} As discussed by Stiglitz and Weiss (1981), the asymmetric information hypothesis states that banks encounter both adverse selection and moral hazard problems when they need to raise lending rates in response to rising market interest rates. In view of these problems, banks are generally reluctant to raise lending rates but they are more likely to ration the amount of credit extended when there is upward pressure on lending rates. Taken together,

7/ As Marotta (2009) argues, an incomplete IRPT could actually violate the Taylor principle – that a central bank should raise its interest rate instrument more than one-to-one with the increase in inflation, and as a result monetary policy would fail to be stabilising. Hofmann and Mizen (2004) however argue that while complete IRPT is more efficient in its ability to control inflation, incomplete IRPT is still effective if it is predictable.

8/ This can also be discussed under the preposition of collusion leading to asymmetric adjustment (Heffernan, 1997; Fuertes and Heffernan, 2009). Because of the collusive price arrangement among banks, rate adjustments in uncompetitive markets can be asymmetric, *i.e.*, deposit rates are expected to be rigid upwards, while lending rates are expected to be rigid downwards (Chong *et al.*, 2006).

if the banking system is perfectly competitive and information is totally transparent, then the market price will be equal to the marginal cost. In that case, price changes perfectly reveal the changes of the marginal cost in Eq. (1), so the ratio of the price change to the marginal cost change is 1 ($\beta=1$).^{9/}

Several studies have shown that the short run adjustment in interest rates may be asymmetric, *i.e.*, adjustment speed may differ when rates are further away from equilibrium (Scholnick, 1996; 1999; Chong *et al.*, 2006; Sander and Kleimeier, 2006; Liu, Margaritis, and Tourani-Rad, 2008; Chong, 2010). Such asymmetry of IRPT needs to be specifically considered as it distorts the MTM (Scholnick, 1996). This is because expansionary and restrictive monetary policy would have differential impacts on the economy and hence the transmission will not be uniform (De Bondt, 2005; Chong, 2010).

Based on this theoretical guidance, it is expected to provide short run and long run estimates for IRPT based on the Sri Lankan context and to assess the effectiveness of interest rate adjustment while focusing on asymmetric adjustments.

3.2 Transmission from Market Interest Rates to Target Variables through Different Channels

The response of macroeconomic aggregates to monetary policy shocks is explained by Bernanke and Gertler (1995) as follows: (i) Although an unanticipated tightening in monetary policy has only transitory effects on interest rates, monetary tightening is followed by a sustained decline in output and prices; (ii) Falling relatively quickly after a change in policy, final demand absorbs the initial impact of monetary tightening (production also falls with a lag implying that inventories could rise in the short run, but declines later); (iii) The earliest and the sharpest declines in final demand can be seen in residential investment; (iv) Fixed business investment eventually declines in response to monetary tightening after housing and consumer durables. Thus, the effectiveness of monetary policy can be gauged by models of MTM, which show the dynamic responses of key economic aggregates targeted by the central bank, *i.e.*, output and prices, to an unanticipated tightening of monetary policy. Moreover, theories of MTM assume that prices react to monetary policy with a longer lag than output (Kilponen and Leitemo, 2011). This is because nominal prices cannot adjust immediately and proportionately following a change in monetary policy due to the degree of frictions in the economy (Ireland, 2008; Walsh, 2010).

9/ Switching and menu costs are more likely to be primary factors in influencing the short-term adjustment speed whereas imperfect competition and asymmetric information are more likely to be primary factors in affecting the long-term adjustment process (Chong *et al.*, 2006).

A number of propagation mechanisms, *i.e.*, different channels of MTM are identified in the monetary economics literature. For example, Mishkin (1995) describes various channels through which monetary policy actions affect the economy: (i) interest rate channel, (ii) exchange rate channel, (iii) other asset prices channel, and (iv) credit based channels.^{10/}

Amongst different channels, interest rates and the credit view deserve much attention as monetary policy actions affect credit flows and the economy either from the ‘interest rate side’ or from the ‘credit side’ (Romer and Romer, 1994). The impact of interest rates on the components of aggregate demand is considered as the interest rate or money view, *i.e.*, the traditional channel (Bernanke and Blinder, 1988; Morris and Sellon, 1995), which is also treated as the primary/central transmission channel (Taylor, 1995; Sellon, 2002).^{11/} It is however argued that policy-induced changes in the cost of capital (through interest rates) are insufficient to explain the size, timing and the composition of economic responses to a monetary policy shock (Bernanke and Gertler, 1995; Kandrac, 2012) as market imperfections play a pivotal role in MTM through the so-called ‘credit channels’ (Kashyap and Stein, 1995). Such channels arise mainly through asymmetric information and the imperfect nature of credit markets (Gertler and Gilchrist, 1993) that depend on several features of the financial system. These financial market frictions and imperfections amplify the effects of monetary policy mainly through two distinct sub-channels: the ‘bank lending channel’ and the ‘balance sheet channel’ (Bernanke and Blinder, 1988; Mishkin, 1995). The bank lending channel suggests that monetary policy is transmitted through the supply of bank loans (Kashyap and Stein, 1995). The balance sheet channel focuses on the role of financial positions of private agents play in the MTM, which operates through borrowers’ balance sheets (Aysun and Hepp, 2011).

The exchange rate channel works through the changes in the currency value and the adjustments in net exports affecting aggregate demand directly, while the asset price

10/ Taylor (1995) classifies these channels into two broad categories: (i) financial market prices (short-term interest rates, bond yields, exchange rates), and (ii) financial market quantities (money supply, bank credit, supply of government bonds, foreign denominated assets). Boivin *et al.* (2010) differentiate channels of MTM into two broad strands: (i) neo-classical channels in which financial markets are perfect, and (ii) non-neo-classical channels that involve financial market imperfections. These neo-classical channels are built upon core models of investment, consumption, and international trade behaviour (*i.e.*, direct interest rate channel) as well as Tobin’s q , wealth effects, intertemporal substitution effects and exchange rate channels. The non-neo-classical channels refer to the credit view, which includes effects on credit supply from government interventions in credit markets, bank-based channels (through lending and bank capital), and balance sheet channel (affecting both firms and households).

11/ This view claims that changes to central bank monetary policy stance influence real economic activity through interest rates affecting the opportunity cost of capital. It also takes bonds and loans to be perfect substitutes and only allows for the monetary policy effects on aggregate investment, consumption and savings through changes in interest rates (Bolton and Freixas, 2006).

channel operates mainly through capital (stock) markets and real estate markets. Hence, these channels are based on the investment decisions of firms and households (Mishkin, 1995; Boivin *et al.*, 2010) as well as the financial wealth of the investors having implications on the aggregate demand (Sellin, 2001). In addition to these core channels, expectations have also gained some attention in contemporary literature (Roberts, 1998; Svensson, 1999). Table 2 provides a schematic overview of different transmission channels including key sub-channels.

Table 2: Stylised Illustration of Key Channels of Monetary Transmission

This table shows the workings of key channels of monetary transmission. The table is compiled by the author based on Mishkin (1995); Taylor (1995) and Boivin *et al.* (2010).

Channel	Causation Chains
Interest Rate Channel	
– Nominal Variant	Money ↑ → Interest Rate ↓ → Investment ↑ → Aggregate Demand ↑
– Real Variant	Money ↑ → Expected Price ↑ → Expected Inflation ↑ → Real Interest Rate ↓ → Investment ↑ → Aggregate Demand ↑
Open Economy Channel	
– Exchange Rate Channel	Money ↑ → Interest Rate ↓ → Exchange Rate ↑ (Depreciates) → Exports ↑ → Net Exports ↑ → Aggregate Demand ↑
Credit Channel	
– Bank Lending	Money ↑ → Deposits ↑ → Bank Loans ↑ → Investment ↑ → Aggregate Demand ↑
– Balance Sheet	Money ↑ → Price of Stocks (Net Worth) ↑ → Adverse Selection ↓ → Moral Hazard ↓ → Lending ↑ → Investment ↑ → Aggregate Demand ↑
– Cash Flow	Money ↑ → Interest Rate ↓ → Cash Flow ↑ → Adverse Selection ↓ → Moral Hazard ↓ → Lending ↑ → Investment ↑ → Aggregate Demand ↑
– Unanticipated Price Level	Money ↑ → Unanticipated Price of Stocks ↑ → Adverse Selection ↓ → Moral Hazard ↓ → Lending ↑ → Investment ↑ → Aggregate Demand ↑
– Liquidity Effects	Money ↑ → Price of Stocks ↑ → Value of Financial Assets ↑ → Likelihood of Financial Distress ↓ → Consumer Durables and Housing Expenditure ↑ → Aggregate Demand ↑
Other Channels	
– Wealth Effect	Money ↑ → Price of Stocks ↑ → Wealth ↑ → Consumption ↑ → Aggregate Demand ↑
– Tobin's q	Money ↑ → Price of Stocks ↑ → Tobin's q ↑ → Investment ↑ → Aggregate Demand ↑
– Expectations	Money ↑ → Expected Inflation ↑ → Consumption/Investment ↑ → Aggregate Demand ↑

In this study, it is expected to examine whether empirical evidence on the effects of monetary policy on output and prices in Sri Lanka corresponds with existing theoretical explanations and empirical findings. Specifically, it will be tested whether target variables of the central bank – output and prices respond following a monetary policy shock. At the same time, it is expected to examine the response of other key macroeconomic aggregates such as money and exchange rates and the working of different intermediate channels in transmitting monetary policy.

4. Data and Methodology

4.1 Transmission from Monetary Policy Changes to Market Interest Rates

The policy interest rate (CBR) is the key interest rate directly administered by a central bank. However, empirical exercises generally rely on proxy rates for monetary policy indicators in place of central bank policy rates, as policy rates do not provide econometrically appealing results. The standard proxies used are the short-term money market rates, *i.e.*, either overnight interbank rate or the Treasury bill rate. Accordingly, as in Amarasekara (2005), preliminary empirical models of this study are estimated using the weighted average of interbank call money rates (MMR). However, co-integrations between the retail rates and the MMR were not observed for most of the cases leading to insignificant and inconsistent results. This could be due to higher volatility in the MMR, which is largely attributed to liquidity fluctuations arising mainly from the impact of foreign exchange operations of the CBSL and the changes in liquidity demand by commercial banks, particularly due to government fiscal operations. Thus, following previous empirical literature, for example, Cottarelli and Kourelis (1994); Espinosa-Vega and Rebucci (2004) and Haughton and Iglesias (2012), the 3-month Treasury bill rate (TBR) is employed as the main exogenous rate, *i.e.*, monetary policy indicator. It remains the appropriate rate that influences monetary policy in the absence of interbank rates (Haughton and Iglesias, 2012).^{12/}

To provide empirical estimates for IRPT, aggregate (average) monthly interest rate data are used for the period January 1990 to December 2012. In addition to the 3-month Treasury bill rates (TBR), the sample consists of average bank lending rates (LR) and deposit rates (DR). Average bank lending rates include average prime lending rates (AWPR) for licenced commercial banks (LCBs) and average lending rates (LRS) for licenced specialised banks (LSBs). Average bank deposit rates include average savings rates and average fixed deposit rates (AWDR and AWFDR) for LCBs and average deposit rates

12/ A strong correlation between CBR and TBR is also observed.

(DRS) for LSBs. The data are mainly obtained from International Financial Statistics (IFS) and the CBSL.

Prior to conducting the empirical analysis, first, contemporaneous correlation coefficients between the money market rates and the retail interest rates are examined as the basic indicators of IRPT (Bredin, Fitzpatrick, and O'Reilly, 2002). Second, unit root tests for each interest rate series are conducted to examine the stationary property of the data using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Thereafter, the Johansen (1988) maximum likelihood procedure is used to examine co-integration between each retail rate and the money market rates. Moreover, standard Granger causality tests (Granger, 1969; 1981) are used to gain a preliminary insight into the nature of the temporal relationships among interest rates and hence, to examine whether changes in money market rates cause changes in retail rates (Diebold and Sharpe, 1990; Chong *et al.*, 2006).

The main empirical approach of this part of study is based on the existing literature, for example, Heffernan (1997); Disyatat and Vongsinsirikul (2003); De Bondt (2005); Chong *et al.*, (2006); Hofmann (2006); De Graeve *et al.*, (2007); Liu *et al.*, (2008); Chong (2010). Accordingly, standard error correction models (ECM) are used to determine empirical estimates of IRPT. The ECM method seems suitable to estimate IRPT since it provides an economically appealing interpretation of model parameters (De Bondt, 2005; Chong *et al.*, 2006). In particular, ECMs based on the single-equation approach is considered appropriate to model both short- and long run pass-through of interest rates (Heffernan, 1997; Bredin *et al.*, 2002).

Accordingly, being guided by the cost of funds approach (Rousseas, 1985; De Bondt, 2005) described by Eq. (1), the long run relationship between the endogenous retail interest rate and the exogenous money market rate is established as follows:

$$R_t = \alpha_0 + \alpha_1 M_t + \varepsilon_t \quad (2)$$

where, R_t is the relevant endogenous retail interest rate (lending or deposit rate), M_t is the exogenous short-term money market rate (proxy for the central bank policy rate) and ε_t is the error term. α_0 and α_1 measure the constant mark-up (or mark-down) and the degree of long run pass-through, respectively. If $\alpha_1=1$, long run IRPT is complete, and to ascertain the completeness, the standard Wald test is used to determine whether $\alpha_1=1$. If α_1 is less than unity, IRPT is said to be incomplete.

In order to examine short run dynamics of IRPT and to determine the extent that takes retail interest rates to fully adjust in response to changes in money market rates,

an ECM representation corresponding to a general auto regressive distributed lag (ARDL) (p,q) model is specified. This is based on the Engle and Granger (1987) error correction procedure. Accordingly, the following model is applied to examine short run adjustments:

$$\Delta R_t = \beta_1 \Delta M_t + \beta_2 (R_{t-1} - \alpha_0 - \alpha_1 M_{t-1}) + v_t \quad (3)$$

where, Δ denotes first differenced operator and v_t is the error term. $R_{(t-1)}$ and $M_{(t-1)}$ are lagged variables and the relevant lag structure is determined by the general to specific method (Mojon, 2000; Bredin *et al.*, 2002) and is based on the information criteria of lag selection.

Eq. (3) characterises the reduced form of the dynamic relationship between retail interest rates and money market rates and the term in brackets represents the lagged deviation of retail interest rate from its steady state equilibrium value, or in general, the error correction term. In this model, β_1 measures short run (immediate, contemporaneous or impact) pass-through, *i.e.*, the degree of the change in retail interest rate in response to a change in money market rate during the same period. $\hat{\varepsilon}_{(t-1)} = (R_{t-1} - \alpha_0 - \alpha_1 M_{t-1})$ represents the extent of retail rate disequilibrium at time $(t-1)$, which is the residual of the long run relationship modelled by Eq. (2). Hence, β_2 captures the error correction adjustment speed to the long run value when the rates are away from their equilibrium level. In the mean reverting case of interest rates, sign of β_2 is expected to be negative and the absolute size of the coefficient indicates how fast a disequilibrium in retail interest rate settings will be removed (Chong *et al.*, 2006; Liu *et al.*, 2008). Moreover, mean adjustment lag (MAL) of a complete pass-through can be calculated as follows using the approach suggested by Hendry (1995):

$$(1 - \beta_2) / \beta_2 \quad (4)$$

Eq. (4) indicates the average months needed to reach the long run value of pass-through, *i.e.*, speed at which the market interest rate is fully passed-through to retail rates (Hendry, 1995). It takes into account the proportion of the adjustment, which takes place in the first period and the total adjustment in the long run. Robustness of these results obtained from the ECM estimates are formally checked by estimating bivariate VAR models and comparing impulse responses as suggested by Diebold and Sharpe (1990); De Bondt (2005) and Berument and Froyen (2006).

Thereafter, to examine the asymmetric adjustment when the rates are above or below the equilibrium, an indicator (dummy) variable λ is created and incorporated into Eq. (3).

λ is equal to 1 if the residual $\hat{\varepsilon}_{(t-1)} = (R_{t-1} - \alpha_0 - \alpha_1 M_{t-1})$ is positive and 0 otherwise. Hence, the asymmetric short run dynamic equation can be specified as follows:

$$\Delta R_t = \delta_1 \Delta M_t + \delta_2 \lambda \hat{\varepsilon}_{t-1} + \delta_3 (1-\lambda) \hat{\varepsilon}_{t-1} + \eta_t \quad (5)$$

where, δ_2 captures the error correction adjustment speed when the rates are above the equilibrium and δ_3 captures the error correction adjustment speed when the rates are below the equilibrium values. A Wald test is used to determine if δ_2 is significantly different from δ_3 and hence to examine the presence of asymmetric adjustment. Similar to the case of symmetric adjustment, asymmetric MALs for a complete IRPT from money market rates to retail rates can be defined as follows:

$$MAL^+ = (1-\delta_1) / \delta_2 \quad (6)$$

$$MAL^- = (1-\delta_1) / \delta_3 \quad (7)$$

Mean adjustment lag when the rates are above their equilibrium value is given by MAL^+ and when rates are below their equilibrium value is represented by MAL^- (Chong *et al.*, 2006; Liu *et al.*, 2008).

4.2 Transmission from Market Interest Rates to Target Variables through Different Channels

In order to provide empirical estimates under this section, quarterly data for the period March 1996 – December 2012 are used. The required data are mainly obtained from the published databases of the CBSL and the IFS.

The empirical approach of this study is based on estimating vector auto regression (VAR) models. VAR models have been progressively used for emerging market studies such as Agung (1998) for Indonesia, Disyatat and Vongsinsirikul (2003); Charoenseang and Manakit (2007) for Thailand and Elbourne and de Haan (2006) for some transition countries, among others.

First, to establish MTM and to examine the effectiveness of monetary policy in Sri Lanka, an unrestricted–baseline VAR model is estimated. This model assumes that the system is recursive and hence the Choleski decomposition is employed for identification. The estimated baseline VAR specification can be written in following matrix form:

$$y_t = k + A(L) y_{t-1} + Bx_t + u_t \quad (8)$$

where, y_t is the vector of endogenous variables, k is the vector of constants, x_t is the vector of exogenous variables and u_t is the vector of serially uncorrelated disturbances that have a zero mean and a time invariant covariance matrix. $A(L)$ denotes a matrix polynomial in the lag operator L and B is a coefficient matrix. In the baseline specification, the vector of endogenous variables *i.e.*, y_t consists of key variables: real gross domestic product (GDP_t), consumer price index (CPI_t), a measure of monetary aggregate, *i.e.*, narrow money supply (MI_t) and the domestic nominal short-term interest rate given by the interbank money market rate (MMR_t), and hence can be written as follows.^{13/}

$$y'_t = (GDP_t \quad CPI_t \quad MI_t \quad MMR_t) \quad (9)$$

GDP_t and CPI_t are the key target variables of the monetary authority, which respond to innovations to the monetary policy rate (MMR_t). The use of narrow money aggregate (MI_t) is guided by prior literature, for example, Sims (1992); Berument and Froyen (2006); Ito and Sato (2008); Rafiq and Mallick (2008); Laopodis (2013) to incorporate the impact of liquidity into the VAR system.^{14/} The use of the money market rate (MMR_t) as the monetary policy indicator is also guided by prior literature such as Ito and Sato (2008); Rafiq and Mallick (2008), and it captures the exogenous shifts in the monetary policy stance (Gertler and Gilchrist, 1993).^{15/} The ordering of variables is consistent with the central bank response to output and inflation dynamics and the dynamic structure of the economy (Disyatat and Vongsinsirikul, 2003). Therefore, the policy variable (MMR_t) is ordered last implying that an innovation in the money market rate has no contemporaneous impact on the variables in the system but has only a lagged influence on the other variables (Gertler and Gilchrist, 1993; Garretsen and Swank, 1998). A dummy variable is also included in the model to capture the impact of the structural break that occurred in 2001 due to exchange rate liberalisation. However, the impact of the global financial crisis is not considered in this model as there was no structural break in the data, which is consistent with the approach used in a study of Carpenter and Demiralp (2012).

Following Gerlach and Smets (1995); Berument and Froyen (2006); Hesse (2007); Carpenter and Demiralp (2012), among others, all non-interest rate variables are measured in natural logarithms. Also, based on the widely used X-11 procedure for seasonal adjustment, variables are seasonally adjusted. If the variables in the system are non-stationary, but co-integrated, Sims, Stock and Watson (1990) and Lütkepohl and

13/ Generally, baseline VAR models include four key variables, *i.e.*, real output, inflation rates, nominal interest rate and a financial variable of interest (for example, monetary aggregates) (Gertler and Gilchrist, 1993).

14/ Base or narrow money allows for the effect of monetary policy on inflation (Ito and Sato, 2008).

15/ In the previous section, the 3-month Treasury bill rate is used as the monetary policy indicator to estimate IRPT in Sri Lanka due to the high volatility in the interbank money market rates. However, based on the standard MTM literature, interbank money market rate is used in this analysis.

Reimers (1992) prescribe that estimating VARs in (log) levels will provide consistent estimates. Although there is loss of efficiency in the VAR due to estimations in levels, it will prevent the loss of information about the long run relationships when a VAR is estimated in first differences. Accordingly, being guided by similar prior research, for example, Disyatat and Vongsinsirikul (2003); Iacoviello and Minetti (2003); Berument and Froyen (2006), among others, an unrestricted VAR model is estimated in levels.^{16/} Impact of monetary policy shocks on the target variables are identified based on impulse response functions (IRFs). Also, in order to get an idea about the share of fluctuations in a given variable that are caused by different shocks, variance decompositions (forecast error decompositions) for each variable at different forecast horizons are also estimated.

Thereafter, a structural VAR (SVAR) model is estimated for Sri Lanka. This SVAR model is consistent with economic theory and it imposes enough restrictions to identify policy shocks, which recognise the intertwinings and complex relationships between policy variables and other macroeconomic variables (Leeper, Sims, and Zha, 1996; Boivin and Giannoni, 2006). Importantly, the SVAR approach is better suited for small open economies like Sri Lanka than the traditional identification methods. This is because of its ability to capture more of the salient features of such economies (Elbourne and de Haan, 2006).^{17/} To that end, using a SVAR model for the Sri Lankan economy is well justified due to several reasons. First, being an open economy, the SVAR model can uncover the interdependence between the domestic monetary policy instrument variable and the nominal exchange rate. Second, although the short-term interest rate remains the main policy variable, the CBSL targets monetary aggregates (base/reserve money) as its operating target. Hence, it is not clear or hard to determine the most appropriate monetary policy instrument used to identify monetary policy shocks. The SVAR model considers combinations of monetary aggregates and short-term interest rates, helping to identify monetary policy shocks appropriately. Third, a SVAR model is preferred as it takes no account of the time series properties of the data (Dale and Haldane, 1995; MacDonald, Mullineux, and Sensarma, 2009) also and due to relatively small sample size (MacDonald *et al.*, 2009).

Guided by the prior literature, mainly Kim and Roubini (2000), the following seven variables are included in the model: global commodity price index of the IMF ($COMP_t$), US Federal funds rate ($FEDR_t$), real output (GDP_t), consumer price index (CPI_t), money stock given by narrow money (MI_t), short-term domestic interest rate given by the

16/ As indicated by the unreported results, the ADF and PP tests all fail to reject a unit root in the levels of these time series but can be rejected in the first differences. Also, both Johansen's λ -max and λ -trace tests decisively reject the hypothesis of no cointegration for both sets of variables.

17/ In general, Kim and Roubini (2000) argue that SVARs resolve a number of anomalies related to exchange rates, prices and liquidity, which are detected in the empirical small open economy recursive VAR models.

interbank money market rate (MMR_t) and the nominal exchange rate (Sri Lankan rupee with respect to US dollar - EXR_t). All these variables are seasonally adjusted and specified in logs except for interest rates. Before estimating the SVAR model, first, an unrestricted VAR model is estimated and is diagnosed for stability, absence of autocorrelation and heteroskedasticity. Then, the same model is augmented in the SVAR setting, which is identified by several short run restrictions as discussed in Appendix I.

Using the 7-variable SVAR model, structural innovations for an unanticipated positive interest rate shock (restrictive monetary policy) are obtained and the variance decompositions are estimated. Also, models are re-estimated using some alternative variables in order to ensure the validity of the 7-variable SVAR model.

After establishing monetary transmission, the workings of different channels are examined based on the extensions to the baseline VAR model. Accordingly, to identify the workings of the particular channel, the shutdown/blocking-off method is used as in the studies of Morsink and Bayoumi (2001) and Disyatat and Vongsinsirikul (2003). As such, to gauge the relative strength of different channels, IRFs for target variables (output and prices) are compared under two scenarios: (i) estimates with relevant channel endogenous versus (ii) estimates with relevant channel exogenous. Any deviation of the IRFs of the later model from IRFs of the former model represent the strength of each channel, *i.e.* the larger the deviation, the stronger or more important the particular channel.

5. Empirical Results

5.1 Transmission from Central Bank Monetary Policy Changes to Interest Rates

First, Table 3 reports the data descriptions and descriptive statistics for different interest rates used for the empirical analysis. The mean value of the short-term money market rate (3-month Treasury bill rate, TBR) is 13.21 per cent. It appears that on average, retail interest rates remain high and volatile in Sri Lanka. This could be due to high volatility in money market rates and the relatively high and volatile inflation rates as well as due to high risk premiums.^{18/} In particular, lending rates in LCBs (for example, AWPR), which are linked to overnight interbank call money market rates, are more volatile. It is also noticed that deposit rates of LCBs (AWDR and AWFDR) remain below the TBR. Mean values suggest that LSBs offer high deposit rates (DRS) while charging high for lending (LRS). This high rate structure could be due to the nature of their business activity, for example, long term lending and due to the impact of higher non-performing assets in LSBs.

18/ It is generally observed that Sri Lankan banks operate with high net interest margins driven by individual bank's dominance in the market, cost structure, risk profile, ownership form, access to alternative funding sources, *etc.* (Perera, Skully, and Nguyen, 2012).

Table 3: Data Description and Descriptive Statistics

This table presents descriptions and descriptive statistics of data for the period 1990:1–2012:12 used to model the transmission from central bank monetary policy changes to interest rates.

Variable	Variable Code	Description	Descriptive Statistics			
			No. of Obs	Mean	Std. Dev.	Min. Max.
Panel A: Monetary Policy Indicator						
Money market rate	TBR	3-month Treasury bill rate	276	13.21	4.07	6.97 21.30
Panel B: Different Interest Rates						
Licensed Commercial Banks (LCBs)						
Average lending rate	AWPR	Weighted average prime lending rate	276	15.42	3.76	8.94 22.86
Average deposit rate	AWDR	Weighted average deposit rate	276	10.05	3.07	4.84 19.40
Average fixed deposit rate ^{1/}	AWFDR	Weighted average fixed deposit rate	193	11.20	2.76	6.82 16.92
Licensed Specialised Banks (LSBs)						
Average lending rate	LRS	Average lending rate for major 3 LSBs	276	16.91	3.16	11.33 22.17
Average deposit rate	DRS	Average fixed deposit rate for major 3 LSBs	276	12.93	3.31	7.00 17.67

1/ Available since 1997

Thereafter, stationary properties, co-integration and Granger causality of money market rates and retail interest rates are established as reported in Table 4. Based on the results presented in Panel A, at the levels, both ADF and PP tests do not reject the hypotheses that all interest rate series are unit root non-stationary, but all series are stationary at the first differences. Thus, all rates are found to be integrated of order one, *i.e.*, I(1). Based on the Johansen's method, Panel B presents evidence for statistically significant long run relationships between money market and retail interest rates. Moreover, the results in Panel C confirm that money market rates Granger cause the retail interest rates and as expected, one-way causality is running from money market rates to retail rates. Unreported results confirm that policy interest rates (CBR) also have the same causality.

After having observed the co-integrating relationships between money market and retail interest rates, long and short run dynamics of IRPT are examined. The results are reported in Table 5. These results are obtained through estimating the long run model given in

Table 4: Stationarity, Cointegration and Granger Causality

This table presents stationarity test results based on unit root tests (Panel A), cointegration test results based on Johansen's method (Panel B) and Granger causality test results (Panel C) of interest rates.

Panel A: Unit Root Tests of Interest Rates									
Category	Variable	Augmented Dickey-Fuller (ADF) Test		Phillips-Perron (PP) Test					
		Level	First Difference	Level	First Difference				
		T-Statistic	Probability*	T-Statistic	Probability*				
Money Market Rate	TBR	-1.90	0.33	-15.05	0.00	-2.25	0.19	-15.16	0.00
	AWPR	-2.97	0.14	-6.94	0.00	-2.55	0.30	-14.67	0.00
	IRS	-2.57	0.29	-6.75	0.00	-1.90	0.65	-17.43	0.00
Deposit Rates	AWDR	-3.32	0.07	-8.34	0.00	-3.00	0.13	-15.23	0.00
	AWFDR	-2.54	0.31	-3.52	0.04	-1.82	0.69	-8.87	0.00
	DRS	-2.65	0.26	-4.81	0.00	-1.99	0.60	-13.72	0.00

Panel B: Cointegration between Money Market and Retail Interest Rates						
Category	Variables	Test Statistics			Cointegration between Interest Rates	
		Trace Test	Maximum Eigenvalue Test			
		None	At Most 1	None	At Most 1	
Full Sample (1990 - 2012)						
Lending Rates	TBR & AWPR	29.96**	4.17**	22.79**	4.17**	Yes
	TBR & IRS	49.09**	5.08**	44.01**	5.08**	Yes
Deposit Rates	TBR & AWDPR	63.39**	4.54**	58.85**	4.54**	Yes
	TBR & AWFDR	23.45**	5.77**	17.69**	5.77**	Yes
	TBR & DRS	35.60**	2.84	32.75**	2.84	Yes

Panel C: Causality between Money Market and Retail Interest Rates					
Category	Direction of Causality	F-Value	P-Value	Decision*	Implication
Lending Rates	TBR to AWPR	15.39	0.00	Rejected	TB3 Granger causes AWPR
	TBR to IRS	36.37	0.00	Rejected	TB3 Granger causes IRS
Deposit Rates	TBR to AWDPR	22.12	0.00	Rejected	TB3 Granger causes AWDPR
	TBR to AWFDR	29.49	0.00	Rejected	TB3 Granger causes AWFDR
	TBR to DRS	11.41	0.00	Rejected	TB3 Granger causes DRS

Table 5: Estimates of Long Run and Short Run Interest Rate Pass-Through

This table provides estimates for long run and short run pass-through coefficients. Long run coefficients are obtained based on the following long run model estimated using the robust OLS method:

$$R_t = \alpha_0 + \alpha_1 M_t + \varepsilon_t \quad (2)$$

where R_t is relevant retail interest rate (lending or deposit rate), M_t is short-term money market rate, i.e., 3-month Treasury bill rate (proxy for central bank policy rate) and ε_t is the error term. α_0 and α_1 measure constant mark-up (or mark-down) and the degree of long run pass-through, respectively. Complete pass-through is examined based on Wald test ($H_0: \alpha_1 = 1$). The relevant standard (symmetric) error correction model (ECM) for short run dynamics is given by:

$$\Delta R_t = \beta_1 \Delta M_t + \beta_2 (R_{t-1} - \alpha_0 - \alpha_1 M_{t-1} + v_t) \quad (3)$$

where Δ denotes first differenced operator and v_t is the error term. R_{t-1} and M_{t-1} are lagged variables and the lag length is identified using Schwarz information criterion (SIC). β_1 measures the short run pass-through, β_2 captures the adjustment speed and mean adjustment lag is measured by $(1-\beta_1)/\beta_2$. All the interest rates are defined in Table 3. Panel A presents the results for lending rates while Panel B presents the results for deposit rates. Model estimates are adjusted for Newey-West procedure that produces 'HAC' (Heteroscedasticity and Autocorrelation Consistent) standard errors correcting for both autocorrelation and heteroscedasticity. n.o. denotes no observations. Subscripts *, ** and *** indicate statistical significance at 10%, 5% and 1% respectively. The sample period is 1990.1-2012.12.

Retail Interest Rates	Model Estimates						Diagnostics					
	Mark-Up (α_0)	Long Run Pass-Through (α_1)	Short Run Pass-Through (β_1)	Adjustment Speed (β_2)	MAL	Wald Test ($H_0: \alpha_1 = 1$)	Adjusted R ²					
							Coefficient t-Value	Coefficient t-Value	F-Value	p-Value		
Panel A: Lending Rates												
AWPR	3.020***	4.420	0.9332***	19.030	0.3389***	8.453	-0.1965***	-6.410	3.36	1.863	0.1720	0.277
LRS	3.988***	2.930	0.9582***	9.799	0.0715***	7.731	-0.0745***	-6.240	12.46	0.178	0.6730	0.181
Panel B: Deposit Rates												
AWDR	0.2901***	0.285	0.7033***	9.680	0.0669***	6.560	-0.0949***	-7.064	9.84	16.701	0.0000	0.164
AWFDR	0.8288	1.296	0.8797***	16.39	0.1007***	11.61	-0.1142***	-10.03	7.89	5.029	0.0250	0.429
DRS	1.452*	2.001	0.8569***	16.45	0.1143***	7.817	-0.1336***	-7.420	6.63	7.553	0.0000	0.187

Eq. (2) and the error correction models given in Eq. (3). It is observed that models are broadly robust for diagnostics, but the long list of test results is not reported for brevity.^{19/}

According to the results in Table 5, somewhat higher mark-ups (α_0) are observed for lending rates. This indicates the riskiness of loans in comparison to deposits (Horváth and Podpiera, 2012) and this is consistent with similar studies of Chong *et al.* (2006) for Singapore, Liu *et al.* (2008) for New Zealand and Zulkhibri (2012) for Malaysia *etc.* Meanwhile, high and almost complete long run pass-through (α_1) is observed for lending rates of LCBs and LSBs (AWPR and LRS, respectively in Panel A). High pass-through in the AWPR could be due to several reasons. First, AWPR is mostly based on short-term loans of LCBs (such as credit granted for working capital needs or trade related activities) and are broadly linked to the changes in short-term money market rates. The higher response of AWPR to money market rates also suggests that monetary policy is quite effective at the shorter end of the yield curve (De Bondt, 2005; Liu *et al.*, 2008).

Second, it indicates that short-term lending rates are much more competitive than the long-term lending and/or deposit rates. In particular, as argued by Bredin *et al.* (2002) in the context of Ireland, high IRPT could be due to the impact of borrowings by large corporations (generally prime customers). These firms have greater access to alternative financing that are unavailable for average customers encouraging the LCBs to fully and quickly adjust their prime lending rates. High pass-through in lending rates of LSBs (LRS) could be due to emerging competition in this sector.^{20/} In contrast, relatively low or somewhat incomplete long run pass-through is observed for deposit rates (Panel B of Table 5). As De Bondt (2005) suggests in the case of European markets, this could be due to the existing uncompetitive forces and/or prevailing switching and asymmetric information costs in deposit markets in comparison to the lending markets.

Table 5 also reports the results for short run dynamics estimated using ECMs.^{21/} Accordingly, lending rates of LCBs (AWPR) record the highest short run pass-through (β_1) of about 34 per cent ($\beta_1 = 0.3389$). Both lending rates of LSBs (LRS) and deposit rates of LCBs (AWDR) report low levels of short run pass-through of around 7 per cent ($\beta_1 = 0.0715$ and 0.0669 , respectively). Meanwhile, error correction adjustments (β_2) that

19/ Key diagnostics tests: Breusch-Godfrey serial correlation Lagrange multiplier test for serial correlation; Ramsey RESET test for functional form; skewness and kurtosis tests for residuals based on Jarque-Bera statistic for normality and White's heteroscedasticity test for homoscedasticity are conducted based on Pesaran and Pesaran (1997); Brooks (2008). The results are available upon request.

20/ This is reflected in the declining market share of the National Savings Bank, which accounted for about more than 90 per cent of total LSB sector assets in 1997 and then declined to about 75 per cent by 2012.

21/ The optimal lag structure for the ECM is determined using Schwartz Information Criteria (SIC) and it suggests that lag of one period is sufficient for Sri Lanka, which is consistent across many studies in this nature [for example, Espinosa-Vega and Rebucci (2004); De Bondt (2005); Zulkhibri (2012), *etc.*].

represent the speed of adjustment are negative and statistically significant indicating the mean reversion of the interest rates toward long run equilibrium. While AWPR records the lowest MAL of 3.36 months indicating the faster adjustment, LRS reports the highest MAL of 12.46 months indicating the slowest adjustment. Hence, although long run IRPT for LSB lending rates is higher, short run adjustment remains sluggish, which could be due to high switching costs, adverse selection as well as due to moral hazard problems in these lending markets (Chong *et al.*, 2006).

Taken together, on average, lending rates report the highest long run and short run pass-through, *i.e.*, 95 per cent and 20 per cent, respectively. For deposit rates, the average long run pass-through is about 86 per cent and the short-run pass-through is about 10 per cent.^{22/}

To confirm the robustness of the above discussed results, the system equation approach is used. Accordingly, responses of retail interest rates to money market rate innovations are examined based on impulse response functions (IRF) within a VAR framework. As such, IRFs are estimated for 12 months for a shock standardised to equal a 1 per cent point (100 basis points) change in the money market rate. The instantaneous response shows how an unanticipated shock to the money market rate (TBR) is transmitted to retail rates within a month. The maximum response represents the maximum pass-through within a year.

Based on the results in Table 6, which reports the results for shocks, it is evident that lending rate pass-through is comparatively higher than the deposit rate pass-through. In particular, both instantaneous and maximum responses are higher for AWPR. Second, amongst the deposit rates, AWFDR records the highest long term pass-through.

Next, in order to observe whether interest rates adjustments are above or below their equilibrium levels, asymmetric rigidity is examined. Table 7 presents the results for both symmetric and asymmetric MALs obtained using the ECM estimates. These results broadly suggest that symmetric and asymmetric MALs are lower for lending rates. For example, Panel A of Table 7 confirms that both symmetric MAL and asymmetric MALs (MAL^+ and MAL^-) remain less than 4 months for AWPR. This indicates that residual errors are lower for AWPR, and hence, they are linked with equilibrium values leading to improvements in MALs (Chong, 2010). Nevertheless, significant asymmetry is observed for lending rates in LSBs and especially for deposit rates.

22/ These results cannot be compared with some previous estimates for Sri Lanka due to the differences in selected interest rates and samples. For example, based on a sample for the regulated period, Cottarelli and Kourelis (1994) observe that short run pass-through is about 15 per cent from discount rates to lending rates. Based on a sample for 1996-2004, Amarasekara (2005) finds that long run pass-through to prime lending rates from call money rates is about 50 per cent.

Table 6: VAR Estimates of Interest Rate Pass-Through

This table provides estimates for instantaneous and long run interest rate pass-through based on the impulse response functions by estimating a VAR model given by the following representation:

$$Y_t = c + \sum_{i=1}^n A_i Y_{t-i} + \varepsilon_t \quad (10)$$

with:
$$Y_t = \begin{bmatrix} R \\ M \end{bmatrix}_t \quad (10.1)$$

where Y_t is a vector of endogenous and exogenous variables and i is optimal lag length decided by SIC. R_t is relevant retail interest rate, *i.e.*, 3-month Treasury bill rate (lending or deposit rate), M_t is short-term money market rate (proxy for central bank policy rate, *i.e.*, TBR), ε_t is error term. Following Choleski decomposition, impulse response functions are estimated for a period of 12 months for a shock standardised to equal a 1 per cent point (100 basis points) change in the money market rate to examine instantaneous and the maximum responses. * Maximum response is the largest response within 12-month period in the same direction as the movement in the money market rate following the innovation. The sample period is 1990:1 – 2012:12.

Retail Interest Rates / Impulse Response	Coefficient
Panel A : Lending Rates	
AWPR	
Instantaneous	0.32
Maximum Response	0.90
LRS	
Instantaneous	0.03
Maximum Response	0.84
Panel B : Deposit Rates	
AWPR	
Instantaneous	0.03
Maximum Response	0.41
AWFDR	
Instantaneous	0.07
Maximum Response	0.72
DRS	
Instantaneous	0.11
Maximum Response	0.49

Table 7: Symmetric and Asymmetric Mean Adjustment Lags

This table provides symmetric and asymmetric mean adjustment lags (MALs), estimated using the coefficients derived based on Eq. (4) and Eq. (6) - Eq. (7). Panel A present results for individual rates and Panel B present results for averages. The sample period is 1990:1-2012:12.

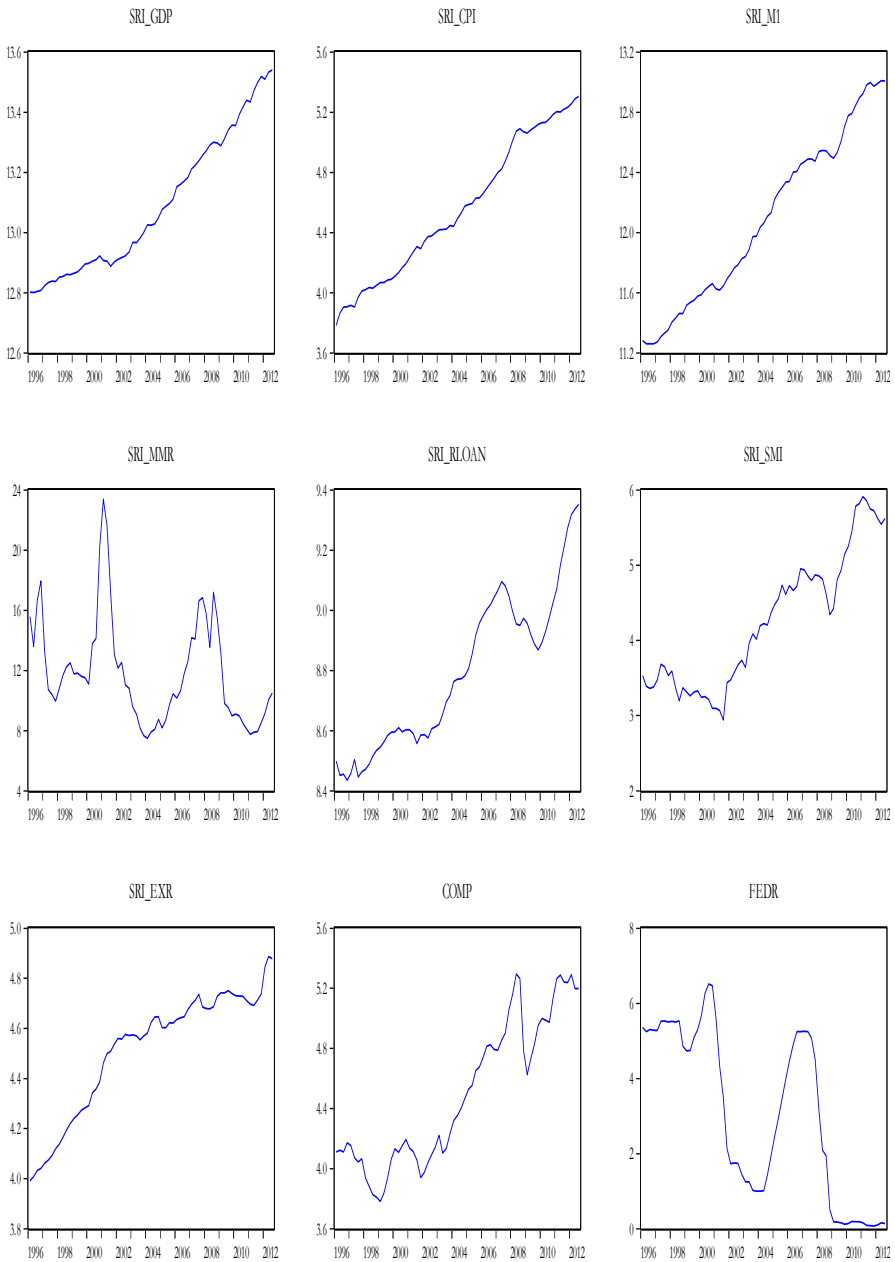
Retail Interest Rates	Symmetric Model	Asymmetric Model	
	MAL	MAL ⁺	MAL ⁻
Panel A : Lending Rates			
AWPR	3.36	3.47	3.33
LRS	12.46	10.52	14.14
Panel B : Deposit Rates			
AWDR	9.84	7.52	17.22
AWFDR	7.89	7.51	8.59
DRS	6.63	6.81	6.52
Panel C : Averages			
Lending Rates	7.91	7.00	8.73
Deposit Rates	8.12	7.28	10.78

To that end, these results suggest that asymmetric adjustments continue to exist in the Sri Lankan context. For example, it is observed that both symmetric and asymmetric MALs are lower for lending rates relative to the deposit rates indicating faster adjustments in AWPR. However, similar adjustments are not observed for other interest rates. As observed in the prior empirical studies for other countries, for example, Chong (2010), such asymmetry could continue to exist due to the oligopolistic structure of the banking market and due to bank market power.

5.2 Transmission from Market Interest Rates to Target Variables through Different Channels

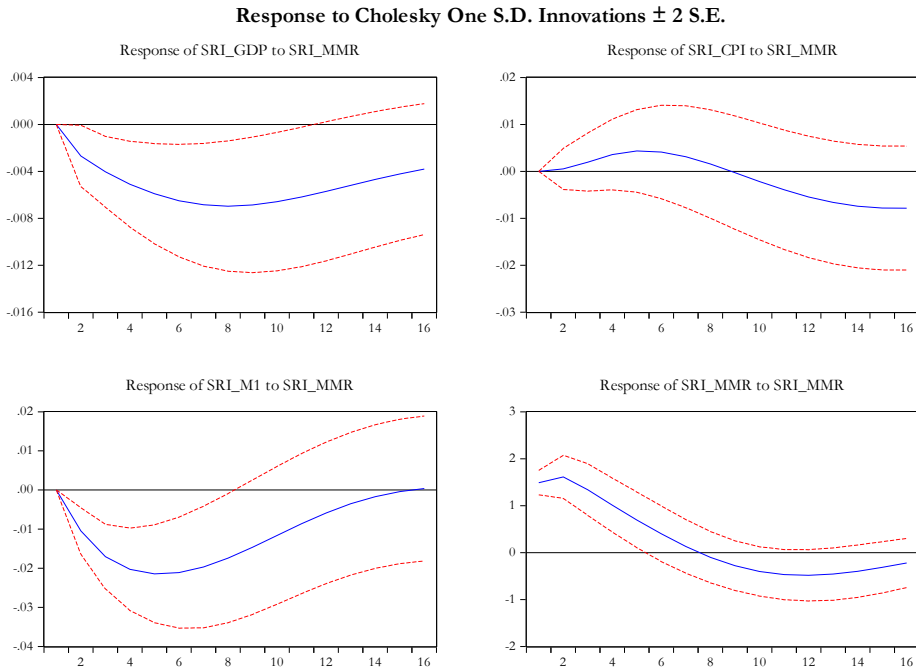
First, Figure 2 depicts the behaviour of the variables used for VAR and SVAR models based on quarterly seasonally adjusted data for the period March 1996 to December 2012. Since these figures are self-explanatory, a detailed discussion is not provided.

Figure 2: Plots of Data Series – Quarterly VAR and SVAR Models



As a benchmark model for monetary transmission, first, an unrestricted VAR model is estimated. This benchmark model (Eq. 8) includes real output (GDP_t), consumer prices (CPI_t), a monetary aggregate (MI_t) and the short-term interbank money market rate (MMR_t).^{23/} Having established a baseline VAR model, then, impulse response functions (IRFs) are calculated and presented in Figure 3.

Figure 3: Impulse Response Functions (Baseline VAR Model)



23/ Unreported unit root (ADF and PP) tests and the Johansen cointegration test results suggest that interest rate is $I(0)$, whilst all the other variables are $I(1)$ and that there are four cointegrating vectors in the VAR system. Hence, it confirms the appropriateness of the strategy suggested by Sims et al. (1990) and Lütkepohl and Reimers (1992) to estimate the VAR in levels despite the fact that series are integrated. Therefore, estimates of the models are carried out in levels. The optimal lag length under different information criteria (Schwarz and Hannan-Quinn criteria) appears to be one. However, one lag is too short to capture underlying dynamics of the system while it could run into the degrees of freedom problem if many lags are included (Disyatat and Vongsinsirikul, 2003). Moreover, in the case of SVAR, it could pose a risk of over-parameterisation. Also, a lag order of one may lead to autocorrelation in the residuals and more lags tend to show greater variability in impulse responses. As such, guided by prior literature, VAR models are estimated with two lags. Relevant VAR models are also tested for stability, no serial correlation and the absence of heteroskedasticity. As suggested by these unreported results, estimated VAR model appears broadly valid. These results are available upon request.

As shown in Figure 3, first, an unexpected rise in short-term interest rates causes a statistically significant decline in real output (SRI_GDP). In particular, an unexpected tightening of monetary policy gives rise to a U-shaped output response that bottoms-out after 6-8 quarters. The relatively quicker response in output to a monetary contraction is consistent with the observations in prior research, for example, Leeper *et al.* (1996) and Berument and Froyen (2006) for US, Disyatat and Vongsinsirikul (2003) for Thailand, Arin and Jolly (2005) for Australia and New Zealand, *etc.* Second, consumer prices (SRI_CPI) initially report a positive reaction to an interest rate innovation showing a ‘price puzzle’.^{24/} Third, following an interest rate shock, monetary aggregates (SRI_M1) react immediately, which is consistent with the evidence reported in Leeper *et al.* (1996); Kim and Roubini (2000); Sousa and Zaghini (2007); Ito and Sato (2008) and Rafiq and Mallick (2008). In fact Leeper *et al.* (1996) describe a similar monetary contraction as a strong liquidity effect: money contracts quickly and stays persistently below average following an interest rate jump that is itself persistent. According to Figure 3, the effect on M1 bottoms out by the fourth quarter and starts dissipating. Finally, the interest rate shock (SRI_MMR) is quite persistent and starts returning to its initial levels after about seven quarters. As expected, the shock results in a considerable initial increase, with the short-term money market rate actually peaking after two quarters and a subsequent steady decline. It continues to decline below the initial level and reaches the lowest point by 11–12 quarters after the shock, and then begins to increase towards the base level.

In order to examine the contributions to fluctuations in a given variable caused by different shocks, variance composition (VD) for each variable at forecast horizons of one through to four years is examined. These results are presented in Table 8.

According to the results, output (SRI_GDP) indicates that after four years (16 quarters), interest rate shocks account for about 31 per cent of the fluctuation in output, with own shocks accounting for most of the rest. This is consistent with prior studies indicating that interest rate innovations lead to long run fluctuations in economic activity. Meanwhile, VD for prices (SRI_CPI) indicates that after four years (16 quarters), money accounts for 41 per cent of the fluctuation in prices while own shocks account for more than 50 per cent of the variance. Interest rate innovations alone account only for about 5 per cent after

24/ In the VAR systems, positive orthogonalised shocks to central bank policy rates are related to a protracted rise in the price levels suggesting that some inflation indicator is missing from the VAR (Laopodis, 2013). This is well known as ‘price puzzle’, *i.e.*, prices increase following an interest rate tightening (Sims, 1992; Leeper *et al.*, 1996; Kim and Roubini, 2000). Sims (1992) suggests that the price puzzle might be due to the fact that interest rate innovations partly reflect inflationary pressures leading to price increases and also states as the failure to include a rich enough specification of the information available to policy makers. This is quite common in similar empirical literature. For example, Dale and Haldane (1995) for UK, Leeper *et al.* (1996) for the US, Morsink and Bayoumi (2001) for Japan, Disyatat and Vongsinsirikul (2003) for Thailand, Arin and Jolly (2005) for Australia and New Zealand, *etc.*, report similar positive responses in prices.

Table 8: Variance Decomposition (Baseline VAR Model)

This table presents forecast error variance decomposition of output (SRI_GDP), prices (SRI_CPI), narrow money (SRI_M1) and short-term interest rate (SRI_MMR) for the baseline VAR model. Cholesky Ordering: SRI_GDP SRI_CPI SRI_M1 SRI_MMR. Period is given by number of quarters.

<i>Variance Decomposition of SRI_GDP:</i>						<i>Variance Decomposition of SRI_M1:</i>					
Period	S.E.	SRI_GDP	SRI_CPI	SRI_M1	SRI_MMR	Period	S.E.	SRI_GDP	SRI_CPI	SRI_M1	SRI_MMR
1	0.0109	100.0	0.00	0.00	0.00	1	0.0238	1.96	0.03	98.01	0.00
2	0.0145	94.90	0.02	1.60	3.48	2	0.0359	2.31	1.65	87.54	8.50
3	0.0176	88.99	0.24	3.13	7.64	3	0.0471	1.73	1.73	78.56	17.99
4	0.0203	82.96	0.41	4.56	12.07	4	0.0569	1.23	1.84	71.83	25.11
5	0.0227	77.33	0.46	5.81	16.41	5	0.0652	0.95	2.35	66.78	29.93
6	0.0249	72.22	0.41	6.89	20.48	6	0.0723	0.87	3.45	62.85	32.83
7	0.0269	67.69	0.35	7.86	24.10	7	0.0786	0.96	5.24	59.70	34.10
8	0.0286	63.73	0.39	8.74	27.14	8	0.0842	1.18	7.73	57.07	34.02
9	0.0302	60.29	0.61	9.57	29.53	9	0.0893	1.48	10.85	54.77	32.90
10	0.0316	57.24	1.09	10.40	31.27	10	0.0942	1.82	14.41	52.69	31.08
11	0.0329	54.50	1.89	11.24	32.37	11	0.0991	2.18	18.16	50.78	28.88
12	0.0342	51.95	3.02	12.13	32.90	12	0.1039	2.54	21.85	49.05	26.56
13	0.0353	49.53	4.47	13.07	32.94	13	0.1088	2.86	25.27	47.53	24.34
14	0.0365	47.17	6.18	14.09	32.56	14	0.1137	3.16	28.27	46.26	22.30
15	0.0376	44.85	8.09	15.18	31.88	15	0.1186	3.44	30.80	45.27	20.49
16	0.0388	42.55	10.13	16.36	30.96	16	0.1235	3.70	32.84	44.55	18.91

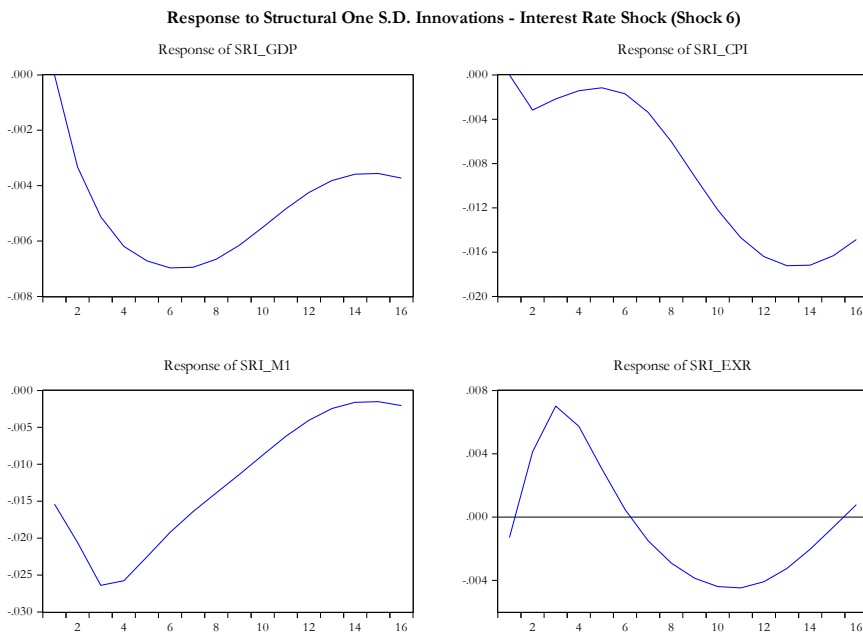
<i>Variance Decomposition of SRI_CPI:</i>						<i>Variance Decomposition of SRI_MMR:</i>					
Period	S.E.	SRI_GDP	SRI_CPI	SRI_M1	SRI_MMR	Period	S.E.	SRI_GDP	SRI_CPI	SRI_M1	SRI_MMR
1	0.0186	0.43	99.57	0.0000	0.00	1	1.541	0.76	1.36	4.40	93.48
2	0.0285	0.41	97.94	1.62	0.03	2	2.307	0.35	5.77	3.39	90.49
3	0.0360	0.46	95.40	3.83	0.32	3	2.710	0.38	7.06	2.50	90.06
4	0.0421	0.48	92.24	6.33	0.95	4	2.907	0.61	6.74	2.35	90.30
5	0.0474	0.49	88.72	9.21	1.59	5	3.003	0.89	6.32	2.82	89.97
6	0.0521	0.48	85.06	12.52	1.94	6	3.055	1.16	6.53	3.68	88.63
7	0.0564	0.45	81.36	16.24	1.95	7	3.096	1.35	7.52	4.69	86.45
8	0.0604	0.41	77.62	20.19	1.77	8	3.144	1.45	9.02	5.57	83.96
9	0.0641	0.37	73.87	24.18	1.57	9	3.202	1.47	10.64	6.18	81.72
10	0.0677	0.33	70.17	27.98	1.51	10	3.266	1.44	12.02	6.47	80.07
11	0.0713	0.32	66.61	31.40	1.67	11	3.328	1.39	13.01	6.51	79.10
12	0.0749	0.35	63.29	34.32	2.04	12	3.382	1.34	13.58	6.41	78.67
13	0.0785	0.43	60.30	36.70	2.57	13	3.423	1.32	13.82	6.27	78.59
14	0.0822	0.56	57.71	38.56	3.17	14	3.451	1.32	13.85	6.17	78.65
15	0.0858	0.76	55.56	39.94	3.73	15	3.468	1.34	13.80	6.14	78.72
16	0.0895	1.01	53.86	40.93	4.20	16	3.477	1.37	13.73	6.19	78.71

four years (16 quarters). Overall, the results of the baseline VAR model (both IRFs and VD analyses) confirm that an unanticipated monetary policy shock given by an interest rate shock causes reductions in output and prices.

Next, the validity of the baseline VAR results is investigated using the SVAR model. This is estimated based on the 'A_B approach' of Amisano and Giannini (1997) and the detailed estimates are reported in Table A.1 in Appendix II. The Likelihood Ratio (LR) test is used to examine over-identification restrictions of the model. According to the results of LR test presented in the same table, the validity of over-identification restrictions cannot be rejected at the standard significance level. The contemporaneous coefficients presented in this table provide some information regarding the importance of particular variables

and the restrictions in the VAR system. However, they do not provide information about the dynamic relationships between the variables. Prior literature, for example, Leeper *et al.* (1996); Elbourne (2008); Li, İşcan and Xu (2010), among others, relies on dynamic responses to structural shocks in order to identify the effects and to gauge the effectiveness of monetary policy innovations. Accordingly, IRFs (structural innovations) obtained from SVAR estimates are used to identify monetary policy effects and the key responses are presented in Figure 4. It suggests that the SVAR model is a satisfactory description of MTM in Sri Lanka and provides an adequate explanation of the theoretical underpinnings. As per structural innovations, a monetary policy shock represented by a one-standard deviation innovation to money market rate (Shock 6 of the SVAR model) has the following effects.

Figure 4: Structural Innovations (Impulse Response Functions) of the SVAR Model



First, the target variable output (SRI_GDP) responds by the second quarter. The relatively immediate decline in output is consistent with prior research like Kim and Roubini (2000) for UK and Canada, Dungey and Pagan (2000); Berkelmans (2005) and Fraser, Macdonald and Mullineux (2012) for Australia, Li *et al.* (2010) for US and Canada, Sousa and Zaghini (2007) for G-5 countries, *etc.* Roughly after 6-7 quarters, the impact on output starts reversing and thus moves up towards the base. Second, after a monetary contraction, despite there remaining a marginal reversal during the first year, price levels (SRI_CPI) decline persistently to reach a maximum of about 1.5 per cent to a 1 per cent increase in interest rates by the 12th quarter. Again, this observation is consistent with prior literature [for example, Dungey and Pagan (2000) for Australia, Kim and Roubini (2000) for Italy, Elbourne (2008) for UK, Ito and Sato (2008) for Thailand and Philippines]. Importantly, structural innovations indicate that the price puzzle is weaker and the impact of monetary policy on prices is persistent although it starts dissipating in the long run.

Third, as in Leeper *et al.* (1996) for US and Kim and Roubini (2000) for UK, monetary aggregates (SRI_M1) respond to monetary policy shock showing some liquidity effect.^{25/} Fourth, the exchange rate (SRI_EXR) indicates some initial increase, but the effect is relatively short-lived. This suggests that after an unexpected shock to interest rates, nominal exchange rates quickly depreciate for up to 2–3 quarters, indicating some evidence for an exchange rate puzzle though it starts appreciating from about the sixth quarter. These observations also correspond with similar research for small open economies. For example, Fraser *et al.* (2012) observe that in the presence of a monetary policy shock, exchange rate rises initially, but the effect is relatively short-lived. Kim and Roubini (2000) also show that initial increase in the exchange rate (depreciation) is justifiable in a VAR model for an open economy. In the context of Indonesia, Afandi (2005) argues that an increase in the domestic interest rate often follows exchange rate depreciation in an attempt to sterilise the expansionary effect of central bank intervention in the foreign exchange market. A similar scenario can also be observed in Sri Lanka as exchange rates tend to depreciate during periods of monetary tightening, which can be considered as a situation of reverse causality.

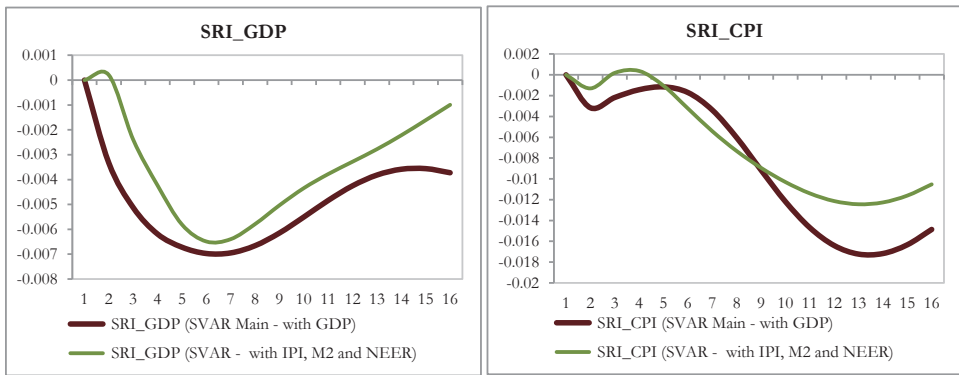
Overall, the results of the SVAR model for Sri Lanka show that both output and prices respond negatively to an unanticipated rise in interest rates (monetary contraction) and the price reaction appears strong and persistent. Hence, the results suggest that monetary policy is quiet effective to affect target variables of the central bank. To that end, any output puzzle (increase in output in response to a contractionary monetary shock) is not observed and there is substantial reduction in the price puzzle. Moreover, a liquidity

25/ When the effect is not persistent, it can be argued that central bank actions do not have direct and persistent effects on monetary aggregates (Duguay, 1994).

puzzle (increase in monetary aggregate in response to a contractionary monetary shock) cannot be observed, but an exchange rate puzzle (exchange rate depreciates in response to a contractionary monetary shock) exists.

These results are quiet robust for alternative SVAR models, which are not reported to preserve space. Amongst them, for example, the results of an alternative SVAR model that includes variables such as industrial production index (IPI), a broad money aggregate (M2), nominal effective exchange rates (NEER) are broadly compatible with the above discussed (7-variable) SVAR model. This consistency can be observed through the structural innovations presented in Figure 5. To that end, it is evident that monetary transmission in Sri Lanka is well explained by the standard 7-variable SVAR model suggested by Kim and Roubini (2000) in the context of advanced countries.

Figure 5: Comparison of 7-Variable SVAR and Alternative SVAR Models

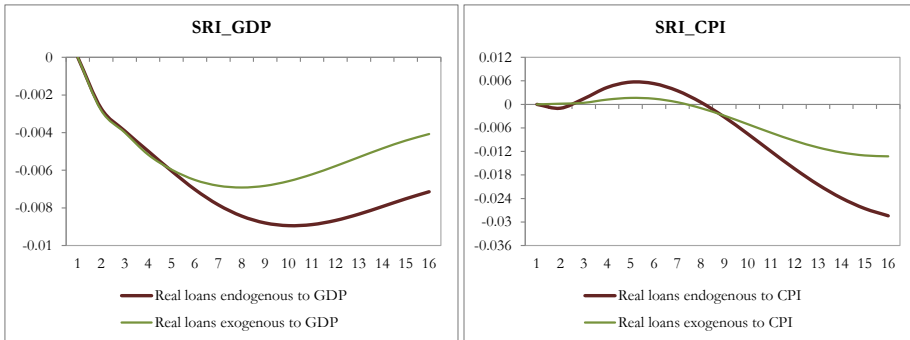


Meanwhile, forecast error variance decompositions (VD) for each variable up to four years is calculated to identify the fluctuations in the target variables. As per VD values presented in Table A.2 in Appendix II, first, except for the own shock, in the short run (around the second quarter), the highest source of variance in output (SRI_GDP) comes from the global commodity prices (Shock 1). In the period commencing from about 4th–5th quarter, the observable variation in the GDP is explained by money shock (Shock 5). However, as observed by Dale and Haldane (1995) and Elbourne (2008) for the UK, the impact of money is not substantially high as it only accounts for about 13 per cent of total GDP variation. In the long run, exchange rate shocks (Shock 7) dominate the variation in GDP. Second, similar to the observations of Ito and Sato (2008), in the short run, commodity price shocks (Shock 1) appear to be the main source of fluctuations in prices apart from its own shock. After about four quarters, innovations in both money and exchange rates (Shock 5 and 7, respectively) dominate price variations. In particular,

consistent with some similar studies, for example, Morsink and Bayoumi (2001) for Japan, money shock (Shock 5) continues to dominate even in the 16th quarter confirming that money is the main source of long run price dynamics. Moreover, similar to Ito and Sato (2008) for Indonesia, Korea, Thailand, and the Philippines, it is observed that exchange rate shock (Shock 7) is an important determinant in the fluctuations of prices. Although, interest rate shocks (Shock 6) remain modest and the maximum impact seems to be about 12 per cent of the total price variation by about 9th quarter, its impact remains broadly persistent over the time horizon. Again, the evidence is consistent with the results of Ito and Sato (2008).

Next, in order to gauge the relative importance of different channels in transmitting monetary policy shocks in Sri Lanka, the baseline VAR model is appended using relevant variables that capture particular channels. First, to identify the bank lending channel, the baseline VAR model is appended using log of real bank credit ($RLOAN_t$). As such, the appended VAR model comprises of GDP_t , CPI_t , MI_t , $RLOAN_t$ and MMR_t . Based on the shut-down method, Figure 6 presents IRFs for the relative importance of the bank lending channel. In the calculation of IRFs, bank loans are exogenised (blocked-off).

Figure 6: Comparison of VAR Models with Bank Lending Endogenous and Exogenous

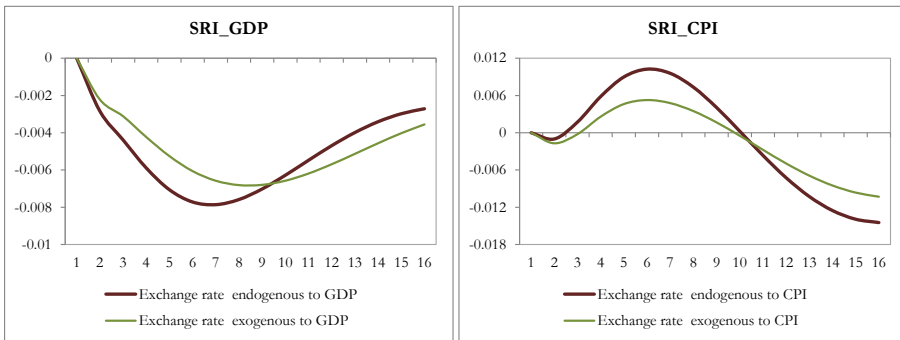


The output response (SRI_GDP) to an interest rate shock with and without real bank loans exogenised is broadly similar during the first five quarters. However, during the latter part of the time horizon, a notable difference is observed. In particular, it is evident that output response is clearly dampened when the role of bank loans is blocked-off. Similarly, the impact of interest rate shock is much pronounced for prices (SRI_CPI) when the bank loans are endogenous in comparison to the shock when bank loans are blocked-off. To that end, it appears that monetary policy in Sri Lanka is also transmitted via bank

credit. Existence of a significant bank lending channel in the Sri Lankan context seems to be justifiable due to heavy reliance on bank credit as a main source of funding in Sri Lanka. This is a common feature for many emerging market economies (Cole, Moshirian, and Wu, 2008).

Second, the importance of the exchange rate channel is assessed by augmenting the baseline VAR model with the log of nominal exchange rate (EXR_t) and hence the relevant VAR model comprises GDP_t , CPI_t , MI_t , MMR_t and EXR_t .^{26/} Figure 7 depicts the reaction of output and prices to innovations in interest rates with and without the nominal exchange rate exogenised. With the exchange rate channel blocked-off, output (SRI_GDP) and price (SRI_CPI) responses appear somewhat dampened. For example, trough output is lower in the exogenous model than the case when the exchange rate is endogenous. This suggests that the endogenous presence of the nominal exchange rate magnifies the effect of a monetary policy shock.

Figure 7: Comparison of VAR Models with Exchange Rate Endogenous and Exogenous



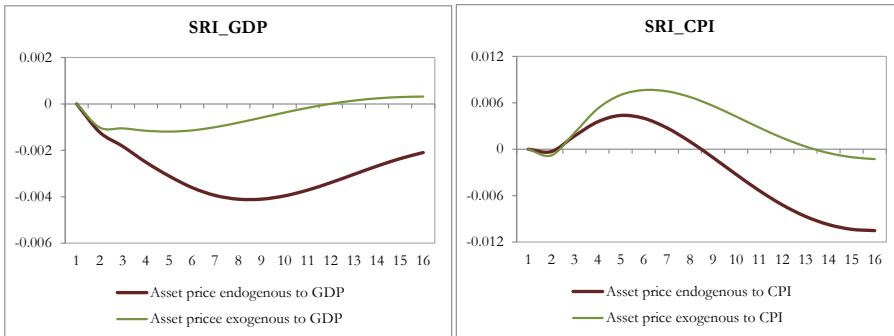
Disyatat and Vongsinsirikul (2003) suggest that evidence related to the exchange rate channel should be viewed with some caution. This is because modifications to the exchange rate system and regime changes could have implications on the non-linear movements in exchange rates. To examine this, the relevant VAR model is re-estimated excluding the impact of the fixed exchange rate regime (period prior to 2001 with the managed floating system) expecting that a move towards a more liberalised exchange rate regime will enhance the effects of monetary policy as monetary policy is subordinate to maintenance

^{26/} Inclusion of nominal exchange rate in the VAR system is consistent with prior studies, for example, Dale and Haldane (1995); Arin and Jolly (2005); Elbourne and de Haan (2006).

of the exchange rate in a fixed regime.^{27/} Also, it can be expected that a move from a fixed to a floating exchange rate regime would enhance the importance of the exchange rate channel for the reason that nominal exchange rates are not allowed to fluctuate in the former case. However, as per unreported results, blocking-off the exchange rate channel does not greatly dampen the impact of monetary policy. To that end, it can be concluded that exclusion of the data for the managed exchange rate period does not increase the significance of the exchange rates in propagating monetary shocks. This may be suggesting the impact of the exchange rate management policy of the CBSL.

Third, the propagation of monetary policy shocks *via* asset prices is examined. Accordingly, the baseline VAR model is appended to include the log of stock market index (SMI_t). The significance of the asset prices in transmitting monetary policy shocks can be clearly examined by exogenising asset prices on the calculation of IRFs as in Figure 8.

**Figure 8: Comparison of VAR Models with Asset Prices
Endogenous and Exogenous**



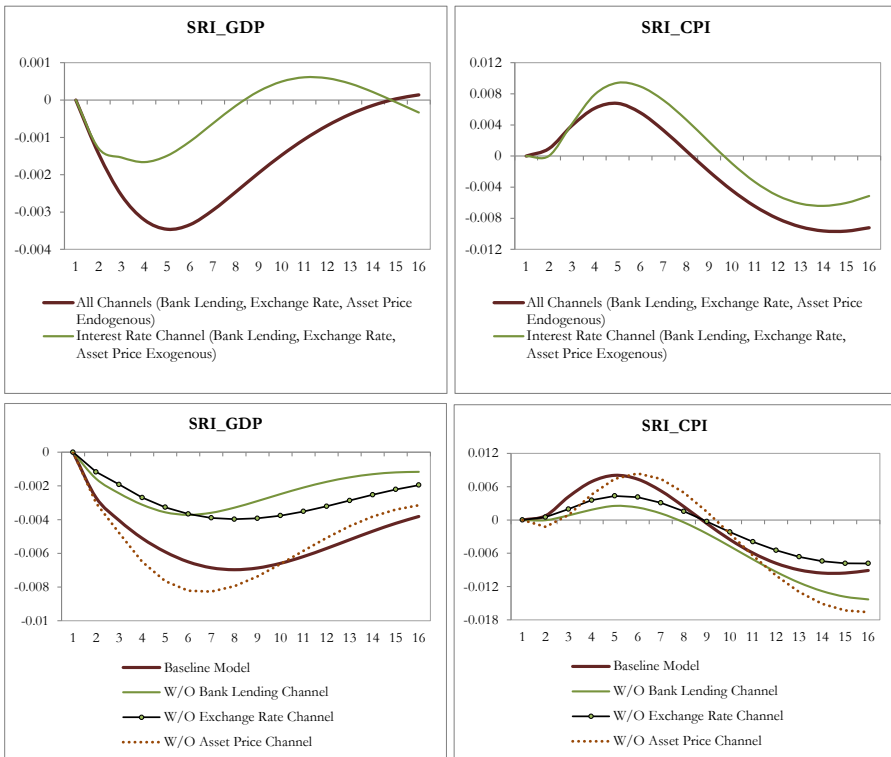
It is observed that exogenising of asset prices significantly dampens the response of output (SRI_GDP) and prices (SRI_CPI) indicating an existence of an asset price channel. In particular, although a significant deviation is not observed between endogenised and exogenised responses for the first 2–3 quarters, a notable difference is observed from about the fourth quarter. It is a common feature that the asset price channel is gradually gaining much importance in emerging market economies in propagating monetary policy shocks (Disyatat and Vongsinsirikul, 2003). An existence of an asset price channel in

27/ For an open economy operating with a fixed exchange rate regime, there is little scope for independent conduct of monetary policy and to have an effective monetary transmission. This is known as ‘impossible trinity’, which suggests that no country can enjoy (i) a fixed exchange rate, (ii) open capital account, and (iii) an independent monetary policy.

Sri Lanka could be due to increased penetration and developments in the stock market activity in recent decades.

Finally, a summary VAR model is estimated to isolate and identify the workings of the traditional direct interest rate channel in the presence of other channels. Accordingly, the baseline unrestricted VAR model is estimated including variables for bank lending, exchange rates and asset prices and hence the relevant model comprises of GDP_t , CPI_t , MI_t , $RLOAN_t$, SMI_t , MMR_t and EXR_t (in the given order) as well as an exchange rate dummy (EXR_DUM) to control for structural changes that occurred due to exchange rate liberalisation. Relevant model is estimated by including bank loans, the nominal exchange rate and the stock market index and then, output and price responses are compared with and without these variables exogenised. Based on these model estimates, Figure 9 presents IRFs for the direct interest rate channel.

Figure 9: Comparison of Direct Interest Rates and Other Channels



First two graphs presented in Figure 9 suggests that the interest rate channel accounts for about one third of the responses of output (SRI_GDP) and prices (SRI_CPI), particularly after about four quarters. In other words, the other three channels (bank lending, exchange rates and asset prices) together explain the remainder. The other two graphs in the lower panel ascertain the relative importance of each transmission channel. The left-hand side graph suggests that output (SRI_GDP) response is significantly dampened when bank lending and exchange rate channels are blocked-off indicating the existence of those two channels. Although the asset price channel is not much significant for some time, after the tenth quarter, it shows some importance indicating that asset prices have effects in the long run. A similar scenario is observed for responses in prices (SRI_CPI) in the right-hand side graph. In particular, in the long run (after about 9–10 quarters), the impact of exchange rates appears to be playing a significant role in explaining price dynamics.

Overall, the results broadly support the existence of four core conduits in transmitting monetary policy shocks in the Sri Lankan economy despite their relative strength being different. Hence it can be argued that an unanticipated increase in short-term interest rate (a restrictive monetary shock) causes reductions in real GDP and consumer price levels via interest rates, credit, exchange rates and asset prices. Nevertheless, it is important to investigate each channel more closely and extensively in order to completely understand the mechanism of propagation of monetary policy shocks in Sri Lanka. In particular, as seen in recent research into the Sri Lankan context, for example, Perera, Ralston and Wickramanayake (2014), sub-channels of broad credit channel need to be examined extensively.

6. Summary and Conclusions

This study finds that interest rate pass-through in Sri Lanka is not complete. Despite the fact that short term lending rates, particularly prime lending rates show some speedy and complete adjustment, a majority of interest rates report sluggish and incomplete adjustments. This calls for the need for implementing policies to further develop the financial and banking sector in Sri Lanka while promoting competition among financial intermediaries. Also, it is observed that prime lending rates and 3-months fixed deposit rate of commercial banks have a strong association with money market interest rates. It may therefore be argued that using short-term rates would be much appropriate when assessing the effectiveness of monetary policy. Nevertheless, as the 3-months fixed deposit rate is based on the stock of deposits, it is important to compile the same based on new deposits to reflect the current interest rate environment.

In the second part of the empirical analysis, it is observed that an unanticipated increase in short-term interest rate (a restrictive monetary policy shock) causes reductions in real GDP and consumer price levels. In particular, both recursive and non-recursive VAR models provide robust and consistent results in relation to the impact of (restrictive) monetary policy shocks on (declining) output and prices. Also, it is noted that an unanticipated increase in the short-term interest rate (a restrictive monetary policy shock) causes reductions in real GDP and consumer price levels via interest rates, credit, exchange rates and asset prices. The results show that the interest rate channel remains the most important transmission channel in Sri Lanka though the other channels also help to propagate monetary policy shocks. From the CBSL's perspective, these results provide implications, which are consistent with the Bank's move towards a monetary policy framework focusing on indirect instruments of monetary policy. Moreover, as the reaction of target variables has been substantially enhanced, i.e. prices are more responsive to interest rate shocks, it provides a strong justification for moving towards an inflation targeting framework, which is considered as an appropriate monetary policy framework for emerging market economies.^{28/} It needs to be further validated by specific research into inflation targeting in Sri Lanka [for example, see Perera (2008)]. Hence, the need for conducting more research into monetary policy transmission in Sri Lanka is much pronounced.

28/ Mishkin (2000) argues that although inflation targeting is not a panacea, it can be highly useful for monetary policy in a number of emerging market economies.

Appendix I

The structural representation of the VAR model of order p takes the following general form:

$$A_0 y_t = c_0 + \sum_{i=1}^p A_i y_{t-i} + \varepsilon_t \quad (\text{A.1})$$

where, y_t is a 7×1 vector of endogenous variables, *i.e.*, $y_t = (COMP_t, FEDR_t, GDP_t, CPI_t, MI_t, MMR_t, EXR_t)$, A_0 represents the 7×7 contemporaneous matrix, A_i are 7×7 autoregressive coefficient matrices, ε_t is a 7×1 vector of structural disturbances, assumed to have zero covariance. The covariance matrix of the structural disturbances takes the following form $E[\varepsilon_t \varepsilon_t'] = D \equiv [\sigma_1^2 \ \sigma_2^2 \ \sigma_3^2 \ \sigma_4^2 \ \sigma_5^2 \ \sigma_6^2 \ \sigma_7^2] \times I$. In order to get the reduced form of the structural model [Eq. (10)], both sides are multiplied with A_0^{-1} providing the following:

$$y_t = a_0 + \sum_{i=1}^p B_i y_{t-i} + e_t \quad (\text{A.2})$$

where, $a_0 = A_0^{-1} c_0$, $B_i = A_0^{-1} A_i$ and $e_t = A_0^{-1} \varepsilon_t$, *i.e.*, $\varepsilon_t = A_0 e_t$. The reduced form errors e_t are linear combinations of the structural errors ε_t , with a covariance matrix of the form $E[e_t e_t'] = A_0^{-1} D A_0^{-1'}$. The structural disturbances can be derived by imposing appropriate restrictions on A_0 .^{29/} Accordingly, the short-run restrictions applied in this model are the following:

$$\begin{bmatrix} \varepsilon_{comps} \\ \varepsilon_{fedrs} \\ \varepsilon_{gdps} \\ \varepsilon_{cpis} \\ \varepsilon_{m1s} \\ \varepsilon_{mmrs} \\ \varepsilon_{exrs} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & 0 & 1 & 0 & 0 & 0 & 0 \\ a_{41} & 0 & a_{43} & 1 & 0 & 0 & 0 \\ 0 & 0 & a_{53} & a_{54} & 1 & a_{56} & 0 \\ a_{61} & 0 & 0 & 0 & a_{65} & 1 & a_{67} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \times \begin{bmatrix} e_{comp} \\ e_{fedr} \\ e_{gdp} \\ e_{cpi} \\ e_{m1} \\ e_{mmr} \\ e_{exr} \end{bmatrix} \quad (\text{A.3})$$

29/ Method suggested by Amisano and Giannini (1997), *i.e.*, the A-B model is employed to identify the SVAR. Innovations can be represented as $Au_t = Be_t$, where u_t represents the structural error and e_t is the reduced form shocks. This strategy imposes enough restrictions on both matrices.

where, *comps* is world commodity price shocks, *fedrs* is Federal funds rate shock, *gdps* is real output (income) shock, *cpis* is price shock, *m1s* is money supply shock, *mmrs* is interest rate (monetary policy shock) and *exrs* is exchange rate shock and all are structural disturbances. e_{comp} to e_{exr} are the residuals in the reduced form equations, which represent the unexpected movements (given information in the system) of each variable. The analysis concentrates on the interaction between monetary policy and output and price developments, identified based on the structural shocks that consist several blocks.

The first two rows in matrix given by Eq. (A.3) is the exogenous block, which represents the shocks originating in the external world, and is given by world commodity prices ($COMP_t$) and the Federal funds rate ($FEDR_t$). The global commodity price of the IMF ($COMP_t$) is used instead of oil prices to isolate negative external supply shocks and it is ordered first because commodity prices are unlikely to be affected contemporaneously by any other shocks except the commodity price (supply) shocks *per se*, while commodity price shocks are likely to affect all variables in the system contemporaneously. Since the monetary authority follows a feedback rule by reacting to information in the economy when setting its monetary policy, the model is also controlled for the systematic component of the policy rule in order to identify the exogenous monetary policy changes (Kim and Roubini, 2000). Accordingly, the Federal funds rate ($FEDR_t$) is used to isolate the exogenous monetary policy changes, *i.e.*, to control for the component of domestic monetary policy that is a reaction to foreign monetary policy shocks. The identifying restriction in the equations for commodity prices and for Federal funds rates [Rows 1 and 2 in Eq. (A.3)] considers these variables as being contemporaneously exogenous to any variable in the domestic economy.

Real output (GDP_t) and prices (CPI_t) in Row 3 and 4, respectively represent goods market equilibrium. A large number of zero restrictions in these rows is consistent with a model exhibiting nominal rigidities (Elbourne and de Haan, 2006). Hence, money, interest rates or exchange rates do not affect real activity and prices contemporaneously.^{30/} However, commodity prices do enter this block, based on a cost mark-up rule for prices (Elbourne and de Haan, 2006). Furthermore, price levels respond contemporaneously to real activity as the equation for prices include, the impact of GDP on CPI. Hence, inflation reacts contemporaneously only to an income shock and a global shock (Kim and Roubini, 2000).

Money supply ($M1_t$) and the money market rate (MMR_t) in Row 5 and 6, respectively, represent money market equilibrium. The money demand equation in Row 5 indicates that demand for real money balances is dependent on real income, prices and the interest rate. This indicates that money is responsive to income, price and monetary policy

30/ Kim and Roubini (2000) assume that real activity responds to prices and financial signals only with a lag.

shocks (Chatziantoniou, Duffy, and Filis, 2013). The money market rate, *i.e.*, equation in Row 6 represents the reaction function of the monetary authority that depends on global commodity prices, monetary aggregates and nominal exchange rates (Kim and Roubini, 2000). Following Sims and Zha (1998), it is assumed that monetary policy does not respond contemporaneously to output or prices since relevant data are not available contemporaneously. Also, the reaction function of the monetary authority does not depend on current values of the Federal funds rate. One justification for this assumption is that, contemporaneously, monetary authorities care more about unexpected changes in the exchange rate (for example, against the US dollar) rather than unexpected changes in (for example, the US) interest rates per se or contemporaneously, (the US) interest rate does not have additional information for other (non-US) monetary authorities after they consider their exchange rate against foreign currency (Kim and Roubini, 2000). By including the commodity price and the exchange rate in the reaction function, it is controlled for current systematic responses of monetary policy to the state of the economy.^{31/}

Finally, Row 7 is based on an arbitrage equation describing the exchange rate market and it considers the effects of identified monetary shocks on the value of domestic currency. This equation allows the exchange rate to respond contemporaneously to all variables considering the assumption that exchange rate is a financial variable, *i.e.*, a forward looking asset price, which reacts immediately to information and hence has contemporaneous effects generated by all variables (Kim and Roubini, 2000; Elbourne and de Haan, 2006).

31/ The assumptions of Kim and Roubini (2000) for exchange rates are still valid for an emerging market economy like Sri Lanka. On the one hand, similar to many other countries, Sri Lanka has been implicitly and explicitly concerned about the effects of a depreciation of domestic currency on the developments in inflation. On the other hand, by controlling for components of interest rate movements that are systematic responses to a depreciation of the domestic currency, it is possible to identify interest rate innovations that are exogenous contractions in monetary policy and that should lead to a currency appreciation.

Appendix II

Table A.1: Estimates of 7-Variable Structural VAR Model

This table presents the estimates for 7-variable SVAR model for quarterly data for the period March 1996–December 2012). Short-run restrictions are given in matrix A. C(1) to C(12) are estimated coefficients. LR statistic is used to test for over-identification.

Model: $Ae = Bu$ where $E[uu'] = I$
Restriction Type: short-run pattern matrix

A =

	1	0	0	0	0	0	0
C(1)	1	0	0	0	0	0	0
C(2)	0	1	0	0	0	0	0
C(3)	0	C(7)	1	0	0	0	0
0	0	C(8)	C(10)	1	C(14)	0	0
C(4)	0	0	0	C(12)	1	C(16)	0
C(5)	C(6)	C(9)	C(11)	C(13)	C(15)	1	0

B =

C(17)	0	0	0	0	0	0	0
0	C(18)	0	0	0	0	0	0
0	0	C(19)	0	0	0	0	0
0	0	0	C(20)	0	0	0	0
0	0	0	0	C(21)	0	0	0
0	0	0	0	0	C(22)	0	0
0	0	0	0	0	0	C(23)	0

(Contd.)

	Coefficient	Std. Error	z-Statistic	Prob.		
C(1)	-0.865189	0.421009	-2.055037	0.0399		
C(2)	-0.038896	0.017777	-2.187993	0.0287		
C(3)	-0.102516	0.026439	-3.877503	0.0001		
C(4)	0.178616	4.364433	0.040925	0.9674		
C(5)	0.093286	0.042359	2.202275	0.0276		
C(6)	-0.004591	0.010005	-0.458852	0.6463		
C(7)	0.032250	0.178029	0.181152	0.8562		
C(8)	0.010603	0.456265	0.023239	0.9815		
C(9)	0.518216	0.248207	2.087836	0.0368		
C(10)	0.012305	0.199297	0.061742	0.9508		
C(11)	-0.303184	0.170573	-1.777449	0.0755		
C(12)	-46.629860	129.3019	-0.360628	0.7184		
C(13)	-0.074215	0.379333	-0.195646	0.8449		
C(14)	0.012854	0.021184	0.606795	0.5440		
C(15)	0.000129	0.005575	0.023103	0.9816		
C(16)	-40.409900	54.72498	-0.738418	0.4603		
C(17)	0.071399	0.006262	11.40175	0.0000		
C(18)	0.242349	0.021255	11.40175	0.0000		
C(19)	0.010233	0.000898	11.40175	0.0000		
C(20)	0.014688	0.001288	11.40175	0.0000		
C(21)	0.024948	0.016112	1.548445	0.1215		
C(22)	1.968424	2.053040	0.958785	0.3377		
C(23)	0.019505	0.003312	5.889142	0.0000		
<hr/>						
Log likelihood	674.35					
<i>L.R. test for over-identification:</i>						
Chi-square(5)	8.673		Probability	0.1395		
Estimated A matrix:						
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.865189	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.038896	0.000000	1.000000	0.000000	0.000000	0.000000	0.000000
-0.102516	0.000000	0.032250	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.010603	0.012305	1.000000	0.012854	0.000000
0.178616	0.000000	0.000000	0.000000	-46.62986	1.000000	-40.4099
0.093286	-0.004591	0.518216	-0.303184	-0.074215	0.000129	1.000000
Estimated B matrix:						
0.071399	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.242349	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.010233	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.014688	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.024948	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.968424	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.019505

Table A.2: Variance Decomposition for 7-Variable Structural VAR Model

This table presents forecast error variance decomposition of commodity price index (COMP); Federal funds rate (FEDR); output (SRI_GDP); prices (SRI_CPI); narrow money (SRI_M1); short-term interest rate (SRI_MMIR); and nominal exchange rate (SRI_EXR) for the 7-variable SVAR model. These shocks are represented as Shock 1 to Shock 7 as given in the table. Period is given by number of quarters.

Variance Decomposition of COMP:								
Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	0.0665	100.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.1030	83.78	0.01	0.82	7.11	4.79	0.03	3.46
3	0.1289	62.24	1.85	2.89	9.95	11.69	0.68	10.70
4	0.1421	51.48	7.18	2.60	9.84	15.37	2.40	11.13
5	0.1528	44.88	12.15	2.69	8.67	14.87	6.95	9.79
6	0.1627	40.38	13.61	2.89	7.68	13.53	12.34	9.58
7	0.1691	37.98	13.66	2.75	7.27	13.39	15.83	9.11
8	0.1737	36.31	13.47	2.62	7.39	15.17	16.41	8.64
9	0.1782	34.63	13.17	2.52	7.65	18.13	15.69	8.22
10	0.1821	33.22	12.87	2.46	7.76	20.76	15.05	7.88
11	0.1849	32.36	12.60	2.49	7.77	22.43	14.70	7.65
12	0.1864	31.91	12.40	2.59	7.79	23.31	14.48	7.53
13	0.1873	31.63	12.33	2.67	7.86	23.72	14.33	7.47
14	0.1881	31.38	12.46	2.68	7.99	23.84	14.22	7.44
15	0.1887	31.17	12.70	2.66	8.13	23.78	14.13	7.42
16	0.1892	31.03	12.98	2.66	8.22	23.67	14.06	7.39

Variance Decomposition of SRI_GDP:								
Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	0.0106	8.28	0.00	91.72	0.00	0.00	0.00	0.00
2	0.0133	15.68	0.87	75.02	1.18	0.48	0.59	6.18
3	0.0159	15.86	2.25	54.05	3.05	4.50	1.26	19.04
4	0.0192	12.07	3.40	41.01	6.24	8.56	0.87	27.85
5	0.0219	9.86	4.11	32.65	8.88	9.87	1.06	33.58
6	0.0243	8.52	4.22	26.43	11.29	10.69	1.39	37.46
7	0.0270	7.40	3.88	21.66	14.12	11.86	1.73	39.35
8	0.0295	6.58	3.50	18.27	16.81	12.69	1.89	40.25
9	0.0316	6.13	3.25	15.99	19.01	12.97	1.88	40.77
10	0.0331	5.90	3.10	14.56	20.83	12.93	1.85	40.84
11	0.0342	5.81	3.01	13.71	22.33	12.70	1.86	40.58
12	0.0349	5.82	2.96	13.22	23.50	12.37	1.92	40.22
13	0.0354	5.90	2.94	12.95	24.37	12.06	1.98	39.81
14	0.0358	6.02	2.94	12.84	24.96	11.82	2.03	39.39
15	0.0361	6.14	2.96	12.85	25.28	11.73	2.05	38.98
16	0.0363	6.23	3.03	12.92	25.36	11.83	2.06	38.58

Variance Decomposition of SRI_CPI:								
Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	0.0151	16.75	0.00	0.00	83.12	0.00	0.13	0.00
2	0.0211	23.94	5.77	0.08	69.72	0.07	0.42	0.00
3	0.0248	25.09	4.84	2.45	61.72	0.08	5.67	0.14
4	0.0272	25.61	4.40	3.56	54.70	0.60	10.22	1.12
5	0.0299	23.80	4.97	2.95	45.58	3.00	9.89	9.82
6	0.0330	20.69	5.55	2.56	37.40	5.24	9.58	18.98
7	0.0357	18.18	6.24	2.70	32.07	5.51	10.64	24.65
8	0.0380	16.41	7.41	2.79	28.49	4.88	11.38	28.64
9	0.0401	14.91	8.91	2.63	25.63	5.34	11.53	31.03
10	0.0422	13.46	10.39	2.40	23.08	7.84	11.35	31.48
11	0.0445	12.12	11.43	2.19	20.79	12.25	10.72	30.49
12	0.0468	11.00	11.77	2.01	18.83	17.90	9.84	28.65
13	0.0492	10.05	11.39	1.89	17.28	24.03	8.97	26.39
14	0.0515	9.21	10.59	1.80	16.22	29.91	8.18	24.08
15	0.0538	8.48	9.72	1.70	15.66	34.88	7.50	22.06
16	0.0559	7.89	9.04	1.61	15.52	38.47	6.96	20.52

Variance Decomposition of FEDR:								
Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	0.2568	6.50	93.50	0.00	0.00	0.00	0.00	0.00
2	0.4965	3.20	79.10	0.77	1.77	11.19	2.38	1.60
3	0.7376	1.53	66.44	2.53	2.21	23.46	1.65	2.18
4	0.9362	0.98	59.59	4.20	1.95	30.47	1.33	1.48
5	1.1137	0.77	53.59	5.61	2.16	35.79	0.94	1.14
6	1.2822	0.61	46.74	7.20	2.93	40.34	0.86	1.32
7	1.4467	0.48	39.97	8.28	4.24	43.91	0.92	2.20
8	1.6021	0.39	34.31	8.72	5.80	46.14	0.96	3.68
9	1.7353	0.34	30.20	9.12	7.22	47.08	1.00	5.06
10	1.8341	0.32	27.52	9.74	8.33	47.07	1.07	5.96
11	1.8975	0.32	25.90	10.44	9.16	46.50	1.19	6.48
12	1.9334	0.35	24.98	11.08	9.75	45.74	1.35	6.74
13	1.9514	0.37	24.53	11.59	10.13	45.09	1.48	6.81
14	1.9596	0.38	24.34	11.93	10.29	44.71	1.56	6.78
15	1.9656	0.39	24.23	12.09	10.28	44.67	1.58	6.75
16	1.9753	0.40	24.04	12.07	10.18	44.89	1.57	6.85

Variance Decomposition of Sri_EXR:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	0.0231	0.04	0.00	0.32	0.30	64.04	35.30	0.01
2	0.0346	1.87	1.51	0.71	6.07	73.43	15.90	0.52
3	0.0460	1.93	3.47	0.73	9.77	73.45	9.08	1.58
4	0.0543	1.44	4.73	0.56	10.28	75.02	6.55	1.42
5	0.0596	1.76	5.33	0.72	10.12	75.35	5.53	1.18
6	0.0625	2.15	5.05	1.02	10.19	75.04	5.43	1.12
7	0.0646	2.21	4.78	1.14	10.71	74.46	5.65	1.06
8	0.0663	2.11	5.00	1.09	11.60	73.62	5.57	1.02
9	0.0677	2.03	5.53	1.09	12.47	72.55	5.35	0.99
10	0.0686	1.99	6.19	1.19	12.94	71.46	5.25	0.99
11	0.0692	1.96	6.89	1.37	12.95	70.27	5.21	1.34
12	0.0701	1.91	7.61	1.68	12.63	68.72	5.10	2.35
13	0.0716	1.83	8.26	2.16	12.15	66.71	4.89	3.99
14	0.0736	1.74	8.76	2.86	11.67	64.36	4.63	5.98
15	0.0759	1.64	9.03	3.77	11.29	61.83	4.38	8.06
16	0.0782	1.55	9.06	4.80	11.06	59.23	4.18	10.13

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	0.0214	10.08	0.61	4.36	0.92	8.11	0.79	75.13
2	0.0364	7.42	0.72	2.22	6.49	18.48	0.63	64.04
3	0.0473	7.69	1.21	1.50	10.08	23.24	0.37	55.90
4	0.0559	6.67	1.66	1.48	12.11	24.10	0.30	53.69
5	0.0629	5.51	2.15	1.41	13.77	23.10	0.69	53.36
6	0.0679	4.83	2.49	1.80	15.27	21.81	1.42	52.38
7	0.0717	4.51	2.64	2.33	16.71	20.49	2.12	51.20
8	0.0748	4.40	2.74	2.49	18.12	19.31	2.51	50.43
9	0.0771	4.41	2.94	2.54	19.29	18.39	2.63	49.80
10	0.0787	4.49	3.36	2.65	20.06	17.72	2.62	49.10
11	0.0798	4.57	4.01	2.78	20.45	17.24	2.61	48.34
12	0.0806	4.64	4.82	2.90	20.54	16.91	2.62	47.56
13	0.0813	4.69	5.76	3.03	20.46	16.63	2.66	46.78
14	0.0820	4.71	6.82	3.15	20.29	16.34	2.70	45.99
15	0.0828	4.71	8.01	3.27	20.06	16.06	2.72	45.16
16	0.0837	4.66	9.29	3.41	19.77	15.87	2.73	44.26

Shock1: COMP shock
Shock2: FEDR shock
Shock3: GDP shock
Shock4: CPI shock
Shock5: M1 shock
Shock6: MMR shock
Shock7: EXR shock

Variance Decomposition of Sri_M1:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	0.0231	0.04	0.00	0.32	0.30	64.04	35.30	0.01
2	0.0346	1.87	1.51	0.71	6.07	73.43	15.90	0.52
3	0.0460	1.93	3.47	0.73	9.77	73.45	9.08	1.58
4	0.0543	1.44	4.73	0.56	10.28	75.02	6.55	1.42
5	0.0596	1.76	5.33	0.72	10.12	75.35	5.53	1.18
6	0.0625	2.15	5.05	1.02	10.19	75.04	5.43	1.12
7	0.0646	2.21	4.78	1.14	10.71	74.46	5.65	1.06
8	0.0663	2.11	5.00	1.09	11.60	73.62	5.57	1.02
9	0.0677	2.03	5.53	1.09	12.47	72.55	5.35	0.99
10	0.0686	1.99	6.19	1.19	12.94	71.46	5.25	0.99
11	0.0692	1.96	6.89	1.37	12.95	70.27	5.21	1.34
12	0.0701	1.91	7.61	1.68	12.63	68.72	5.10	2.35
13	0.0716	1.83	8.26	2.16	12.15	66.71	4.89	3.99
14	0.0736	1.74	8.76	2.86	11.67	64.36	4.63	5.98
15	0.0759	1.64	9.03	3.77	11.29	61.83	4.38	8.06
16	0.0782	1.55	9.06	4.80	11.06	59.23	4.18	10.13

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	1.4425	0.41	0.00	0.36	0.26	62.39	36.57	0.01
2	2.0010	0.22	0.45	0.19	0.57	65.25	30.67	2.65
3	2.1952	0.31	1.85	0.94	0.58	60.16	29.49	6.67
4	2.2989	0.55	4.74	1.80	0.53	55.54	26.90	9.95
5	2.4416	0.51	10.56	1.99	0.83	49.23	25.02	11.86
6	2.6139	0.51	16.61	1.73	1.60	43.17	22.70	13.67
7	2.7629	0.59	20.68	1.81	2.22	39.53	20.43	14.74
8	2.8741	0.60	22.79	2.14	2.24	39.18	18.89	14.17
9	3.0088	0.55	23.05	2.40	2.10	41.60	17.30	13.00
10	3.2108	0.48	21.70	2.65	2.48	45.18	15.23	12.27
11	3.4493	0.42	19.77	3.01	3.30	48.12	13.22	12.16
12	3.6699	0.38	18.02	3.49	4.22	49.72	11.72	12.44
13	3.8434	0.39	16.66	4.08	5.10	50.12	10.79	12.87
14	3.9668	0.42	15.67	4.67	5.91	49.74	10.30	13.30
15	4.0479	0.43	15.05	5.12	6.65	49.00	10.07	13.68
16	4.0957	0.43	14.79	5.40	7.25	48.23	9.95	13.95

Variance Decomposition of Sri_MMR:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7
1	1.4425	0.41	0.00	0.36	0.26	62.39	36.57	0.01
2	2.0010	0.22	0.45	0.19	0.57	65.25	30.67	2.65
3	2.1952	0.31	1.85	0.94	0.58	60.16	29.49	6.67
4	2.2989	0.55	4.74	1.80	0.53	55.54	26.90	9.95
5	2.4416	0.51	10.56	1.99	0.83	49.23	25.02	11.86
6	2.6139	0.51	16.61	1.73	1.60	43.17	22.70	13.67
7	2.7629	0.59	20.68	1.81	2.22	39.53	20.43	14.74
8	2.8741	0.60	22.79	2.14	2.24	39.18	18.89	14.17
9	3.0088	0.55	23.05	2.40	2.10	41.60	17.30	13.00
10	3.2108	0.48	21.70	2.65	2.48	45.18	15.23	12.27
11	3.4493	0.42	19.77	3.01	3.30	48.12	13.22	12.16
12	3.6699	0.38	18.02	3.49	4.22	49.72	11.72	12.44
13	3.8434	0.39	16.66	4.08	5.10	50.12	10.79	12.87
14	3.9668	0.42	15.67	4.67	5.91	49.74	10.30	13.30
15	4.0479	0.43	15.05	5.12	6.65	49.00	10.07	13.68
16	4.0957	0.43	14.79	5.40	7.25	48.23	9.95	13.95

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