A Vector Autoregression (VAR) Analysis of the Monetary Transmission Mechanism in Vietnam

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Abstract

Understanding the monetary transmission mechanism is crucial to central bankers. The way monetary policy is transmitted to the economy through different channels and the time it needs to take effect are both important. In this paper, I analyzed the monetary transmission mechanism in Vietnam, using the vector autoregression approach (VAR) and focusing on the reduced-form relationships between money, real output, price level, real interest rate, real exchange rate and credit. I found evidence that monetary policy can affect output and price level and that the effect of monetary policy on output was strongest after four quarters but it took longer for monetary policy to have effects on the price level, specifically from the third to the ninth quarter. However, the significance of each channel was weak and the credit and exchange rate channel appeared to be the most significant channels.

Keywords: Vector autoregression, monetary transmission mechanism, Vietnam.

1. Introduction

Monetary policy is a powerful tool in affecting the economy, therefore it is crucial to have a good understanding of the channels through which monetary policy is transmitted to the economy. Theory indicates that an increase in money supply leads eventually to an increase in aggregate demand and thus, through different channels, raises total output. Those channels include the interest rate channel, the credit channel, the exchange rate channel, and the asset price channel (Mishkin, 1995).

The analytical framework for the monetary transmission mechanism has been set forth in several studies, but most remarkably by Taylor (1995), where he proposed an empirical framework for analyzing the mechanism and pointed out several policy implications. There have been an increasing number of empirical studies on the monetary transmission mechanism, focusing mainly on the US transmission mechanism (Poddar, Sab, and Khatrachyan, 2006). Additionally, recently several authors have applied similar approaches to the analysis of their own countries. For example, Morsink and Bayoumi (2001) provided an analysis of Japan's stance; Disyatat and Vongsinsirikul (2003) analyzed the monetary policy and the transmission mechanism in Thailand; and Poddar, Sab, and Khatrachyan (2006) studied the monetary transmission mechanism in Jordan.

However, thus far the monetary transmission mechanism in Vietnam has not been studied quantitatively. The mechanism remains a "black box" to monetary policymakers at the State Bank of Vietnam (State Bank). This creates difficulties in formulating and implementing monetary policy as the significance, effect and timing of each transmission channel is not quantified. Therefore, an empirical study of the monetary transmission mechanism is timely and useful, revealing many important policy implications for Vietnam, such as whether monetary policy should target output or inflation and should the exchange rate be fixed or floated.

In this paper, I addressed the following questions: First, does an increase in the money supply affect output and price level in Vietnam? Second, how is this increase in the money supply transmitted to the economy through different channels? Finally, how long does it take for the different channels to operate? In my research, I used the vector autoregression approach (VAR), focusing primarily on the reduced-form relationships between monetary policy and output using a small number of variables such as real output, price level, money supply, real interest rate, credit to the economy, and real effective exchange rate (REER).

Basic VAR model suggested that an increase in the money supply increased real output from the first to the third quarter and price level from the third to the ninth quarter. I then added the real interest rate to the basic model to examine the effect of the interest rate channel, and found that money supply still affected output, real interest rate and price level. The real interest rate did affect real output, but the effect was not very significant. For the exchange rate channel, the real effective exchange rate affected output but was not affected by money supply. The effect of the credit channel was also insignificant, with money supply causing credit and vice versa, but credit did not affect output.

2. Channels of Monetary Transmission Mechanism

2.1. The Interest Rate Channel

According to Mishkin (2006), expansionary monetary policy (increasing money supply - M) causes the real interest rate (i_r) to fall, which means that the cost of capital is lowered. The fall in real interest rate induces businesses to increase spending on investments spending and consumers to increase their housing and durable expenditures, which are also considered investment. This increase in investment spending (I) leads in turn to an increase in aggregate demand and a rise in output (Y). This process is illustrated in the following schematic:

$$M \uparrow \Rightarrow i_r \downarrow \Rightarrow I \uparrow \Rightarrow Y \uparrow$$

2.2. The Exchange Rate Channel

According to Mishkin (2006), an increase in money supply (M) causes the domestic real interest rate (i_r) to fall. Therefore, assets which are denominated in domestic currency are less attractive than assets denominated in foreign currency, resulting in a depreciation of domestic currency (E). The depreciation of the domestic currency makes domestic goods relatively cheaper than foreign goods, thereby causing net export (NX) and output to rise. This is demonstrated in the following schematic:

$$M \uparrow \Rightarrow i_r \downarrow \Rightarrow E \downarrow \Rightarrow NX \uparrow \Rightarrow Y \uparrow$$

2.3. Other Asset Price Channels

These channels operate mainly through two effects: Tobin's q theory of investment and wealth effects on consumption (Mishkin, 1995). According to Tobin (1969), q is defined as the market value of a firm divided by the replacement cost of capital. If q is high, the replacement cost of capital is low compared with the market value of the firm. This enables the firm to buy more plant and equipment with their now higher-value equity. Thus, investment spending increases. Conversely, if q is low, then the market value of the firm is also low in comparison with the replacement cost of capital and the firm will not purchase investment goods. Thus, investment decreases.

In the monetarist view, this effect is explained by the fact that if money supply decreases, the public has less money and wants to try to decrease their spending. One way to do this is to reduce the amount of money invested in the stock market, thus depressing the demand for and the price of equities (P_e). Combining this with Tobin's q effect, this channel is expressed in the following schematic:

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow q \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$$

The wealth effect on consumption is based on the life-cycle model of Modigliani (1971). In his model, consumers determine their consumption spending by considering their lifetime resources, including human capital, real capital, and financial wealth. Common stocks are a major component of consumers' financial wealth. When stock prices decrease, consumers' wealth also decreases and they spend less on consumption. Because a contractionary monetary policy can result in lower stock price, the process is seen in the following schematic:

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow \text{wealth} \downarrow \Rightarrow \text{consumption} \downarrow \Rightarrow Y \downarrow$$

2.4. The Credit Channel

This channel mainly involves with the agency problems arising from asymmetric information and costly enforcement of contracts in the financial market. The credit channel operates via two main channels, that are the bank lending channel and the balance-sheet channel (Mishkin, 1995).

A decrease in money supply leads to a decrease in bank deposits, which further decreases the volume of money that banks have to loan out. This, in turn, decreases investment and, ultimately, aggregate demand. This channel allows monetary policy to operate without interest rate, meaning that decreasing interest rates may not be sufficient to increase investment. However, it is worth noting that, with financial innovation, the significance of this channel has been doubted (Mishkin, 1995). The schematic for the bank lending channel is as follows:

$$M \downarrow \Rightarrow \text{bank deposits} \downarrow \Rightarrow \text{bank loans} \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$$

The balance-sheet channel operates through the net worth of firms, with the effects of adverse selection and moral hazard. A decrease in the firm's net worth means that lenders can rely on lower collateral for their loans, which raises the problem of adverse selection and reduce lending for investment spending. Lower net worth also results in the problem of moral hazard because business owners have a lower equity stake in the firm and, therefore, have incentive to take part in risky projects. As a result, lending and investment spending decreases (Mishkin, 1995). The ways monetary policy affect firms' balance-sheets are as follows:

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow \text{adverse selection \& moral hazard} \uparrow \Rightarrow \text{lending} \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$$

A tightened monetary policy leads to a decrease in the prices of equities (P_e), raising the problems of adverse selection and moral hazard. As a result, lending for investment spending decreases.

$$M \downarrow \Rightarrow i \uparrow \Rightarrow \text{cashflow} \downarrow \Rightarrow \text{adverse selection \& moral hazard} \uparrow \Rightarrow \text{lending} \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$$

Contractionary monetary policy increases the interest rate, which in turn increases the problems of adverse selection and moral hazard. Similar to a tightened monetary policy, when a contractionary policy is implemented, lending and investment spending decrease.

3. The Conduct of Monetary Policy in Vietnam

3.1. Legal Framework of the State Bank of Vietnam and Monetary Policy

The legal framework for the State Bank was formed by the "Law on the State Bank of Vietnam" (enacted in 1996 and amended in 2003) and other regulations. According to the law, the State Bank is a government agency and the central bank of the Socialist Republic of Vietnam. The State Bank is responsible for exercising state management in the monetary and banking fields and acts as the currency issuing bank, the bank of credit institutions, and the bank of the government. Its activities aim at stabilizing the value of the currency, safeguarding banking activities and the banking system, and contributing to socio-economic development within the context of the country's socialist orientation. Headquartered in Hanoi, it is a legal entity whose capital belongs to the state (State Bank of Vietnam [SBV], 2003).

As stipulated by the "Law on the State Bank of Vietnam," the process of monetary policy formulation involves the National Assembly, the Government, the National Monetary Policy Advisory Board (NMPAD), and the State Bank. The NMPAD is chaired by a deputy Prime Minister; its members include the Governor of the State Bank, the Minister of Finance, and other experts.

Every year, the State Bank prepares a report on the implementation of the previous year's monetary policy and the monetary outlook for the next year. The State Bank then submits a projection for the next year's monetary policy to the government for consideration and approval. After consulting with the NMPAD, the government submits the projection to the National Assembly for final approval.

Once the draft receives the National Assembly's approval, the State Bank of Vietnam will conduct the implementation of the monetary policy and reports to the government and the National Assembly the policy's progress as well as any adjustments necessary to suit the development of the money market.

In reviewing the regulation process, it is obvious that the State Bank has little autonomy or control over monetary policy. The main responsibility for monetary policy lies with the National Assembly, which decides the annual rate of expected inflation, credit and money growth.

3.2. Instruments of Monetary Policy in Vietnam

Discount Policy

The State Bank has two lending facilities, a refinancing facility and a discount facility. Both are collateralized, but the latter gives commercial banks access to funds subject to quotas. Discount operations can take the form of either an outright purchase of securities or a repurchase agreement. The maximum maturity of the repurchase agreement is ninety-one days. The refinancing rate is the upper interest rate and the discount rate the lower rate for lending from the State Bank.

Recently, the State Bank has actively used both the refinance and discount rates to tighten monetary policy. In January and March 2005, they were increased together by one percentage point so that, as of 1 April 2005, the refinance and discount rates are 6% and 4% per annum, respectively (SBV, 2005).

Open Market Operations

The State Bank started using open market operations in July 2000. Over the years, these types of operations have gained in importance and now have become the single most important monetary instrument for controlling liquidity. This is evidenced by fact that, of the total liquidity injected into the market by the State Bank, open market purchases provided close to 80% in 2003, compared to about 39% in 2002. Open market operations take the form of outright sales and purchases of securities or repurchase agreements. The purchase or sale of securities may be in the form of auctions by volume or by interest rate. Securities eligible for open market transactions are primarily government securities, State Bank bills, or securities that have been selected by the State Bank. Initially only short-term securities could be used for open market transactions, but since the 2003 amendment of the "Law on the State Bank of Vietnam," securities with a maturity of more than one year are also eligible. Auctions take place three times a week, and, in 2004, the State Bank launched a web-based auction system.

Reserve Requirements

The State Bank has been using required reserves in various forms since the 1990s and changes of reserve requirements for deposits have been considered an important instrument of monetary policy in the past.

Currently, reserve requirements are classified according to the maturity of deposits, the sectoral focus of banks, and whether a deposit is denominated in domestic or foreign currency. Reserve requirements for deposits of less than one year are higher than those for deposits of more than one year; and lower still for banks that are active in the agricultural sector and for

People's Credit Funds. The State Bank currently pays interest of 1.2% on required reserves in Vietnamese dong (VND) and 0% on excess reserves. Conversely, it does not pay any interest on required reserves in US dollars (USD), but does pay 1% on excess reserves held in USD.

During recent years, reserve requirements have been raised several times to tighten monetary policy. In June 2004, reserve requirements on short-term VND and foreign currency deposits were increased from 2% to 5% and from 4% to 8%, respectively; those on longer-term VND and foreign currency deposits were increased from 1% to 2%. In June 2007, the State Bank doubled the reserve requirements to 10% to cope with heightened inflationary pressure.

4. Empirical Evidence from VAR

4.1. Literature Review

There have been a growing number of studies done on the monetary transmission mechanism, mainly dealing with the US transmission mechanism. Generally speaking, studies in this field mainly used the VAR approach and focused primarily on the reduced-form relationships between monetary policy and output using a small number of variables such as, real output, inflation, interest rate, credit growth, REER, foreign reserve, and stock index. However, recently, several authors have applied similar approaches to analyses of their own countries. For example, Morsink and Bayoumi (2001) provided an analysis of Japan's stance; Disyatat and Vongsinsirikul (2003) analyzed the monetary policy and the transmission mechanism in Thailand; Poddar, Sab, and Khatrachyan (2006) studied the monetary transmission mechanism in Jordan; and Hwee (2004) analyzed the monetary transmission mechanism in Singapore.

Morsink and Bayoumi (2001) used VAR models with quarterly, seasonally-adjusted data from 1980Q1 to 1998Q3, using two lags to analyze the effect of monetary shock on the economy. In their basic model, they used economic activity, prices, interest rates, and broad money. They found that both interest rate and broad money significantly affect output. Then, after examining the basic model, they extended the VAR to examine different channels of the monetary transmission mechanism and concluded that both monetary policy and banks' balance sheets are important sources of shocks to output, that banks play a crucial role in transmitting monetary shocks to economic activity, and that business investment is especially sensitive to monetary shocks.

In their analysis, Disyatat and Vongsinsirikul (2003) also used the VAR approach with quarterly, seasonally-adjusted data from 1993Q1 to 2001Q4 with two lags to analyze the monetary transmission mechanism in Thailand. Their basic model included real output, price level, and the fourteen-day repurchase rate, which they assumed to be the measure of monetary policy. They found that tightening monetary policy led to a decrease in output, which bottomed out after around 4–5 quarters and dissipated after approximately eleven quarters. The aggregate price level initially responded very little, but ultimately started to decline after about a year. Investment appeared to be the most sensitive component of gross domestic product (GDP) to monetary policy shocks. Their findings were consistent with those of other countries and with what monetary theory suggests.

In the case of Jordan, the results were different. Poddar, Sab, and Khatrachyan (2006) found no evidence of monetary policy affecting output. However, Jordan's monetary policy, which is measured by the spread between the three-month CD rate and the US Federal Funds rate, was effective in influencing foreign reserves. Other channels, like equity prices and exchange rate, were not significant channels for transmitting monetary policy to economic activity. The effect of monetary policy on the stock market also seemed insignificant.

In Singapore, Hwee (2004) used the real effective exchange rate as a measure for monetary policy and found that output reacted immediately and significantly to a contractionary monetary policy shock. He also found that the exchange rate channel was more effective in transmitting monetary policy to the economy than was the interest rate channel.

4.2. Data Description

In my analysis of Vietnam, I used quarterly, seasonally-adjusted data from 1996Q1 to 2005Q4. The dataset included the following variables:

output:	Real industrial output (constant 1994 price)
cpi:	Consumer Price Index (CPI), (2000=100)
m2:	Broad money, measured in billions of VND
irate:	Real lending rate, which equals bank lending rate minus inflation rate in the same period
credit:	Domestic credit, measured in billions of VND
reer:	Index of REER (1996=100)
oil:	World oil price, in USD/barrel
rice:	Rice price, in USD/ton
ffr:	Federal Funds rate, in percentage

These variables are taken from the International Monetary Fund's (IMF) International Financial Statistics (IFS), except for *output* (from the Vietnam General Statistics Office) and *reer* (CPI-based, calculated with data collected from IMF's IFS and Direction of Trade databases). I took industrial output as a proxy for GDP because quarterly data on GDP for Vietnam was only available from the year 2000. The summary statistics for these variables are presented in Table 1 (Appendix A).

4.3. Methodology

I used VAR, impulse response function, the Granger causality test, and variance decomposition to analyze the effect of monetary shocks on output. Then I added other variables to the basic model to examine the effects of specific channels, namely the interest rate channel, the credit channel, and the exchange rate channel. I did not analyze the effect of the asset channel because the stock market in Vietnam was only just established in 2000 and has been, thus far, subjected to speculative pressure from domestic investors.

The Augmented Dickey-Fuller test showed that all the variables are nonstationary (Table 2, Appendix A). Therefore, I decided to transform the variables to eliminate nonstationarity by taking differences of the natural logarithm of the variables and multiplying by 100—in other words, running VAR in percentage changes of the variables. After transforming, all the variables were stationary (Table 2, Appendix A). The summary statistics for the variables in percentage change are presented in Table 1 (Appendix A).

The optimal lag lengths for the VAR model suggested according to different criteria were mixed; therefore I decided to use 4 lags in the basic and extended models (Table 3, Appendix A).

4.4. Basic VAR Model

I ran the basic VAR with the order of endogenous variables (*output, cpi, m2*) and a vector of exogenous variables (*oil, rice, ffr*). The ordering of the variables was based on the assumption that a shock to the monetary policy would be transmitted to price level and output.

The variables *oil, rice,* and *ffr* were put into the model as exogenous because I wanted to control for external shocks, taking into consideration the openness of Vietnam's economy and the use of the USD/VND exchange rate as a nominal anchor in monetary policy.

As suggested by Taylor (1995), in analyzing the monetary transmission mechanism, one should focus on "*financial market prices*—short-term interest rates, bond yields, exchange rates, and so on—rather than on *financial market quantities*—the money supply, bank credit, the supply of government bonds, foreign denominated assets, and so on." However, the prime interest rate that the State Bank frequently announces does not reflect the supply of and demand for money in the money market. Rather, it serves as a reference rate for commercial banks in setting their own deposit and lending rates. Therefore, interest rates do not seem to be a suitable representative of the monetary policy stance in Vietnam. For the purposes of my analysis, I took the broad money variable *m2* as a proxy for monetary policy shocks because the growth rate of M2 is considered as an operating target in formulating and implementing monetary policy at the State Bank of Vietnam (SBV, 2003).

Monetary theory suggests that an increase in money leads to an increase in output and price level. In my analysis, the impulse response functions of the basic model (Figure 1, Appendix B) showed that a positive shock to money led to a positive response of output from the first quarter to the third quarter. Moreover, price level also responded positively to the positive shock of money from the third quarter until the ninth quarter; however, the response was not significant. This complies with what macroeconomics often refers to as "prices stickiness."

The Granger causality test (Table 4, Appendix A) showed that money (*m2*) Granger caused output (*output*) at 5% significance level. However, in the basic model, neither money nor output Granger caused the price level (*cpi*). This is in some extent contradictory to monetary theory but can be explained partly by the fact that industrial output is not a perfect proxy of GDP. Moreover, price level, which is represented by the CPI, was also affected by other factors, such as prices of imported goods and fluctuations of the nominal exchange rate and not much affected by industrial output.

Variance decomposition showed that money shocks are a very important source of fluctuations in output, accounting for 44.24% shocks in output after four quarters (Table 8, Appendix A), while own shocks accounted for 50.18% and price level accounted for only 5.58%. For price level, own shocks accounted for most of the shocks—82.2%—while money accounted for only 0.64% and output accounted for 17.16%. This result suggested that money can affect output but has little effect on price level.

4.5. Interest Rate Channel

In order to analyze the effect of the traditional interest rate channel, I added the variable real lending rate (*irate*), which is equal to the bank lending rate minus inflation in the same period, to the basic model. Now, the ordering of VAR was *output, cpi, irate,* and *m2* as endogenous variables and *oil, rice, and ffr* as a vector of exogenous variables. This ordering reflected the fact that a change in the money supply would affect the real interest rate, which would, in turn, affect investment. According to traditional Keynesian economics, an increase in real interest rate discourages investment and eventually leads to a decrease in output.

The Granger causality test (Table 5, Appendix A) showed that when the real lending rate was added to the model, *m2* still Granger caused *output* at 5% significance level. However, *m2* neither Granger caused interest rate nor price level. Moreover, the interest rate did not Granger cause money, output, or price level. This is explained by the fact that interest rates were not liberalized in Vietnam until recently and do not fully reflect the demand for and supply of money in the money market.

The impulse response functions (Figure 2, Appendix B) suggested that a positive shock to the real lending rate led to a decrease in output from the first to the third quarter. A positive shock to money supply (expansionary monetary policy) decreased the real lending rate, from the second to the sixth quarter, and increased output from the first through the third quarter. This evidence supported monetary theory, which suggests that expansionary monetary policy causes the interest rate to fall and thus encourage investment, which in turn increases aggregate demand and output. However, the timing of the responses in the real lending rate and output were different, where output reacted to the money supply faster than the interest rate did. Increasing the real lending rate caused price level to rise from the first to the sixth quarter, then to fall from the seven to the tenth quarter. Money supply also responded negatively to an increase in the real lending rate, from the first to the third quarter.

Variance decomposition (Table 9, Appendix A) showed that in adding the real lending rate to the basic model, 48.06% of the shocks in output after four quarters were due to shocks in money supply, which was higher than that in the basic model. However, the real lending rate accounted for only 3.63% of the shock in output, meaning that the significance of the interest rate channel might be small. In the long run, money appeared to be a significant source of the increase in the price level. It accounted for 12.37% shocks in price level after twelve quarters. However, aggregate demand appeared to be an important determinant of inflation, which accounted for 31.59% of the shocks in price level after only four quarters.

4.6. Exchange Rate Channel

In order to analyze the effect of the exchange rate channel, I added the real effective exchange rate (*reer*) to the basic model. The ordering of the model was *output*, *cpi*, *reer*, and *m2* as endogenous and *oil*, *rice*, and *ffr* as exogenous, based on the assumption that increasing money supply would lead to a depreciation of domestic currency, thus boosting net export and aggregate demand. However, I found that this channel was not very significant due to the existence of capital controls and the rigid exchange rate regime in Vietnam.

The impulse response functions in Figure 3 (Appendix B) showed that a positive shock to the real effective exchange rate (real appreciation) led to a decrease in output from the first through the fourth quarter. Output still responded positively from the first through the third quarter to a positive shock in money supply. This result supported what theory suggests. However, a positive shock to the money supply caused the real effective exchange rate to appreciate from the first to the second quarter, then to depreciate from the third to the fourth quarter, which seemed contradictory to what theory suggests.

The Granger causality test (Table 6, Appendix A) showed that when adding the real effective exchange rate to the basic model, money supply still Granger caused output and now price level also Granger caused output. The real effective exchange rate only Granger caused output at 10% significance level. However, money supply did not Granger cause the real effective exchange rate. This can be explained by the fact that until recently, the State Bank maintained a rather rigid exchange rate regime, where the nominal exchange rate was allowed to fluctuate only within a narrow range.

Variance decomposition (Table 10, Appendix A) showed that both the real effective exchange rate and money supply were important sources of shocks in output. After four quarters, money supply accounted for 28.03% of the shocks in output, whereas the real effective exchange rate accounted for 26.12% of the shocks in output after five quarters. However, money supply accounted for only 5.57% of the shocks in the real effective exchange rate after four quarters while own shocks and shocks in the price level accounted for 51.5% and 41.22%, respectively. Output appeared to contribute little to the shocks in the real effective exchange rate, only 1.71% after four quarters.

4.7. Credit Channel

As suggested by Mishkin (1995), the credit channel operates through two main channels—the balance sheet channel and the bank lending channel. In analyzing the balance sheet channel, Bernanke and Gertler (1995) focused on the external finance premium, which they defined as the wedge between the cost of funds raised externally and the opportunity cost of internal funds. However, in Vietnam this channel may be insignificant because, until recently, most credits were given to large, state-owned enterprises according to government directives without consideration of their financial positions.

To analyze the credit channel, I added the domestic credit variable to the basic VAR model. The ordering of the VAR was *output*, *cpi*, *credit*, and *m2*, based on the assumption that an increase in the money supply would lead to an increase in credit and eventually to an increase in aggregate demand and output. The VAR model also contained a vector of exogenous variables, including *oil*, *rice*, and *ffr*.

The Granger causality test in Table 7 (Appendix A) showed that money supply still Granger caused output at 5% significance level. However, credit Granger caused neither output nor price level but did Granger cause money supply. This reflected the fact that the State Bank used mainly credit as a channel to inject liquidity into the market.

Theory suggests that increasing money supply increases the total credit that banks can supply to the economy and, through the bank lending channel, will in turn boost aggregate demand and output. In my analysis, impulse response functions (Figure 4, Appendix B) showed that a positive shock to domestic credit increased output from the first to the third quarter. Output still responded positively to a positive shock in money supply. Also, a positive shock in money supply increased credit from the first to the third quarter. Remarkably, money supply responded significantly to a positive shock in the credit.

In Table 11 (Appendix A), variance decomposition showed that, after eight quarters, credit accounted for 23.08% of the shocks in output, while money supply accounted for only 13.17% of the shocks in output after four quarters. Credit also accounted for 62.15% of the shocks in money supply.

5. Conclusion

My analysis showed that monetary policy did affect output and price level and that the effect of monetary policy was strongest after four quarters; however, the significance of each channel was weak. Basic VAR model suggested that an increase in money supply increased real output from the first to the third quarter and price level from the third to the ninth quarter. When adding real interest rate to the basic model to examine the effect of the interest rate channel, money supply still affected output and real interest rate. The real interest rate affected real output, but the effect was not very significant. For the exchange rate channel, the real effective exchange rate did affect output but was not affected by money supply. The credit channel was also insignificant, with money supply causing credit and vice versa, but credit did not affect output.

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Appendix A: Tables

Table 1. Summary Statistics of the Variables

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Obs.
In level						
OUTPUT	61827.01	55203.43	120663.3	28398.60	27232.04	39
CPI	103.1740	100.8558	128.6603	88.23409	10.20717	39
M2	238101.1	213453.8	636762.8	50619.41	168142.8	39
REER	98.62579	98.31585	113.4883	88.16898	5.568012	39
IRATE	10.83745	9.623981	19.71921	6.440278	3.249083	39
CREDIT	192970.2	165199.3	584006.1	22688.75	159939.3	39
OIL	27.03983	26.07000	59.96330	11.64330	11.59889	39
RICE	246.6716	246.5830	342.1330	164.7070	54.69332	39
FFR	3.817521	4.733330	6.520000	0.996667	1.905454	39
In % change						
PC_OUTPUT	3.807010	4.651403	10.62698	-8.26111	3.522909	38
PC_CPI	0.986811	1.029158	3.329325	-1.19715	1.107763	38
PC_M2	6.663323	6.360483	28.76148	1.950645	4.064888	38
PC_IRATE	-2.02846	-1.28835	24.29948	-25.7237	11.35459	38
PC_REER	-0.04589	0.115061	7.584238	-7.27387	3.319504	38
PC_CREDIT	8.547479	6.522036	68.72253	-0.11358	11.14978	38
PC_FFR	-0.72987	0.211328	35.14013	-49.4127	15.64495	38
PC_OIL	2.803511	4.305816	31.97310	-28.5328	12.69881	38
PC_RICE	-0.43602	0.278831	12.55798	-15.887	7.555437	38

Table 2. Augmented Dickey-Fuller Test

Variable	Lag length	Exogenous	t-statistic	p-value
1. Data in level				
OUTPUT	0	c	3.325627	1.0000
CPI	1	c	1.191122	0.9975
M2	0	c	9.918067	1.0000
IRATE	0	c	-2.881207	0.0570
REER	0	c	-1.985176	0.2919
CREDIT	0	c	7.659496	1.0000
2. Data in % change				
PC_OUTPUT	0	c	-6.896093	0.0000
PC_CPI	0	c	-2.671783	0.0883
PC_M2	0	c	-4.719655	0.0005
PC_IRATE	0	c	-6.728744	0.0000
PC_REER	0	c	-7.310975	0.0000
PC_CREDIT	0	c	-7.396318	0.0000

Table 3. Lag Length Selection of the Basic and Extended Models.

Basic Model:

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-235.1408	NA	273.6119	14.12233	14.65559*	14.30641
1	-223.2690	18.99486	235.3314	13.95823	14.89144	14.28037*
2	-220.2227	4.351910	341.6829	14.29844	15.63160	14.75865
3	-204.8113	19.37432*	252.2316	13.93207	15.66518	14.53034
4	-192.2303	13.65935	228.8619*	13.72745*	15.86050	14.46378

Interest Rate Channel:

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-354.3412	NA	34120.33	21.78478	22.50307	22.02973
1	-307.9705	70.91996*	5899.927*	19.99826	21.43484*	20.48818*
2	-300.4601	9.719307	10646.77	20.49765	22.65252	21.23252
3	-280.0063	21.65698	9957.244	20.23566	23.10881	21.21549
4	-253.1115	22.14866	7609.178	19.59479*	23.18623	20.81958

Exchange Rate Channel

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-324.8875	NA	3400.874	19.47928	20.19030*	19.72473*
1	-307.2128	27.26942*	3181.043*	19.38359	20.80562	19.87448
2	-299.5922	10.01570	5578.414	19.86241	21.99546	20.59874
3	-275.7927	25.83944	4262.548	19.41673	22.26079	20.39850
4	-249.5736	22.47353	3317.518	18.83278*	22.38786	20.05999

Credit Channel:

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-363.1502	NA	30279.63	21.66573	22.37674	21.91117
1	-344.8843	28.18170	27381.40	21.53625	22.95828	22.02713
2	-305.1560	52.21437*	7666.302	20.18034	22.31339*	20.91667
3	-283.0527	23.99780	6454.164	19.83159	22.67565	20.81336
4	-260.3850	19.42947	6153.449*	19.45057*	23.00565	20.67779*

Note: * Indicates lag order selected by the criterion; LR: sequential modified LR test statistic (each test at 5% level); FPE: Final Prediction Error; AIC: Akaike Information Criterion; SC: Schwarz Information Criterion; HQ: Hannan-Quinn Information Criterion.

Table 4. Granger Causality Test – Basic Model

Dependent variable: PC_OUTPUT

Excluded	Chi-sq	df	Prob.
PC_CPI	5.025384	4	0.2847
PC_M2	24.18330	4	0.0001
All	28.39364	8	0.0004

Dependent variable: PC_CPI

Excluded	Chi-sq	df	Prob.
PC_OUTPUT	2.794857	4	0.5927
PC_M2	0.459345	4	0.9773
All	3.231149	8	0.9190

Dependent variable: PC_M2

Excluded	Chi-sq	df	Prob.
PC_OUTPUT	5.076791	4	0.2795
PC_CPI	7.026200	4	0.1345
All	9.425454	8	0.3077

Table 5. Granger Causality Test – Interest Rate Channel

Dependent variable: PC_OUTPUT			
Excluded	Chi-sq	df	Prob.
PC_CPI	3.570372	4	0.4673
PC_IRATE	4.362027	4	0.3592
PC_M2	18.23518	4	0.0011
All	32.09678	12	0.0013
Dependent variable: PC_CPI			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	5.098436	4	0.2773
PC_IRATE	5.880666	4	0.2082
PC_M2	1.285036	4	0.8639
All	9.461846	12	0.6631
Dependent variable: PC_IRATE			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	5.456380	4	0.2436
PC_CPI	4.075667	4	0.3959
PC_M2	1.311791	4	0.8594
All	13.45744	12	0.3367
Dependent variable: PC_M2			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	4.690865	4	0.3205
PC_CPI	4.069292	4	0.3967
PC_IRATE	2.958016	4	0.5649
All	11.37524	12	0.4971

Table 6. Granger Causality Test – Exchange Rate Channel

Dependent variable: PC_OUTPUT			
Excluded	Chi-sq	df	Prob.
PC_CPI	10.40083	4	0.0342
PC_REER	9.397338	4	0.0519
PC_M2	25.29281	4	0.0000
All	45.85677	12	0.0000
Dependent variable: PC_CPI			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	2.813173	4	0.5896
PC_REER	1.307669	4	0.8601
PC_M2	0.642305	4	0.9582
All	4.080959	12	0.9819
Dependent variable: PC_REER			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	1.942226	4	0.7464
PC_CPI	3.575462	4	0.4665
PC_M2	1.492550	4	0.8280
All	8.549864	12	0.7408
Dependent variable: PC_M2			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	2.715141	4	0.6066
PC_CPI	7.180492	4	0.1267
PC_REER	4.232245	4	0.3755
All	13.77291	12	0.3154

Table 7. Granger Causality Test – Credit Channel

Dependent variable: PC_OUTPUT			
Excluded	Chi-sq	df	Prob.
PC_CPI	7.270965	4	0.1222
PC_CREDIT	3.992701	4	0.4070
PC_M2	19.83151	4	0.0005
All	32.37544	12	0.0012
Dependent variable: PC_CPI			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	1.845715	4	0.7641
PC_CREDIT	0.880519	4	0.9273
PC_M2	0.319391	4	0.9885
All	3.581168	12	0.9899
Dependent variable: PC_CREDIT			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	5.289263	4	0.2589
PC_CPI	6.247168	4	0.1814
PC_M2	5.040856	4	0.2831
All	18.87838	12	0.0915
Dependent variable: PC_M2			
Excluded	Chi-sq	df	Prob.
PC_OUTPUT	4.285960	4	0.3687
PC_CPI	1.796952	4	0.7730
PC_CREDIT	99.74396	4	0.0000
All	156.6657	12	0.0000

Table 8. Variance Decomposition – Basic Model

Variance Decomposition of PC_OUTPUT:

Period	S.E.	PC_OUTPUT	PC_CPI	PC_M2
1	2.531301	100.0000	0.000000	0.000000
4	4.250921	50.17867	5.578518	44.24281
8	4.884607	45.09337	13.60534	41.30129
12	5.050159	43.42043	13.58206	42.99751

Variance Decomposition of PC_CPI:

Period	S.E.	PC_OUTPUT	PC_CPI	PC_M2
1	0.897993	8.356039	91.64396	0.000000
4	1.251890	17.15812	82.19844	0.643435
8	1.309995	17.69901	77.37377	4.927222
12	1.316514	17.90684	76.86665	5.226503

Variance Decomposition of PC_M2:

Period	S.E.	PC_OUTPUT	PC_CPI	PC_M2
1	4.177275	8.634223	1.840927	89.52485
4	5.140451	16.51359	19.12127	64.36515
8	5.421916	19.94445	18.74922	61.30633
12	5.510154	20.24798	18.93506	60.81695

Cholesky Ordering: PC_OUTPUT PC_CPI PC_M2

Table 9. Variance Decomposition – Interest Rate Channel

Variance Decomposition of PC_OUTPUT:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_IRATE	PC_M2
1	2.566654	100.0000	0.000000	0.000000	0.000000
4	4.493872	44.09496	4.212760	3.627896	48.06438
8	5.305756	36.93716	12.86560	3.877325	46.31992
12	5.581538	34.90629	15.30198	3.712484	46.07925
Variance Decomposition of PC_CPI:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_IRATE	PC_M2
1	0.866815	12.65819	87.34181	0.000000	0.000000
4	1.327807	31.59659	61.71975	3.465880	3.217779
8	1.444533	32.20745	53.93650	3.890664	9.965380
12	1.501948	31.23401	51.83905	4.560417	12.36652
Variance Decomposition of PC_IRATE:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_IRATE	PC_M2
1	10.16935	1.862046	83.96790	14.17005	0.000000
4	11.89440	3.979972	69.20432	18.49249	8.323211
8	14.00503	9.984913	61.73428	15.81846	12.46235
12	15.85806	15.49202	51.22953	14.30347	18.97498
Variance Decomposition of PC_M2:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_IRATE	PC_M2
1	4.421171	1.894707	1.121246	0.415475	96.56857
4	5.758152	17.03740	15.40825	3.583754	63.97060
8	6.357110	21.62277	14.67243	4.055286	59.64952
12	6.542640	21.55338	15.16488	4.413562	58.86818
Cholesky Ordering: PC_OUTPUT PC_CPI PC_IRATE PC_M2					

Table 10. Variance Decomposition – Exchange Rate Channel

Variance Decomposition of PC_OUTPUT:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_REER	PC_M2
1	2.233826	100.0000	0.000000	0.000000	0.000000
4	3.999364	47.12915	16.09084	8.750082	28.02992
8	5.318727	31.47089	21.19882	26.08166	21.24863
12	5.528928	29.47616	22.32137	27.37815	20.82431
Variance Decomposition of PC_CPI:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_REER	PC_M2
1	0.969290	8.337146	91.66285	0.000000	0.000000
4	1.435057	15.18630	78.11890	5.672713	1.022079
8	1.530718	16.15263	69.35658	10.26827	4.222520
12	1.549593	16.33088	68.11458	11.05373	4.500803
Variance Decomposition of PC_REER:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_REER	PC_M2
1	3.877867	0.379133	21.39136	78.22951	0.000000
4	4.884887	1.710701	41.22437	51.49840	5.566532
8	5.212970	4.934498	40.16794	48.61805	6.279508
12	5.420560	5.808026	38.26282	46.89624	9.032918
Variance Decomposition of PC_M2:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_REER	PC_M2
1	4.151977	31.38383	5.840761	0.348950	62.42646
4	5.312988	24.49584	16.09132	20.22519	39.18766
8	5.897219	22.59448	16.15833	27.84864	33.39855
12	6.117772	21.65463	17.18112	29.82214	31.34212
Cholesky Ordering: PC_OUTPUT PC_CPI PC_REER PC_M2					

Table 11. Variance Decomposition – Credit Channel

Variance Decomposition of PC_OUTPUT:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_CREDIT	PC_M2
1	2.531787	100.0000	0.000000	0.000000	0.000000
4	3.717905	65.98112	17.03372	3.812860	13.17231
8	4.928847	43.55862	23.84875	23.08519	9.507444
12	5.396613	39.47116	30.59954	20.76617	9.163129
Variance Decomposition of PC_CPI:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_CREDIT	PC_M2
1	0.982240	6.075471	93.92453	0.000000	0.000000
4	1.330438	13.80681	81.98439	2.662838	1.545959
8	1.384798	15.86257	77.36889	3.397911	3.370622
12	1.404659	15.50260	76.29815	4.701342	3.497916
Variance Decomposition of PC_CREDIT:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_CREDIT	PC_M2
1	9.184155	0.532259	13.54592	85.92182	0.000000
4	12.54463	4.131389	26.31545	63.47617	6.076991
8	16.20224	5.496640	38.16399	51.40943	4.929946
12	17.63511	5.765780	43.64159	46.30266	4.289970
Variance Decomposition of PC_M2:					
Period	S.E.	PC_OUTPUT	PC_CPI	PC_CREDIT	PC_M2
1	1.699828	8.628700	0.189504	8.219680	82.96212
4	4.006908	5.978526	13.39855	57.13775	23.48517
8	5.100115	12.41268	32.01033	38.31414	17.26285
12	5.496793	11.03631	35.98710	36.05111	16.92548
Cholesky Ordering: PC_OUTPUT PC_CPI PC_CREDIT PC_M2					

Appendix B: Figures

Figure 1. Impulse Response Functions – Basic Model

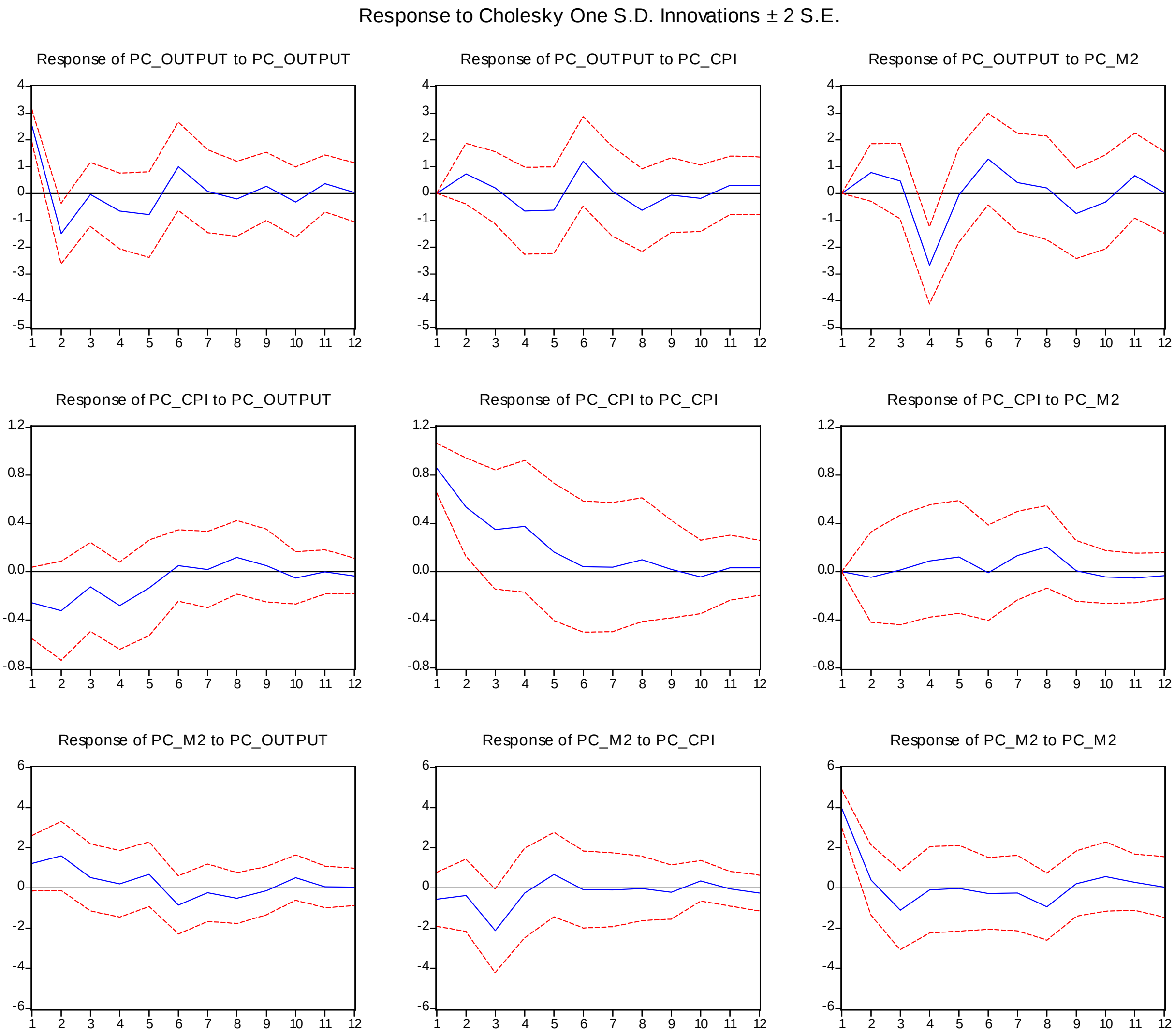

Figure 2. Impulse Response Functions – Interest Rate Channel

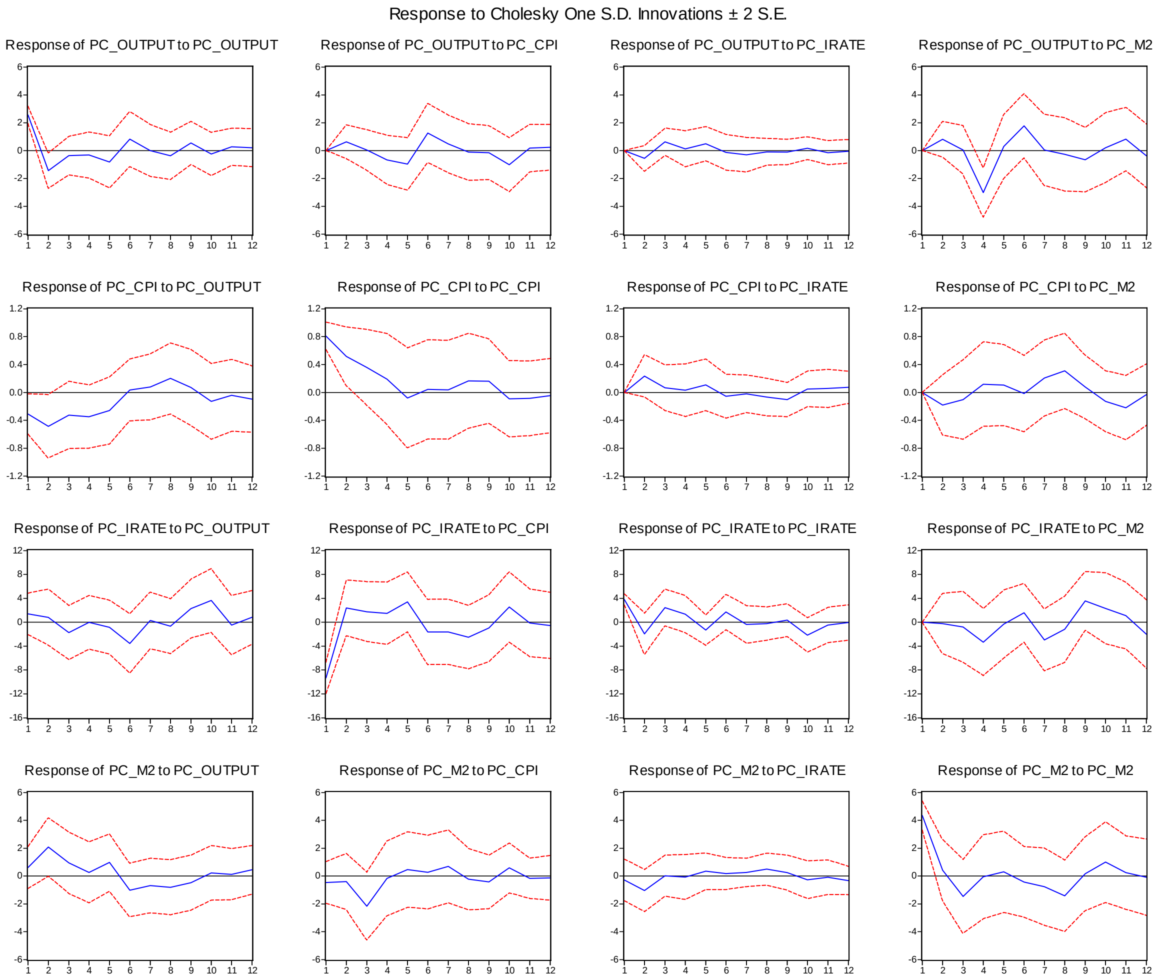

Figure 3. Impulse Response Functions – Exchange Rate Channel

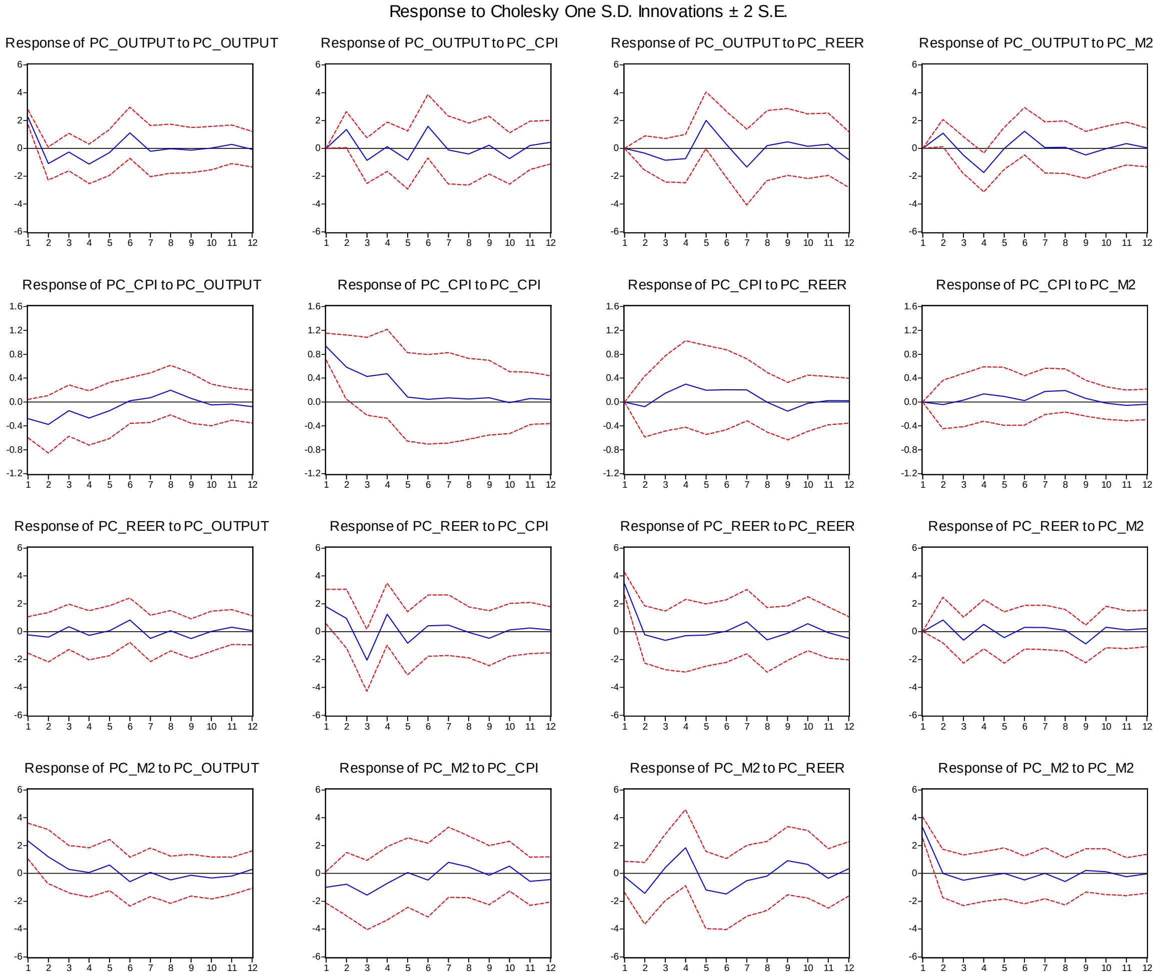

Figure 4. Impulse Response Functions – Credit Channel