Structural VAR Approach to Malaysian Monetary Policy Framework: Evidence from the Pre- and Post-Asian Crisis Periods

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Abstract

This paper employs a structural vector autoregression (SVAR) model to investigate the monetary policy framework of a small emerging open economy - Malaysia, especially how the economy dynamically respond to money, interest rate, exchange rate and foreign shocks. We establish identification conditions to uncover the dynamic effects of monetary policy shocks on various domestic variables. Following the financial crisis in July 1997, Malaysia adopted a pegged exchange regime in September 1998. By analysing the intensity of the responses of the domestic variables to various monetary shocks, we aim to find out whether the Malaysian monetary transmission mechanism has changed in the post-crisis period. Using monthly data from January 1980 to May 2006, a nine variable SVAR model is established to study the dynamic responses of the Malaysian economy to domestic and foreign shocks. The empirical results show notable differences: in the pre-crisis period, monetary policy and exchange rate shocks significantly affect the output, price, money, interest rate and exchange rate, while, in the post-crisis period, only the money shock tends to have stronger influence on output. Moreover, the domestic monetary policy appear to be far more vulnerable to foreign shocks especially the world commodity price shock and output shock in the post-crisis than in the pre-crisis period. The findings clearly indicate that the crisis has changed the role of the monetary transmission channels in propagating various policy shocks to the real sectors of the Malaysian economy.

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1. Introduction

In the economic literature, monetary policy is seen as a stabilization policy instrument to steer the economy in the direction of achieving sustainable economic growth and price stability. Though the overriding objective of monetary policy is to focus on price stability and economic growth, the impact of this policy is always felt throughout the economy, especially in the short run, on monetary aggregates, interest rates and exchange rates which eventually affect the financial markets, economic activities and price levels in the economy.

The efficacy of the monetary policy depends on the ability of policy makers to make an accurate assessment of the timing and the effect of the policy on economic activities and prices. Therefore, to shove monetary policy with the appropriate force and in the right direction policy makers need to have a clear understanding of the propagation mechanism of the monetary policy shock and the relative importance of the various channels, namely money, interest rates and exchange rates in affecting the real sectors of the economy. See, for example, Kuttner and Mosser (2002) and Clinton and Engert (2000) for details.

This paper uses a structural vector autoregression (SVAR) methodology to model the monetary policy framework of a small emerging open economy - Malaysia. The SVAR methodology is very flexible as it can accommodate various relationships among macroeconomic variables inferred from economic theories and stylised facts, which in turn allow us to identify the orthogonal monetary shocks (see Bernanke (1986), Sims (1986) and Blanchard and Watson (1986)). We establish the necessary identification conditions to uncover the Malaysian monetary and exchange rate shocks and subsequently assess the effectiveness of monetary policy and the various transmission channels in affecting the price levels and the economic activities.

Since the 1980's, due to liberalization and globalization processes, the emerging Malaysian economy along with its neighbours witnessed widespread changes in its conduct of monetary policy and the choice of monetary policy regimes (see for example Tseng and Corker (1991), Dekle and Pradhan (1997), Athukorala (2001), McCauley (2006) and Umezaki (2006)). The monetary policy regime is characterized by the degree of autonomy in the conduct of monetary policy, the choice of exchange rate regime and the degree of international capital mobility.

In the mid-1997, emerging Southeast East Asian economies experienced a devastating financial crisis which lashed the region and caused a huge financial and economic turmoil in these countries. The volatile short-term capital flows and the excessive volatility of the Ringgit made it impossible for Bank Negara Malaysia (BNM), the Central Bank of Malaysia to influence interest rates based on domestic considerations. Prior to 1997 crisis, BNM was conducting monetary policy based on a certain policy rule, depending not only on inflation and real output but also on foreign interest rates, while maintaining a managed float exchange rate system (see Cheong (2004) and Umezaki (2006)).[1] In September 1998, Malaysia made a controversial decision to implement exchange rate and selective capital control measures to stabilize the depreciating exchange rate and the outflow of short term capital.[2] In view of the changing financial environment and the choice of policy regimes, the Malaysian monetary policy had to adhere to a suitable policy framework so that it can remain as an effective policy in promoting economic growth and maintaining price stability. The evolution of the Malaysian monetary policy framework and its monetary literature is discussed in Section 2 in detail.

In the Malaysian monetary literature, with an exception of Azali and Matthews (1999) and Fung (2002), there were numerous studies that used the standard VAR methodology to study the effects of monetary policy shocks Tang (2006), Ito and Sato (2006), Ibrahim (2005), Raghavan (2004) and Domac (1999). Much of these papers conveniently blamed on the lack of theoretical foundation to identify the Malaysian monetary policy framework and hence used the Choleski's atheoretical approach instead. Azali and Matthews (1999) modeled the Malaysian monetary policy framework using a closed economy SVAR approach, mainly to study the effects of financial liberalization. They used a fully specified macroeconomic model similar to that in Bernanke (1986) to come up with the necessary identifying restrictions in the SVAR model. Fung (2002) used a semi SVAR approach similar as Bernanke and Mihov (1995)'s contemporaneous SVAR model, to study the effects of monetary policy shocks in seven East Asian economies including Malaysia. The U.S. variables were included in the SVAR model as exogenous variables.

[1] Though BNM has paid systematic attention to expected inflation, the policy rule however has been applied rather flexibly due to its vulnerability to foreign shocks.
[2] These measures were imposed to give BNM the independence to conduct expansionary monetary policy and the required breathing space to restructure the Malaysian financial and corporate sectors.

In our earlier work Raghavan and Silvapulle (2007), we modelled the Malaysian monetary policy framework using a six-dimensional VAR and the variables are the world commodity price index and five domestic variables that is output, price, money supply, interest rates and exchange rates. The choice of these variables is similar to that in Sims (1992). We have also included three US variables - output, price and interest rates in the SVAR model to control for foreign factors, and these three variables are assumed to be exogenous. Since there is no consensus reached by empirical studies on Malaysian monetary policy on a set of assumptions and or restrictions for identifying various monetary shocks, we used the standard VAR approach and the widely used Choleski's recursive identifying restrictions. Applying this technique led to some economic puzzles in our findings such as price, liquidity and exchange rate puzzles.

In this paper, we attempt to construct an SVAR model that is more representative of the Malaysian monetary policy framework. Our aim is also to overcome the economic puzzles observed by earlier empirical studies. See for example, Azali and Matthews (1999), Fung (2002) and Tang (2006). Using monthly data from January 1980 to May 2006, a nine-dimensional SVAR model - which includes both the domestic and foreign variables - was set up to study the dynamic responses of the Malaysian economy to domestic and foreign shocks. Further, to impose the necessary identifying restrictions on the contemporaneous and the lag structure of the SVAR model, we used the results of the existing Malaysian VAR models and the SVAR models of advanced small open economies (see, for example, Cushman and Zha (1997) and Dungey and Pagan (2000)) as guides. The identified SVAR model is then used to evaluate to what extent the 1997 Asian crisis and the subsequent shift from the managed float exchange rate regime to pegged exchange rate system have affected the conduct of monetary policy in Malaysia.[3] By analyzing the intensity of the responses of the various monetary channels to policy shocks, we aim to identify whether the dynamics of the Malaysian monetary transmission mechanism have changed since the crisis. The research finding is expected to provide BNM with valuable insights into identifying the important transmission channels that carry more information about the monetary policy

[3] In a floating exchange rate regime, the exchange rate is considered as one of the macroeconomic variables that respond to economic policies, while in a fixed exchange rate regime, policies are assigned to keep the exchange rate at the desired level.

shocks. It would also help BNM to influence the appropriate channels to ensure that the monetary policy is effective in achieving economic growth and maintaining price stability.

The paper is organised as follows: Section 2 briefly describes the evolution of the Malaysian monetary policy framework and the existing monetary literature. Section 3 states the SVAR methodology while Section 4 discusses the choice of variables. Section 5 illustrates model and the identification issues and Section 6 reports the empirical data analysis and the empirical findings. Finally Section 7 concludes this paper.

2. The Evolution of Malaysian Monetary Policy Framework

The financial liberalization and globalization processes have opened up new avenues and increased opportunities for financial market developments in Malaysia. However, in the new environment with greater financial integration, strong capital flows and managed floating exchange rate, the effectiveness of monetary policy has often been questioned. Therefore, this section presents an overview of the reform processes and their implications on the Malaysian monetary policy framework.

2.1 The Pre-1997 Asian Crisis Period

The changes and the developments in international economic and financial environments in the early 1980s posed great challenges to BNM in conducting its monetary policy operation (see Cheong (2004)). The deregulation of deposit and lending rates in 1978 led to a more market-oriented interest rate determination process. Prior to 1990s, the conduct of monetary policy focused on monetary targeting, especially the broad money M3. This was an internal strategy and was not formally announced to the public. BNM influenced the day-to-day volume of liquidity in money market to ensure that the supply of liquidity was sufficient to meet the economy's demand for money, so that the bank's monetary policy objective of price stability can be maintained.

A major phase of financial reforms was undertaken in January 1989, whereby BNM introduced a package of reforms to broaden, deepen and modernize the financial system (see BNM (1999) and BNM (1994) for details). Subsequent developments in the economy and the globalisation of financial markets in the early 1990s however weakened the relationship between monetary aggregates and the target variables of income and prices. The large capital inflows in 1992-93 and an immediate outflow the following year caused the monetary aggregates to be extremely volatile and less reliable as indicators of economic activity and as guides for stabilising prices. There are many studies that support the view that financial liberalization has caused the demand for money in Malaysia to be unstable. See, for example, Tseng and Corker (1991), Tan (1996) and Dekle and Pradhan (1997) for details.

Around this time, the globalization processes also caused notable shifts in the financing pattern of the economy that is moving from an interest-inelastic market (government securities market) to a more interest rate sensitive market (bank credit and capital market).[4] As investors became more interest rate sensitive, the monetary policy framework based on interest rate targeting was seen as an appropriate measure to promote stability in the financial system and to achieve the monetary policy objectives. As a result, in the mid-1990s, BNM shifted towards interest rate targeting framework.

Woo (1991) attempted to investigate the degree of autonomy enjoyed by BNM in a managed float exchange rate regime and its ability to steer and control the monetary aggregates as its target variables.[5] According to Woo, BNM strives to achieve monetary autonomy and was successful to a great degree in achieving it.[6] Similar conclusions were also drawn by Umezaki (2006) and McCauley (2006), whereby these papers state that BNM was able to pursue autonomous monetary policy and managed exchange rate stabilization due to imperfect substitutability of its capital market and the sterilized intervention in its foreign exchange market.

A number of studies such as Raghavan (2004), Azali (2003) Azali and Matthews (1999), Azali (1998), Mulyana (1995), Kwek (1990a) and Kwek (1990b) Kwek (1990a, Kwek (1990b)have used the VAR methodology to examine the impact of financial liberalization on the intermediate targets of credit, money and interest rates and the effectiveness of monetary policy. Most of these studies upheld the role of monetary aggregates as intermediate target in the monetary policy transmission mechanism, while Raghavan (2004) found interest rate

[4] The preference for interest rate was precipitated due to the global financial and economic integration.
[5] Monetary autonomy here is defined as the ability of the Central Bank to control particular sets of target variables.
[6] Based on textbook references, it is not possible to achieve autonomy in the conduct of monetary policy, choice of exchange rate regime and the degree of international capital mobility, all at the same time. A Central bank needs to choose two out of the three options. However, this may not hold for small emerging open economies like Malaysia due to imperfect substitutability of financial assets, imperfect information and the existence of huge transaction costs.

to play a major role in the post 1990 periods. With an exception of Azali and Matthews (1999), all the paper's mentioned above used the domestic based standard VAR approach.

Azali and Matthew modeled the Malaysian monetary policy framework in the spirit of Sims-Bernanke's contemporaneous SVAR approach and studied the effects of liberalization on money-income and credit-income relationships during the pre- and post-liberalization periods in Malaysia. To identify the SVAR model and to impose the necessary restrictions, they used a fully specified macroeconomic model, similar to that used by Bernanke (1986). One major drawback of this paper and the other VAR papers mentioned above is that only domestic variables were taken into consideration and no attention was given to the effects of foreign variables on the Malaysian economy. As highlighted by Cushman and Zha (1997), the U.S monetary policy can be modeled using its domestic variables only, as it is a large economy and it's reactions to foreign shocks could be assumed to be negligible.[7] However, the use of a similar approach to model the monetary policy of small open economies like Malaysia is less likely to be valid as these economies are expected to be very vulnerable to foreign shocks, especially foreign monetary and exchange rate shocks. Therefore, it is essential to include these foreign variables in the Malaysian SVAR model for correct identification of monetary policy shocks.

2.2 The Post-1997 Asian Crisis Period

The globalisation process came with a cost to Malaysia as the economy was not only vulnerable to domestic shocks but was also largely exposed to external shocks. The conduct of monetary policy by BNM has been largely in response to global developments and to compensate for the effects of external shocks. In 1997-98, the ability of BNM to influence domestic interest rates based on domestic considerations has been affected by the volatile short-term capital out-flows and the instability of the ringgit during the Asian financial crisis. In September 1998, Malaysia imposed exchange rate and selective capital control measures to stabilise the depreciating exchange rate, and it was fixed at RM3.80 per US dollar, while the short-term capital flows were restricted.

[7] The U.S. monetary policy can be modelled using the domestic variables only as in Bernanke and Blinder (1992), Sims (1992) and Christiano and Eichenbaum (1992) without much loss of generality.

The exchange control gave BNM a greater degree of monetary autonomy to influence the domestic interest rates without having to pay so much attention on managing the ringgit exchange rate (see Cheong (2004)). Since then, the focus of monetary policy was to manage the liquidity level in the economy in order to maintain the interest rate at a level that is sufficiently low to promote economic growth. The pegged exchange rate is expected to provide stability and certainty to facilitate and improve trades and investments. In this regard, the policy continues to be directed at sustaining, and where necessary strengthening the economic fundamentals to support the sustainability of the exchange rate.

The 1997 Asian crisis has triggered yet another dimension of empirical research to study the impact of financial crisis on monetary transmission mechanism. Tang (2006) used a high dimensional VAR model with four foreign variables and eight domestic variables to explore the Malaysian monetary policy transmission mechanism. Using the Choleski's recursive identifying restrictions, Tang realistically ordered the foreign variables (U.S. output, price and interest rates) ahead of domestic variables so as to imply that the foreign variables are exogenous to domestic variables.[8] However, Tang imposed such exogeniety restrictions on the contemporaneous relationship but allowed a feedback from Malaysia to the U.S. in the lag structure. This process could however compromise the reliability of the estimated model and the empirical results. Moreover, Tang explored the impact of the crisis on Malaysian monetary transmission mechanism implicitly by comparing the results for the full period (which includes both pre- and post-crisis period) with those of the pre-crisis period.

Using a simple semi-SVAR model in the spirit of Bernanke and Mihov (1995)'s contemporaneous SVAR approach, Fung (2002) studied the effects of monetary policy shocks on seven East Asian economies, namely Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand. The U.S. variables were included as exogenous foreign variables in the SVAR model. As pointed out by Bernanke and Blinder (1992), the empirical results obtained from the SVAR model can be very sensitive to the choice of model specifications and identifying assumptions. Hence, one has to be cautious especially when imposing similar identifying restrictions on the various economies with the contention of

[8] However, the foreign block was not completely exogenous as advocated by Cushman and Zha (1997 and Dungey and Pagan (2000).

"one-size for all" approach, more so when there is lack of universal theoretical guidance for improving the modelling and estimating aspects of the SVAR.

Since Malaysia is a small open economy, this paper sets up and investigates a nine-variable-SVAR model - which includes both the domestic and foreign variables to capture the dynamic responses of the Malaysian economy to domestic and foreign shocks. This will enable us to explore the responses of the Malaysian monetary policy and other domestic variables to both the foreign and domestic shocks. In the spirit of Cushman and Zha (1997) and Zha (1999), foreign block exogeneity restrictions are imposed whereby it is assumed that there is neither contemporaneous nor lagged effects of Malaysian variables on foreign variables. The contemporaneous and dynamic restrictions on the domestic block are also applied to provide some economic structure to the SVAR model. See Dungey and Pagan (2000) and Dungey and Fry (2003) for the use of similar structures. We carry out the investigation for the pre- and post-crisis periods separately.

3. SVAR Methodology

The rise in the prominence of monetary policy in the advanced economies since the 1990s has seen an equally synchronized rise in the use of the VAR technique developed by Sims (1980) to model an economy's monetary policy framework.[9] Over the years, the development of structural VAR (SVAR) methodology further facilitated in handling various economic issues and problems concerning the identification of the contemporaneous and dynamic relationships between macroeconomic variables and the policy instruments. In this section, we have provided a brief description of the SVAR methodology.

The relationships among the macroeconomic variables can be modelled by the following SVAR:

$$A_0 Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \varepsilon_t \qquad (1)$$

where Y_t is a $(N \times 1)$ vector of endogenous variables at time t, A_i is a $(N \times N)$ matrix of parameters for $i = 0, 1, 2, \ldots, p$ while ε_t is a $(N \times 1)$ multivariate white noise error process with the following properties:

[9] This methodology provided useful tool to evaluate macroeconomic shocks that originate from both the domestic and foreign economies to which smaller economies are susceptible.

$$E(\varepsilon_t) = 0, \tag{2}$$

$$E(\varepsilon_t \varepsilon_\tau^{'}) = \begin{cases} \Sigma & t = \tau \\ 0 & otherwise \end{cases} \tag{3}$$

The SVAR approach assumes that the structural innovations ε_t are orthogonal, whereby the structural disturbances are uncorrelated and the variance-covariance matrix Σ is constant and diagonal.[10] The contemporaneous matrix A_0 described in (1) is normalised across the main diagonal so that each equation in the SVAR system has a designated dependent variable.

The SVAR model parameters are estimated in two stages. The first stage is to obtain the following reduced form equations associated with (1):

$$Y_t = A_0^{-1} A_1 Y_{t-1} + A_0^{-1} A_2 Y_{t-2} + \ldots + A_0^{-1} A_p Y_{t-p} + A_0^{-1} \varepsilon_t \tag{4}$$

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + \ldots + B_p Y_{t-p} + v_t \tag{5}$$

where $B_i = A_0^{-1} A_i$, $i = 1,2,.....p$ and $v_t = A_0^{-1} \varepsilon_t$. The expression described in (5) is the reduced VAR and v_t is the innovation corresponding to the reduced form and has zero mean and constant variance $v_t \sim N(0, \Omega)$. 'N' equations in the VAR in (5) are estimated by OLS and the VAR residuals v_t are obtained. The innovations in structural models represented by (3) are linked to the reduced form innovations as follows:

$$E(v_t v_t^{'}) = A_0^{-1} (\varepsilon_t \varepsilon_t^{'}) A_0^{-1}{}' \tag{6}$$

$$\Omega = A_0^{-1} \Sigma (A_0^{-1})' \tag{7}$$

The second stage consists of identifying the contemporaneous matrix A_0 and the variance-covariance matrix Σ which maximises the likelihood function conditional on the parameter estimates of the VAR obtained in the first stage. The full information maximum likelihood (FIML) of a structural VAR with dynamics (Hamilton (1994) is represented as follows:

$$\ln L_t = -(1/2)\log(2\pi) - (1/2)\log | A_0^{-1} \Sigma (A_0^{-1})' | - \frac{1}{2} \hat{v}^{'} A_0^{-1} \Sigma (A_0^{-1})' \hat{v} \tag{8}$$

[10] As mentioned by (Bernanke 1986), the structural shocks are primitive exogenous forces that do not have common causes and hence can be treated as uncorrelated.

where Σ is restricted to be a diagonal matrix, while v_t is the estimated residuals from the reduced VAR. In the SVAR system, A_0 has N^2 parameters, while Ω has only $N(N+1)/2$ distinct values. This leads to an identification problem as the structural model requires $N(N-1)/2$ number of restrictions to be imposed on the system in order to establish exact identification conditions and the system is under identified otherwise.[11] Further, the residuals from the reduced VAR are transformed into a system of structural equations by imposing restrictions based on prior theories and empirical findings about policy reaction functions rather than based on the commonly used Choleski's decomposition method. This approach of orthogonalizing the reduced form residuals to recover the underlying shocks are advocated by Bernanke (1986), Sims (1986) and Blanchard and Watson (1986)).

4. Choice of Variables and Preliminary Data Analysis

This section describes the international and domestic variables used to represent the Malaysian monetary policy framework. The choice of variables is similar to those used by Cushman and Zha (1997) and Fung (2002) and are summarised in Table 1.

Table 1. Variables included in the Malaysian SVAR system

Variable	Definition	Abbreviation
Commodity Prices	World Commodity Price Index, Logs	PC
US		
Output	Industrial Production (SA), Logs	IP_U
Price	Consumer Price Index (SA), Logs	P_U
Interest Rate	Federal Funds Rate, Percent	IR_U
Malaysia		
Output	Industrial Production (SA), Logs	IP_M
Prices	Consumer Price Index (SA), Logs	P_M
Money	Monetary Aggregate M1 (SA), Logs	$M1_M$
Interest Rate	Overnight Inter-Bank Rate, Percent	IR_M
Exchange Rate	Nominal Effective Exchange Rate, Logs	EX_M

Sources: International Financial Statistics.

Of the nine variables used in the model, four variables represent the foreign block and they are the world commodity price index (PC), the US production index (IP_U), the US consumer price Index (P_U) and the Federal Funds Rate (IR_U). As discussed before, in a VAR

[11] Therefore, without any clear identifying restrictions, no conclusion regarding the structural parameters of the "true" model can be drawn from the data as different structural models give rise to the same reduced form.

model of an open economy, the inclusion of foreign variables is essential for correct specification, improved identification of contemporaneous relationships and for capturing underlying impulse responses of variables to various shocks. PC is included to account for inflation expectations, mainly to capture the non-policy induced changes in inflationary pressure to which the central bank may react when setting monetary policy (see Sims (1992) and Cushman and Zha (1997)).[12] The three US variables are included to represent the open economy component of the model, and were chosen as proxy for foreign variables in the Malaysian SVAR system, and to capture the close link between the US and Malaysian economies. The US is Malaysia's largest trading partner, accounting for almost 16 per cent of total trade in 2006.[13] It is also fairly common in the monetary literature of small open economies to use these US variables as proxy for foreign variables (see for example Cushman and Zha (1997), Dungey and Pagan (2000), Fung (2002), and Tang (2006)).

The remaining five variables describe the Malaysian domestic economy. The Malaysian production index (IP_M) and the consumer price index (P_M) are taken as the target variables of monetary policy and are known as non-policy variables.[14] The policy block is represented by the M1 monetary aggregate (M_M) and the overnight inter-bank rate (IR_M). According to Cheong (2004), then assistant governor of BNM, instead of heavily relying on one policy tool, the BNM used a combination of several instruments such as monetary aggregates and various interest rates. Among the various potential monetary aggregates investigated, Tang (2006) found that the M1 to be the most reasonable candidates for monetary policy instruments. In many recent studies Domac (1999), Ibrahim (2005) and Umezaki (2006)) on Malaysian monetary policy, the overnight interbank rate was selected as the instrument of monetary policy.[15] The exchange rate (EX_M) represents as information market variable. The use of the nominal effective exchange rate instead of bilateral US dollar exchange rate was necessary considering the US dollar peg of the Malaysian ringgit during the period of study. As stated in Mehrotra (2005), this trade-weighted exchange rate is also believed to capture

[12] It can also represent the terms of trade effect in small open economies.

[13] Source: Malaysian External Trade Development Corporations (MATRADE).

[14] In the literature, it is assumed that both the target variables of output and prices as non-policy variables as they do not react instantaneously to changes in the policy variables (see Bernanke and Mihov 1995).

[15] In early 1998, BNM designated the three-month intervention rate as a policy rate and subsequently in April 2004, formally announced the Overnight Policy rate as the official monetary policy rate.

more comprehensively the movements in the exchange rate that may have inflationary consequences in the Malaysian economy.[16]

The SVAR model uses monthly data from January 1980 up to May 2006. The sample period covers only the post liberalization period in Malaysia which also includes the East Asian financial crisis. As stated in Awang, Ng and Razi (1992), the major phase of liberalization commenced in October 1978 when the Bank Negara introduced a package of measures as a concrete step towards a more market-oriented financial system. The measures include, freeing the interest rate controls and reforming the liquidity requirements of the financial institutions. All data have been extracted from the IMF's International Financial Statistics (IFS) data base. The variables are seasonally adjusted and are in logarithm except for the interest rates which are expressed in percentages.

The time series properties, including the non-stationarity and stationarity of the variables were examined by applying the Augmented Dickey Fuller and the Philips-Perron unit root tests. These tests were carried out separately for both the pre- and post-crisis periods. The results indicated that all the variables under consideration are integrated of order one and are stationary in first differences. The Johansen's co-integration test also provides evidence of long run relationships among the nine variables.[17] Given that the variables are non-stationary and are cointegrated, the use of a VAR model in first differences leads to loss of information contained in the long run relationships. Since the objective of VAR analysis in this study is to assess the interrelationships between the variables rather the parameter estimates, we concur that the VAR in level remains as an appropriate measure to identify the effects of monetary shocks.[18]

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[16] It is also common in the monetary business cycle literature to include these five domestic variables for identifying the monetary policy shocks in small open economies.

[17] We do not provide the results in the paper in order to conserve space; however they are reported in the Second Chapter of my thesis.

[18] The choice between VAR in levels (unrestricted VAR) and VECM (restricted VAR), depends on the economic interpretation attached to impulse response functions from the two specifications (See Ramaswamy and Slok (1998) for details).The impulse response functions generated from VECM tend to imply that the impact of monetary shocks is permanent while the unrestricted VAR allow the data series to decide on whether the effects of the monetary shocks are permanent or temporary. It is common in the monetary literature to estimate the unrestricted VAR model at levels (for example see (Sims 1992), (Bernanke and Mihov 1996), (Cushman and Zha 1997), just to name a few).

5. Model Structure and Identification Issues

In this section, the identification of the Malaysian SVAR model is established. A common approach in the literature is to apply identification restrictions that are consistent with economic theory and prior empirical research findings (see Buckle et al (2007), Christiano et al (2005), Dungey and Fry (2003) and Dungey and Pagan (2000)).[19] In this paper, to establish the identification conditions, the results of Malaysian VAR studies and those of the SVAR studies of advanced small open economies are used to guide us in obtaining the appropriate restrictions to be imposed on the contemporaneous and the lagged structure of the Malaysian SVAR model.[20]

5.1 Block Exogeneity Restrictions

It is well-known that the shocks to small open economies have very little impact on major foreign countries and therefore it is proper to treat the foreign variables as exogenous to domestic economic variables. To capture this phenomenon, the Malaysian SVAR system is divided into foreign and domestic blocks. To describe the reduced VAR system for a small open economy first, the set of variables Y_t is divided into two blocks as follows:

$$Y_t = (Y_{1,t}, Y_{2,t})' \tag{9}$$

$$Y_{1,t} = (PC_t, IP_{u,t}, P_{u,t}, IR_{u,t})' \tag{10}$$

$$Y_{2,t} = (IP_{m,t}, P_{m,t}, M_{m,t}, IR_{m,t}, EX_{m,t})' \tag{11}$$

where $Y_{1,t}$ represents the foreign block, while $Y_{2,t}$ represents the domestic block. The VAR in (5) can now be represented as follows:

$$Y_t = \begin{bmatrix} Y_{1,t} \\ Y_{2,t} \end{bmatrix} \qquad B(L) = \begin{bmatrix} B_{11}(L) & B_{12}(L) \\ B_{21}(L) & B_{22}(L) \end{bmatrix} \qquad v_t = \begin{bmatrix} v_{1,t} \\ v_{2,t} \end{bmatrix} \tag{12}$$

The two blocks, $B_{11}(L)$ and $B_{12}(L)$ contain the coefficients that correspond to the foreign economy while $B_{21}(L)$ and $B_{22}(L)$ contain the coefficients that correspond to the domestic economy. Similarly, the A_0 matrix in equation (1) can be decomposed as follows:

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19 Alternative to this approach is to impose restrictions based on fully specified macroeconomic model (Bernanke (1986), Sims (1986) and Blanchard and Watson (1986)).

20 See (Tang 2006), (Ibrahim 2005), (Raghavan 2004), (Azali 2003), (Fung 2002), (Domac 1999), (Azali and Matthews 1999), (Azali 1998), (Mulyana 1995) and (Kwek 1990a; Kwek 1990b).

$$A_0 = \begin{bmatrix} A_{0,11} & A_{0,12} \\ A_{0,21} & A_{0,22} \end{bmatrix} \tag{13}$$

It is assumed that the foreign variables in the Malaysian VAR system are predetermined and the domestic variables do not Granger cause the foreign variables. Hence, a block exogeneity is imposed by excluding all domestic variables from the foreign block of equations both contemporaneously and in the lag structure of the reduced form VAR by imposing the following restrictions, $A_{0,12} = 0$ and $B_{12}(L) = 0$ respectively. In the context of a small open economy, the block exogeneity restrictions has clear benefits as it allows for a larger set of international variables to be included into the model, while reducing the number of parameters to be estimated.

5.2 Restrictions on Contemporaneous and Lagged Dynamics

In addition to foreign block exogeneity restrictions imposed in the model, restrictions on the contemporaneous and lagged matrices are also imposed.[21] The variables entering into each equation of the SVAR system in (1) are summarized in Tables 2 and 3. Table 2 highlights the restrictions on the contemporaneous relationships among the variables, while Table 3 highlights the restrictions on the lag dynamics.

Table 2. Restrictions on the Contemporaneous Structure – A_0

Dependent Variables	Explanatory Variables								
	PC	IP_U	P_U	IR_U	IP_M	P_M	M_M	IR_M	EX_M
PC	1	0	0	0	0	0	0	0	0
IP_U	0	1	0	0	0	0	0	0	0
P_U	0	a_{32}	1	0	0	0	0	0	0
IR_U	0	a_{42}	a_{43}	1	0	0	0	0	0
IP_M	0	0	0	0	1	0	0	0	0
P_M	0	0	0	0	a_{65}	1	0	0	0
M_M	0	0	0	0	a_{75}	a_{76}	1	0	0
IR_M	a_{81}	0	0	a_{84}	a_{85}	a_{86}	a_{87}	1	0
EX_M	a_{91}	a_{92}	a_{93}	a_{94}	a_{95}	a_{96}	a_{97}	a_{98}	1

[21] See (Bernanke 1986), (Sims 1986), (Blanchard and Watson 1986), (Eichenbaum and Evans 1995), (Cushman and Zha 1997), (Christiano et al 1999), (Azali and Matthew 1999), (Dungey and Pagan 2000)), (Fry 2001), (Fung 2002) and (Joiner 2003).

Our assumption is based on "successive relationship", where the relationship between the variables are determined in a block recursive way. The use of identifying restrictions on the contemporaneous matrix is reasonably common in the monetary literature and in this case, the over-identifying restrictions are specified.[22] The restrictions on the lag matrices however are less common and so far in the existing Malaysian monetary literature, no such restrictions were imposed.

Table 3. Restrictions on the Lag Structure – B(L)

Dependent Variables	Explanatory Variables								
	PC	IP_U	P_U	IR_U	IP_M	P_M	M_M	IR_M	EX_M
PC	b_{11}	0	0	0	0	0	0	0	0
IP_U	b_{21}	b_{22}	b_{23}	b_{24}	0	0	0	0	0
P_U	b_{31}	b_{32}	b_{33}	b_{34}	0	0	0	0	0
IR_U	b_{41}	b_{42}	b_{43}	b_{44}	0	0	0	0	0
IP_M	b_{51}	b_{52}	0	0	b_{55}	b_{56}	b_{57}	b_{58}	b_{59}
P_M	b_{61}	0	0	0	b_{65}	b_{66}	b_{67}	b_{68}	b_{69}
M_M	b_{71}	0	0	0	b_{75}	b_{76}	b_{77}	b_{78}	b_{79}
IR_M	b_{81}	0	0	b_{84}	b_{85}	b_{86}	b_{87}	b_{88}	b_{89}
EX_M	b_{91}	b_{92}	b_{93}	b_{94}	b_{95}	b_{96}	b_{97}	b_{98}	b_{99}

5.2.1 Identification of the Foreign Sector

The foreign block constitutes PC, IP_U, P_U and IR_U, and is characterized by the block exogeneity assumption described in section 5.1. The commodity price index is assumed to be completely exogenous to all the other variables in the model and affected only by its own lags. As shown in Table 2, the three US variables are identified recursively, with the assumption that the US output is contemporaneously exogenous to all other variables in the model, while the price level is assumed to be contemporaneously affected only by demand driven fluctuations in output.

The specification of the Federal Reserve's monetary policy is assumed to follow the "Taylor Rule" where its primary concern is to maintain output growth and price stability (see Taylor (2000) and McCallum (1999)). Referring to Table 3, apart from the block exogeneity

[22] The contemporaneous matrix requires $((9^2–9)/2=36)$ restrictions for exact identification while in Table 2 more than 36 restrictions were imposed, leading to over identification.

restrictions, no other restrictions on the lag structures of the US variables are imposed, thus allowing for feedback among the three variables and with the commodity price index.

5.2.2 Identification of the Domestic Sector

The domestic block is divided into three sub-blocks. The first sub-block, known as the non-policy block is represented by domestic output and prices. These two variables are assumed to be contemporaneously unaffected by other domestic variables in the system. In the domestic output equation, IP_M is assumed to be contemporaneously exogenous to all variables in the SVAR system. The Malaysian output however is assumed to depend on the lagged commodity price index, US output and all domestic variables. The US output is used as proxy for overseas economic conditions, while commodity prices represent foreign price pressure and trade effects, and finally the domestic variables to represent the domestic economic and policy conditions. Similar to US price equation, the Malaysian price is also assumed to be contemporaneously affected only by the Malaysian output activities. The commodity price and all the domestic variables are included in the lags of the price equation.

The second sub-block, known as the policy block is represented by the central bank's policy instruments of money and interest rates. The money demand equation M_M, is assumed to be contemporaneously affected by the domestic output and price levels. Though in several studies in the monetary literature, interest rates are assumed to contemporaneously affect the money (see Cushman and Zha (1997) and Leeper and Zha (1999)), in this paper, we assume interest rates affects money only in the lag structure.[23] Tang (2006) has also made a similar assumption when modeling the Malaysian monetary policy. The commodity prices and all the domestic variables are included in the lags of the money demand equation.

The monetary policy reaction function is represented by the interest rate (IR_M) equation. The contemporaneous identification includes the commodity prices, foreign interest rates, domestic output, prices and money. The contemporaneous inclusion of output and prices gives the reaction function a similar form to that of the Taylor rule identification, while the commodity price represents external inflationary pressure in the economy and the monetary

[23] We run the model by allowing the interest rate to contemporaneously affect money and found no notable differences in the results with and without interest rate in the contemporaneous relationship. Hence, we decided to restrict interest rate from affecting money contemporaneously and thus uphold the recursive assumption.

aggregate as part of the transmission process. From the results of the other studies, we found that it was necessary to include the Federal Funds rate for correct identification as a foreign monetary policy influence (see, for example Fung (2002) and Tang (2006)). The commodity prices, Federal funds rate and all the domestic variables are included in the lags of interest rate equation.

Finally, the third block is the information market variable. The exchange rate equation is seen as an information market variable that reacts quickly to all relevant economic disturbances and hence is contemporaneously affected by all the variables in the SVAR system. The lag structure is left unrestricted. The exchange rate, while contemporaneously being affected by all other variables in the system, it is assumed not to have any instantaneous effects on these variables (see Eichenbaum and Evans (1995), Christiano, Eichenbaum and Evans (1998) and Dungey and Pagan (2000)). Through the exchange rate equations, the foreign variables are allowed to indirectly influence the domestic variables.

5.3 Impulse Responses and Variance Decomposition

The effectiveness of monetary policy and the roles of various transmission channels in transmitting the policy shocks can be observed through the responses of the target variables to unexpected shocks. The estimated SVAR system is used to analyse the dynamic characteristic of the model by estimating the impulse response functions and forecast variance decompositions. The derivation of these empirical tools is briefly described below.

5.3.1 Impulse Response Functions

The Impulse response function is derived and used to examine the dynamic responses of the variables to various shocks within the SVAR system. Using the lag operator L, the model (5) can be written as follows:

$$B(L)Y_t = v_t \tag{14}$$

For a covariance stationary VAR, the effect of any shock given by v_t (the reduced form innovations) in (14) dies out at some point in time in the future. In this case (14) can be reparameterized to express the endogenous variables in Y_t as a function of the current and past values of v_t, where the vector moving average (VMA) representation is given as:

$$Y_t = v_t + C_1 v_{t-1} + C_2 v_{t-2} + ... = C(L)v_t \qquad (15)$$

where $C(L) = (B(L))^{-1}$. The impulse response function derived from the VMA traces the path of the response for the ith variable over time, following an innovation to v_t from the jth variable, while holding all other reduced form innovations constant. However, the MA model in (15) may not have the ability to attribute the response of a certain variable to an economically interpretable shock, because v_t by its construction reflects the combination of all the fundamental economic shocks and does not correspond only to a particular shock. One way to circumvent this problem is to transform innovations v_t to recover the set of orthogonal structural innovations ε_t defined in the original SVAR model (1).

The SVAR approach assumes that the structural innovations ε_t are orthogonal, that is the structural disturbances are uncorrelated. The MA representation in (15) can be transformed as follows:

$$Y_t = C^*(L)\varepsilon_t \qquad (16)$$

where $C^*(L) = C(L)A_0^{-1}$ generates the impulse response functions of Y_t to the structural shocks to ε_t. As the structural innovations are orthogonal, the covariance between the primitive shocks will be restricted to zero. The effects of monetary policy shocks on other domestic variables, especially on the target variables of income and price can be captured more effectively by calculating the initial impulse response function given in (16). The disturbances ε_t have economic meaning and therefore the impulse response functions can be interpreted in a meaningful way. For example, the transmission mechanism of a monetary policy shock can be analyzed by observing the response of other variables in the system to monetary policy shocks.

5.3.2 Variance Decomposition

Forecast error variance decomposition describes what proportion of a shock to a specific variable is related to either its own innovations or those associated with other dependent variables at various forecast time horizons in the system. The s-period-ahead forecast error is expressed as:

$$y_{t+s} - \hat{y}_{t+s|t} = v_{t+s} + C_1 v_{t+s-1} + C_2 v_{t+s-2} + ... + C_{s-1} v_{t+1} \qquad (17)$$

The mean squared error of the s-period forecast is:

$$MSE(\hat{y}_{t+s|t}) = \Omega + C_1 \Omega C_1^{'} + C_2 \Omega C_2^{'} + ... + C_{s-1} \Omega C_{s-1}^{'} \qquad (18)$$

$$MSE(\hat{y}_{t+s|t}) = A_0^{-1} \Sigma (A_0^{-1})' + C_1 A_0^{-1} \Sigma (A_0^{-1})' C_1' + ... + C_{s-1} A_0^{-1} \Sigma (A_0^{-1})' C_{s-1}' \qquad (19)$$

where $\Omega = A_0^{-1} \Sigma (A_0^{-1})'$. Expression (19) describes the contribution of the orthogonal innovations ε_t to the MSE of the s-period-ahead forecast of variables in Y_t.

6. Empirical Results

The sample period of this study is divided into pre-crisis period (1980:1 to 1997:6) and post-crisis period (1998:1 to 2006:5). The two sub-periods are considered primarily to assess the impact of the 1997 crisis on the Malaysian monetary transmission mechanism. According to Fung (2002), the use of monthly data series is appropriate to study the monetary framework, especially in justifying the identification assumption of no contemporaneous feedback from the policy variables to the non policy variables.

The parameters of the SVAR are estimated in two stages as outlined in Section 5.2. In the first stage, the restrictions given in Table 3 were imposed and the OLS residuals of reduced-form VAR are obtained.[24] As for the number of lags in the model, the standard information criteria of Akaike (AIC) and Hannan-Quinn (HQC) chose an optimal lag length of two, while Schwarz (SC) suggested lag length 1 for the two sub-sample periods. However, the lag length identified by the information criteria is found to be inadequate to capture the underlying dynamics of the system as it is not sufficiently long to eliminate the autocorrelations present in the residual series. Subsequently, the Portmanteau and LM-test for residual autocorrelation were carried out, and this test identified the lag length of four for both sub-periods. Hence a common VAR(4) is used in this analysis. In the second stage, the contemporaneous matrix A_0 defined in Section 3 is identified using the sets of restrictions given in Table 2.

[24] If there are no restrictions imposed on B(L) coefficients, then an efficient estimation of the reduced form VAR can be achieved by the separate applications of OLS to each equation. The single equation estimation of the VAR in (5) however, yields consistent but asymptotically inefficient parameter estimates. The loss in efficiency arises from the zero restrictions imposed on the lag structure.

6.1 Impulse Response Analysis

A selection of key impulse response functions of domestic variables to independent (one-standard deviation) shocks is discussed in this section. The sizes of the shocks are measured by the standard deviations of the corresponding orthogonal errors obtained from the SVAR model. The sizes of the one standard deviation shocks during the pre- and post-crisis periods are presented in Table 4 below.

Table 4. Magnitude of One Standard Deviation Shocks during the Pre- and Post-Crisis Periods

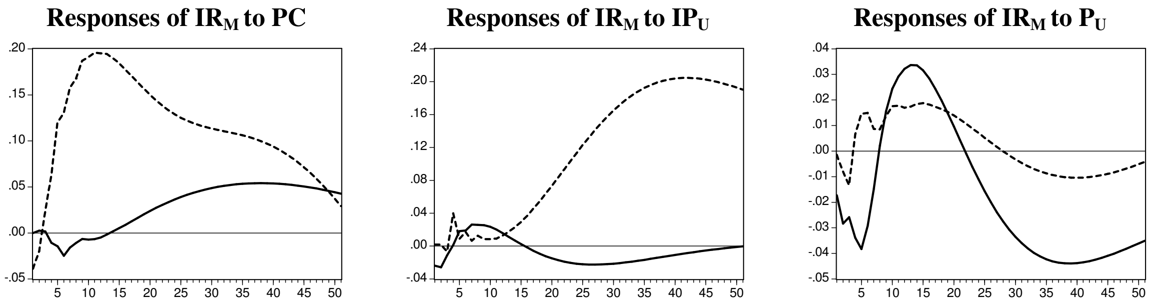
Periods	Size of shocks from foreign variables				Size of shocks from domestic variables				
	PC	**IP_U**	**P_U**	**IR_U**	**IP_M**	**P_M**	**M_M**	**IR_M**	**EX_M**
Pre- Crisis	0.0198	0.0052	0.0020	0.4473	0.0510	0.0035	0.0220	1.0340	0.0093
Post Crisis	0.0185	0.0049	0.0025	0.1178	0.0235	0.0025	0.0192	0.2048	0.0085

With an exception of domestic monetary shock, which is notably different for the two periods, the sizes of the rest of the orthogonal shocks in the SVAR system appear to be the similar for both sub-periods. The size of Malaysian monetary policy shock in the post-crisis period seems to have declined to one fifth of its size in the pre-crisis period. Such an outcome implies that the BNM had more autonomy in the conduct of monetary policy under the pegged exchange rate and capital control regimes introduced in the post crisis period.

6.1.1 Impulse Responses of Malaysian Interest Rate to Foreign Shocks

Figure 1 below shows the impact of foreign shocks namely the world commodity price shock (PC), US output shock (IP_U) and US price shock (P_U) on Malaysian monetary policy instrument (IR_M).

Figure 1: Responses of IR_M to PC, IP_U and P_U Shocks
(Solid Line – Pre-Crisis Period; Dashed Line – Post-Crisis Period)

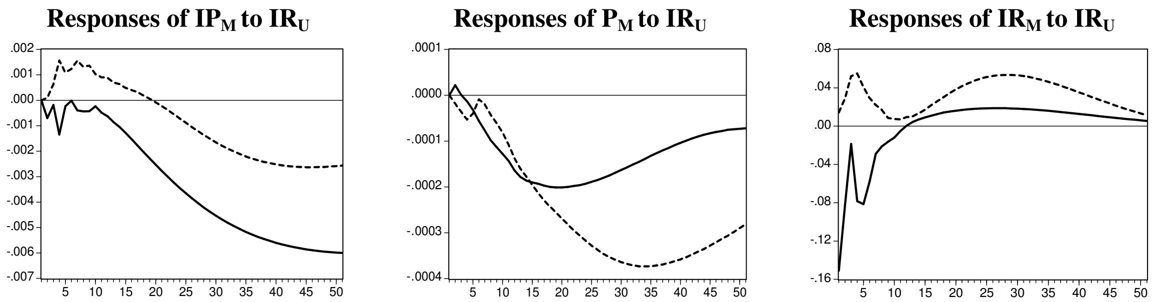


As expected, a positive shock to PC, results in an increase in IR_M in both sub-periods. However the effect of this shock was immediate and stronger in the post-crisis period. A positive shock to IP_U tend to have a brief positive effect on the interest rate in the pre-crisis period, while more persistent and intense effect were observed in the post-crisis period. Though a positive shock to P_U provides a similar movement in the responses of the interest rate, the strength of the movement was more prominent only in the pre-crisis period. Overall the Malaysian monetary policy appears to be more vulnerable to foreign inflationary and output shocks during the post crisis period.

6.1.2 Impulse Responses of Malaysian Output, Price and Interest Rates to US Monetary Shocks

A positive shock to US interest rate (IR_U) is interpreted as tightening of US monetary policy. Figure 2 below shows the impact of US monetary shock on domestic variables namely the Malaysian output (IP_M), price (P_M) and interest rates (IR_M).

Figure 2: Responses of IP_M, P_M and IR_M to US Monetary Shock
(Solid Line – Pre-Crisis Period; Dashed Line – Post-Crisis Period)



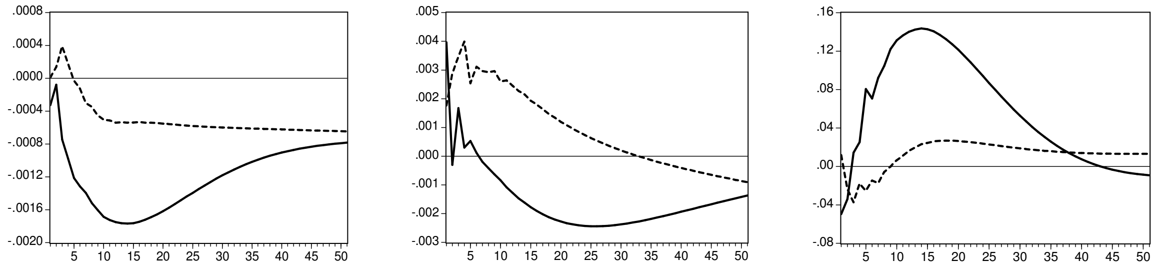
In the pre-crisis period, the US contractionary monetary policy seems to have a dampening effect on Malaysian output and price, resulting in the reduction of Malaysian interest rate. In the post-crisis period, the output tends to increase initially and then starts to decline after 10 months while the interest rate respond positively to the US monetary shock. Overall, output responded to foreign monetary shock more strongly in the pre-crisis period, while the price responded more intensively in the post-crisis period.

6.1.3 Responses of Malaysian Output, Price, Monetary Aggregate and Interest Rates to Domestic Output and Price Shocks

Figures 3 and 4 below shows the impact of positive shocks to output and prices on domestic variables. Positive shocks to Malaysian output and prices appear to have led to some contradicting results in both sub-periods. In the pre-crisis period, a positive shock to output induces a tightening of the monetary policy resulting in an increase in the domestic interest rate. This rise in interest rate seems to cause the money demand and the price level to decline. In the post-crisis period, the response of interest rate to output shock was not strong, and hence the negative response of price to this shock was also mild. The positive response of money to positive output shock in the post-crisis period could have been induced by the rise in the demand for money.

Figure 3: Responses of P_M , M_M and IR_M to IP_M Shock
(Solid Line – Pre-Crisis Period; Dashed Line – Post-Crisis Period)

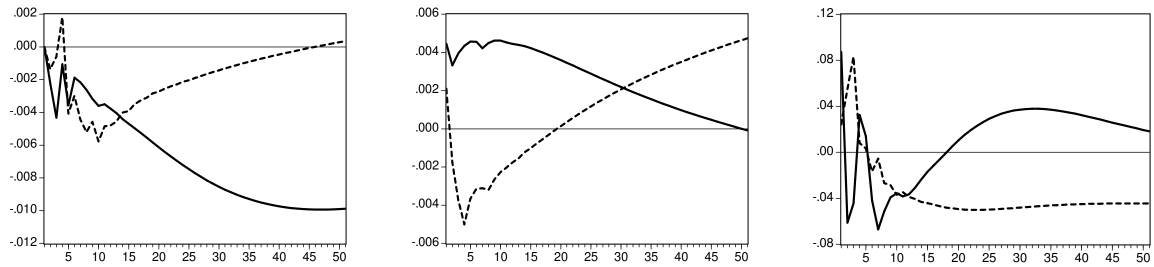
Responses of P_M to IP_M | **Responses of M_M to IP_M** | **Responses of IR_M to IP_M**



Interestingly, as observed in Figure 4, the responses of the three domestic variables namely the output, money and interest rate to price shock tend to move in the opposite direction in both sub-periods.

Figure 4: Responses of IP_M, M_M and IR_M to P_M Shock
(Solid Line – Pre-Crisis Period; Dashed Line – Post-Crisis Period)

Responses of IP_M to P_M | **Responses of M_M to P_M** | **Responses of IR_M to P_M**

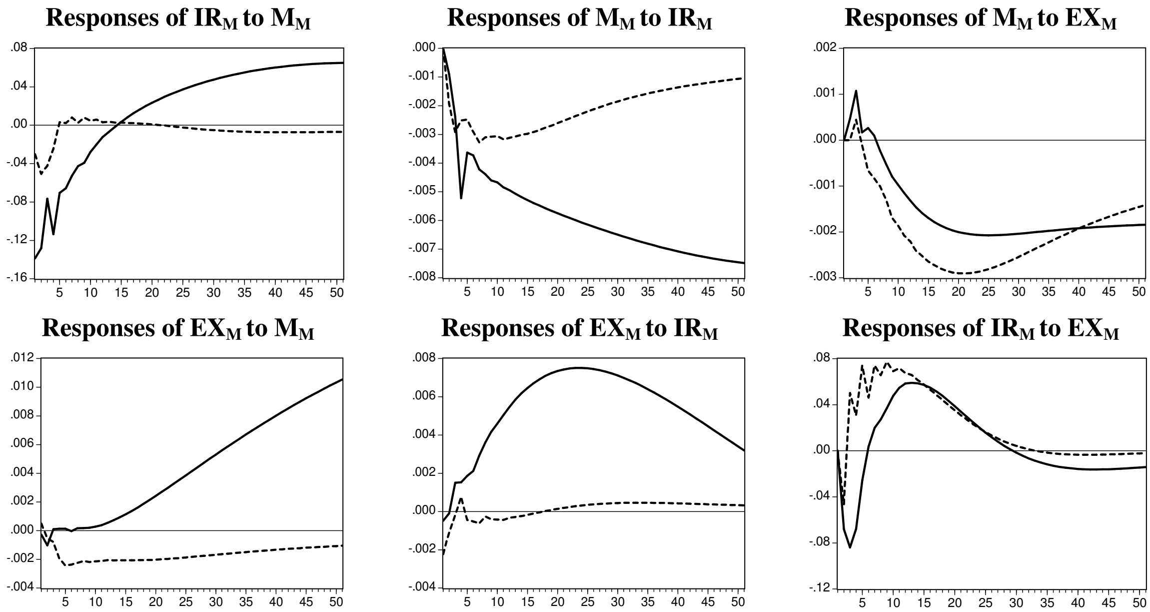


A positive shock to price level leads to an inflationary pressure in the economy and as a result the output declines in both sub-periods. However, the effect was more persistent in the pre-crisis period. The three variables' responses to price shock in the post-crisis period is more in line with the consensus view that output and money react negatively, while interest rate react positively to price shock.

6.1.4 Responses of Malaysian Policy Variables to Money, Interest Rate and Exchange Rate Shocks

Referring to Figure 5, a positive shock to money leads to an easing of monetary policy where the interest rate declined, consistent with the liquidity effect and the effect was larger in the pre-crisis period than that in the post-crisis period. A similar positive money shock on exchange rate however, did not produce the expected results in pre-crisis period, where the exchange rate appreciated instead of depreciating.

Figure 5. Responses of IR_M , M_M and EX_M to IR_M , M_M and EX_M Shocks
(Solid Line – Pre-Crisis Period; Dashed Line – Post-Crisis Period)



In the pre-crisis period, a positive shock to interest rate provided the expected contractionary effect on money and exchange rate whereby the money declined and the exchange rate appreciated. In the post crisis period, the rise in interest rate did not induce the exchange rate changes and this result is not surprising as BNM pegged the Malaysian ringgit to the US dollar during this period.

In the pre-crisis period, a positive shock to exchange rate, representing an appreciation of the domestic currency led to a brief fall in the interest rate. As expected, a positive shock to exchange rate causes the money demand to respond negatively in both sub-periods. Overall, we can conclude that the domestic policy variables responded to policy shocks more prominently and consistently in the pre-crisis period.

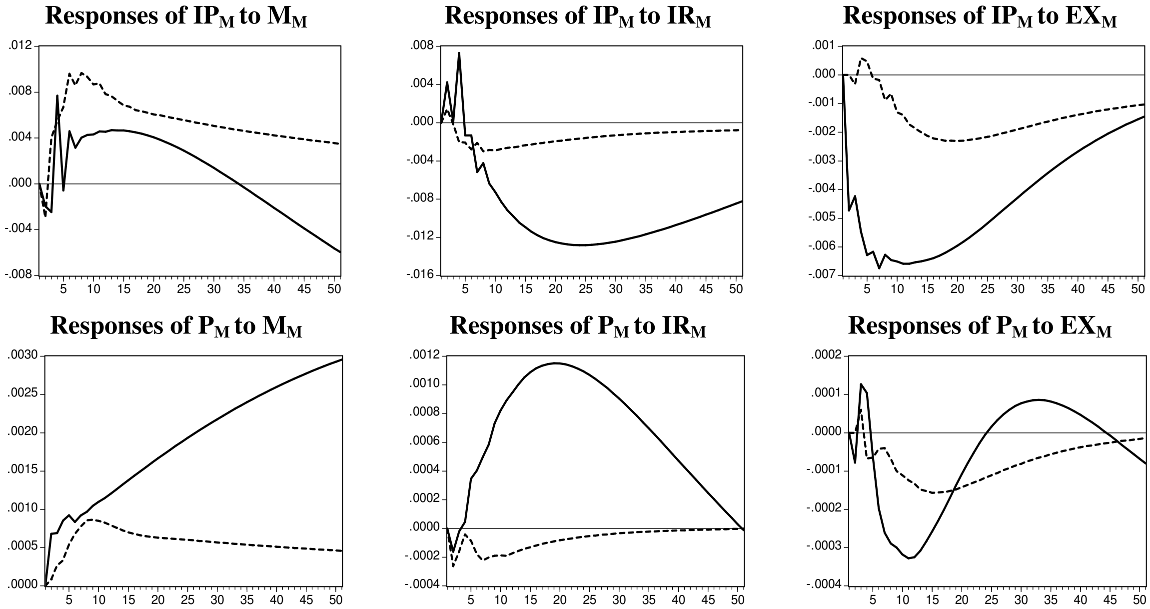
6.1.5 Responses of Malaysian Output and Price to Money, Interest Rate and Exchange Rate Shocks

With an exception of price puzzle in the pre-crisis period, both output and price responded as expected to all three policy shocks. The output responded positively to the expansionary money shock and negatively to the contractionary interest rate shock. An appreciation of the exchange rate may have affected the export market which leads to a fall in the output level. The shocks to the interest rate and the exchange rate had a stronger influence on output in the pre-crisis period, while the money shock had a larger influence on output in the post-crisis period.

A positive money shock causes the price level to increase, suggesting a demand driven inflationary pressure and the effect was much more persistent in the pre-crisis period. A price puzzle - which is prevalent empirical finding in the monetary literature - is present in the pre-crisis period on the Malaysian economy whereby a positive shock to interest rate leads to an increase in price level. The inclusion of world commodity price in the SVAR model to account for inflation expectation did not help to solve this problem.

An appreciation of the domestic currency causes the price level and output to decline. This appears to be consistent with Taylor (2000)'s view that the exchange rate affects output through expenditure switching effect while, the price is affected via pass-through effect. Overall the results indicate that the three monetary channels played a more significant role in transmitting the monetary shock to the target variables of output and price in the pre-crisis period.

Figure 6. Responses of IP_M and P_M to IR_M , M_M and EX_M Shocks
(Solid Line – Pre-Crisis Period; Dashed Line – Post-Crisis Period)



6.2 Variance Decomposition

The forecast error variance decomposition is a useful tool to examine the interactions between the variables over the impulse response horizon. Tables 5 and 6 report the proportion of the variations of the five domestic variables, explained by other variables in the SVAR model for the pre- and post-crisis periods respectively. The variance decomposition for the first, twelfth, twenty fourth and forty eighth horizon into the future are reported.

During the pre-crisis period, much of the variation in output in the medium term is explained by its own shock followed by the shocks on interest rates and exchange rates. In the longer horizon, it is largely affected by the world commodity prices, US output, domestic price levels and interest rates. As for prices, in the shorter horizon, the variations is mostly explained by its own shock, while in the longer horizon, much of the movement is caused by the world commodity price index followed by domestic money shocks. The variations in the money supply and interest rates are mainly affected by their own shocks. In the long run, money is mildly affected by interest rates, while interest rate is affected by price level in the economy. Further, the exchange rate is largely affected by the world commodity price index and the domestic price levels.

Table 5. Variance Decomposition of the Domestic Variables during the Pre-Crisis Period

	% of Variation due to								
Horizon	**PC**	**IP_U**	**P_U**	**IR_U**	**IP_M**	**P_M**	**M_M**	**IR_M**	**EX_M**
Output									
1	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
12	0.70	0.62	0.81	0.04	87.58	1.04	1.88	3.42	3.90
24	0.95	3.73	0.70	0.53	69.82	3.82	2.67	11.87	5.91
48	15.86	8.80	3.35	2.69	38.77	10.21	2.03	14.20	4.10
Price									
1	0.00	0.00	0.00	0.00	0.86	99.14	0.00	0.00	0.00
12	10.64	0.02	0.11	0.06	13.02	67.10	6.25	2.32	0.47
24	41.42	0.17	0.07	0.12	11.83	34.06	8.60	3.45	0.28
48	73.76	0.12	0.04	0.06	4.60	10.76	9.35	1.24	0.07
Money									
1	0.00	0.00	0.00	0.00	3.03	3.82	93.15	0.00	0.00
12	0.13	0.01	0.07	0.05	0.90	4.79	88.87	4.78	0.40
24	0.78	0.33	0.16	0.06	1.70	3.47	85.67	6.60	1.24
48	1.13	2.24	0.47	0.54	1.62	2.07	79.89	10.39	1.64
Interest Rate									
1	0.01	0.05	0.03	1.95	0.22	0.66	1.73	95.36	0.00
12	3.17	0.18	0.30	1.46	3.64	0.80	2.56	86.80	1.09
24	3.99	0.28	0.47	1.41	7.44	0.92	2.59	81.10	1.79
48	3.86	0.51	1.48	1.49	7.44	1.89	4.90	76.61	1.81
Exchange Rate									
1	0.12	3.22	7.01	0.06	0.32	0.33	0.07	0.24	88.63
12	8.52	10.89	8.30	1.30	2.65	25.64	0.08	5.24	37.38
24	28.86	9.83	4.35	1.94	6.00	26.40	0.98	8.84	12.80
48	59.61	4.78	3.33	1.52	4.33	13.24	5.15	4.75	3.29

Notably, a different set of results emerges for the post-crisis period. During this period, the world commodity price index appears to be playing an important role in explaining much of the variations in the domestic variables, especially in the longer horizon. Apart from the world commodity price index, the US output also seems to be affecting the movements in the Malaysian monetary aggregate, interest rates and exchange rates in the longer horizon. This result is consistent with what was observed in the impulse response function analysis whereby the variations in the domestic variables tend to be largely affected by the movement in the foreign variables in the post-crisis period.

Table 6. Variance Decomposition of the Domestic Variables during the Post-Crisis Period

Horizon	% of Variation due to								
	PC	**IP_U**	**P_U**	**IR_U**	**IP_M**	**P_M**	**M_M**	**IR_M**	**EX_M**
Output									
1	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
12	30.60	0.22	0.02	0.44	45.04	1.73	17.24	4.06	0.65
24	42.23	1.00	0.15	0.64	30.01	1.34	18.16	3.97	2.54
48	53.10	10.90	0.11	1.62	15.33	1.59	13.44	2.14	1.77
Price									
1	0.00	0.00	0.00	0.00	0.03	99.97	0.00	0.00	0.00
12	10.33	0.04	0.01	0.05	3.64	76.88	8.35	0.56	0.13
24	62.52	0.04	0.01	0.02	2.63	29.62	4.94	0.14	0.09
48	92.12	0.08	0.00	0.01	0.58	5.69	1.49	0.02	0.01
Money									
1	0.00	0.00	0.00	0.00	0.12	1.16	98.71	0.00	0.00
12	3.15	0.27	0.02	0.41	2.73	3.72	84.76	4.08	0.84
24	7.25	1.42	0.17	0.90	1.91	2.78	77.64	4.85	3.08
48	31.53	13.49	0.12	2.14	1.05	4.10	43.00	2.38	2.24
Interest Rate									
1	3.44	0.01	0.00	0.44	0.46	1.31	1.91	92.43	0.00
12	46.25	2.83	0.46	2.98	1.18	4.72	1.58	29.13	10.88
24	59.59	5.58	0.57	2.63	2.15	5.71	0.82	14.61	8.34
48	57.66	23.72	0.32	2.52	1.20	3.57	0.78	6.51	3.72
Exchange Rate									
1	2.76	0.26	0.82	0.77	0.25	0.20	0.25	6.19	88.50
12	46.13	5.15	4.57	3.36	0.63	5.82	6.83	1.23	26.27
24	45.41	9.63	3.30	5.16	1.23	8.71	9.02	0.85	16.69
48	54.35	23.97	1.29	2.99	0.82	4.65	4.71	0.52	6.69

7. Conclusion

In this paper, we employed the SVAR methodology to model and investigate the Malaysian monetary policy framework and how it has been affected by the 1997 financial crisis. We establish identification conditions to uncover the dynamic effects of monetary policy shocks on various domestic variables in the both pre- and post-crisis periods. The orthogonal policy shocks obtained from the SVAR model are used to assess the effectiveness of monetary policy and the roles of various transmission channels in affecting the price levels and the economic activities in Malaysia.

A nine-variable-SVAR model and monthly data from January 1980 to May 2006 are used to study the Malaysian monetary policy framework. This sample period covers only the post liberalization period in Malaysia which also includes the East Asian financial crisis in 1997. Both the domestic and foreign (US) variables were used to capture the dynamic responses of the Malaysian economy to domestic and foreign shocks. The foreign block exogeneity and the contemporaneous and dynamic restrictions on the domestic block are imposed to provide some economic structure to the Malaysian SVAR model. To examine the effect of Asian crisis in 1997, the analysis was conducted in the pre- and post-crisis periods 1980:1 to 1997:6 and 1998:1 to 2006:5 respectively.

The empirical results show notable differences in the monetary policy transmission mechanism during these two sample periods. In the pre-crisis period, monetary policy and exchange rate shocks have significantly affected the output, price, money, interest rate and exchange rate. In the post-crisis period, on the other hand, money tends to have a stronger influence on the output. Moreover, the domestic monetary policy appear to be far more vulnerable to foreign shocks especially the world commodity price shock and output shock in the post-crisis than in the pre-crisis period. The variance decomposition results also support these findings.

Considering the notable differences in the effects of monetary policy during the pre- and post crisis periods, the task of steering the economy in the right direction with an appropriate pressure can be a very challenging task for BNM. In addition, we also concur with Umezaki (2006) that the BNM not only need to take the domestic factors into consideration but also the external factors especially the foreign monetary and inflationary shocks when devising an appropriate monetary policy measure.

There is evidence of price puzzle in our analysis that a positive shock to interest rate increased the price level instead of reducing it. This economic puzzle seems to be commonly inherent in the monetary literature. According to Sims (1992), the price puzzle is the result of the SVAR model not reflecting perfectly the information set the central bank possesses about the future inflation and it is unknown to researchers. However, it is also worth noting that a large scale VAR model may capture the required information but it can lead to over parameterisation problem and statistically inefficient results.

As pointed out in Fry and Pagan (2005) there are also other possible sources of specification errors in VARs. One such mis-specification is due to the assumption of the VAR being of finite order when it can be of infinite order. In this regard, a reduced system may follow a vector autoregressive moving average (VARMA) process rather than a VAR process. The suitability of the VARMA methodology for Malaysian monetary policy framework will be investigated in our future work.

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References

Athukorala, P C, 2001, *Crisis and Recovery in Malaysia: The Role of Capital Controls* (Cheltenham: Edward Elgar).

Awang, A H, T H Ng, and A Razi, 1992, Financial Liberalisation and Interest Rate Determination in Malaysia, (Bank Negara Malaysia).

Azali, M, 1998, The Role Of Money And Credit In The Monetary Policy Transmission Mechanism, *Asian Economic Review* 40.

Azali, M, 2003. *Transmission mechanism in a developing economy : does money or credit matter?*

Azali, M, and K G Matthews, 1999, Money-income and credit-income relationships during the pre- and the post-liberalization periods: evidence from Malaysia *Applied Economics* 31, 1161-1170.

Bernanke, B S, 1986, Alternative Explanations of the Money-Income Correlations, *Carnegie-Rochester Conference Series on Public Policy* 25, 49-99.

Bernanke, B S, and A S Blinder, 1992, The Federal Funds Rate and the Channels of Monetary Transmission, *The American Economic Review* 82, 901-921.

Bernanke, B S, and I Mihov, 1995, Measuring Monetary Policy, NEBR Working Paper.

Blanchard, O J, and M W Watson, 1986, Are Business Cycles All Alike?, in R Gordon, ed.: *The American Business Cycle: Continuity and Change* (University of Chicago Press).

BNM, 1994. *Money and Banking in Malaysia* (Kuala Lumpur).

BNM, 1999. *The Central Bank and the Financial System in Malaysia: A Decade of Change* (Kuala Lumpur).

Cheong, L M, 2004, Globalisation and the Operation of Monetary Policy in Malaysia, *Bank of International Settlement* 23, 209-215.

Christiano, J L, and M Eichenbaum, 1992, LiquidityEffects and theMonetary Transmission Mechanism, *American Economic Review* 82, 346-353.

Christiano, L J, M Eichenbaum, and C L Evans, 1998, Monetary Policy Shocks: What Have We Learned and to What End, NBER Working Paper.

Clinton, K, and W Engert, 2000, Conference Summary "Money, Monetary Policy, and Transmission Mechanism", Bank of Canada Review.

Cushman, D O, and T A Zha, 1997, Identifying Monetary Policy in a Small Open Economy Under Flexible Exchange Rates, *Journal of Monetary Economics* 39, 433-448.

Dekle, R, and M Pradhan, 1997, Financial Liberalization And Money Demand In ASEAN Countries: Implications For Monetary Policy, IMF Working Paper (Washington DC.).

Domac, I, 1999, The Distributional Consequences of Monetary Policy: Evidence from Malaysia, World Bank Policy Research Working Papers.

Dungey, M, and R Fry, 2003, International Shocks on Australia - the Japanese Effect. , *Australian Economic Papers* 42, 158-182.

Dungey, M, and A R Pagan, 2000, A Structural VAR Model of the Australian Economy, *Economic Record* 76, 321-342.
Eichenbaum, M, and C L Evans, 1995, Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates, *Quarterly Journal of Economics* 110, 1075-1010.
Fry, R, and A R Pagan, 2005, Some Issues in Using VARs for Macroeconometric Research, CAMA Working Paper Series.
Fung, S C, 2002, A VAR Analysis of the Effects of Monetary Policy in East Asia, Working Paper (Bank of International Settlement).
Ibrahim, M, 2005, Sectoral Effects of Monetary Policy: Evidence from Malaysia, *Asian Economic Journal* 19, 83-102.
Ito, T, and K Sato, 2006, Exchange Rate Changes and Inflation in Post-Crisis Asian Economies: VAR Analysis of the Exchange Rate Pass-Through, CIRJE Discussion Paper.
Joiner, A, 2003, Modelling Monetary Policy in Small Open Economies Using Bayesian VARS, Department of Econometrics and Business Statistics (Monash University).
Kuttner, K N, and P C Mosser, 2002, The Monetary Transmission Mechanism: Some Answers and Further Questions, Economic Policy Review (Federal Reserve Bank of New York).
Kwek, K T, 1990a, Financial Aggregates And Economic Activity In An Open Economy: Implications For Monetary Policy In Malaysia, The Faculty Of Economics And Administration (University Malaya, Kuala Lumpur).
Kwek, K T, 1990b, The Short-run Stability Of Monetary Aggregates And Long-run Effects Of Co-integration: The Case For Malaysia, *Asian Economies* 20.
Leeper, E M, and T A Zha, 1999, Modest Policy Intervention, Federal Reserve Bank of Atlanta.
McCauley, R N, 2006, Understanding Monetary Policy in Malaysia and Thailand: Objectives, Instruments and Independence, in BIS, ed.: Discussion Papers.
Mehrotra, A N, 2005, Exchange and Interest Rate Channels During a Deflationary Era - Evidence from Japan, Hong Kong and China, Discussion Paper (BOFIT).
Mulyana, S, 1995, Financial Reform And Transmission Mechanism Of Monetary Policy In The SEACEN Countries, (SEACEN Research And Training Centre, Kuala Lumpur).
Raghavan, M V, 2004, The Changing Malaysian Financial Environment and the Effects on its Monetary Policy Transmission Mechanism, The 21st Australasian Meeting of the Econometric Society (Melbourne).
Raghavan, M V, and P Silvapulle, 2007, Exploring the Malaysian Monetary Transmission Mechanism During the Pre- and Post-Crisis Periods, mimeo (Monash University).
Ramaswamy, R, and T Sloek, 1997, The Real Effects of Monetary Policy in the European Union: What are the Differences?, IMF Working Paper.
Sims, C A, 1980, Macroeconomics and Reality, *Econometrica* 48, 1-48.
Sims, C A, 1986, Are forecasting Models Useful for Policy Analysis?, Quarterly Review (Federal Reserve Bank of Minneapolis).
Sims, C A, 1992, Interpreting the Macroeconomic Time Series Facts; The Effects of Monetary Policy *European Economic Review*
36, 975-1011.

Tan, E C, 1996, Money Demand Amid Financial Sector Developments in Malaysia, in University Malaya, ed.: The Conference on Globalization and Development (Kuala Lumpur).
Tang, H C, 2006, The Relative Importance of Monetary Policy Transmission Channels in Malaysia, CAMA Working Paper Series.
Taylor, J B, 2000, Alternative Views of Monetary Transmission Mechanism: What Difference do They Make for Monetaru Policy, Stanford University, Mimeo.
Tseng, W, and R Corker, 1991, Financial Liberalization, Money Demand, Monetary Policy In Asian Countries, in IMF, ed.: Occasional Paper (Washington DC).
Umezaki, S, 2006, Monetary and Exchange Rate Policy in Malaysia before the Asian Crisis, Institute of Developing Economies (JETRO).
Woo, M T, 1991, Capital Mobility and Monetary Autonomy In A Small Open Economy: The Case For Malaysia, Faculty Of Economics And Administration (University Malaya, Kuala Lumpur).
Zha, T A, 1999, Block Recursion and Structural Vector Autoregression, *Journal of Econometrics* 90, 291-316.