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RELATIVE PRICE EFFECTS OF MONETARY POLICY SHOCK IN MALAYSIA: A SVAR STUDY

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ABSTRACT

Studies on Malaysia monetary policy mostly examine the effect of monetary policy change on output and inflation in aggregate terms. While sectoral output effects of monetary policy have also been investigated, there is however a lack in the study on the effect of policy change on disaggregated inflation. This paper attempts to examine the later issue by employing structural vector autoregressive (SVAR) model. By estimating the model separately for each sub-group of Malaysian consumer price index, we find that a modest monetary policy shock results in varying degree of responses in disaggregated inflation. In other words, some sub-group inflation react instantly while others respond sluggishly to a monetary policy shock. In contrast to aggregate inflation response, there is also evidence of price puzzle. The results give some insight to monetary authority on how to control inflation in aggregate as well as in disaggregate terms and in turn manage the cost of living issues in Malaysia.

Keywords: Monetary Policy; SVAR; Inflation; Relative Price.

1. INTRODUCTION

A good understanding of monetary policy effects upon disaggregated inflation is pivotal to monetary authority in assessing the effectiveness of monetary policy as a stabilization policy. The monetary authority has to make an accurate assessment of the speed of price adjustment in order to understand the sources of business cycle fluctuations, and also the effects of monetary policy on the economy. The effects of monetary policy upon the relative prices are also vital for macroeconomists in understanding the concept of non-neutralities of money. This is because non-neutralities of money are reflected in relative price movements. For example, at microeconomic level, if economic agents react purely to monetary shocks by changing their consumption or labor supply decision, these changes would be reflected in relative price

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changes. Alternatively, relative price changes due to monetary policy shocks also induce economic agents to alter their real behavior. However, if money is neutral, there would be no relative price effects of a monetary shock.

Most of the controversy in the empirical studies of monetary policy analysis have centered on issues whether the price level of goods is flexible or sticky in response to monetary policy changes. According to the sticky price model (menu cost model), firm will not adjust the price level immediately in response to demand changes because the firms will incur direct and indirect costs (for example, managerial costs, and potential loss of consumer goodwill). Numerous studies focusing on specific wholesale or retail items have found evidence of prices maintained fixed for several months in the U.S. economy[1]. Studies using VAR model have also provided similar evidence about the stickiness of the aggregate price level. For example, under a wide range of identifying assumption, Christiano et al. (1999) found that the aggregate price index are commonly found to remain unchanged for about a year in response to unexpected monetary policy tightening. However, recent evidence on disaggregated prices series has cast doubts on the validity of existing model with price rigidities. For example, Bils & Klenow (2004) found that disaggregated consumer prices are much more volatile than conventionally assumed in studies based on aggregate data. This indicates that if price responds quickly (or is being flexible), any changes in aggregate demand due to a change in monetary policy can be associated with a change in the relative prices.

Empirical studies investigating the effect of monetary shock on price or inflation have also found evidence of 'price puzzle' in which an increase in interest rates (or monetary tightening) causes the price level to increase rather than to decrease. In the U.S economy, for example, Bils et al. (2003), and Balke and Wynne (2007) found prize puzzles when examining the disaggregated response of inflation to a monetary shock. Barth and Ramey (2001) have suggested that because of financial market frictions, contractionary monetary shocks acts like a cost shocks (cost channel effect). They argue that contractionary monetary policy operates on aggregate supply as well as aggregate demand. For example, an increase in interest rates raises the cost of holding inventories, and as a consequent acts as a positive cost shocks. This negative supply effects raises prices and lower output. Firms that must borrow working capital see their costs rise as interest rates rise, and these cost increases result in an increase in prices.

Empirical studies on Malaysia monetary policy have mostly examined the effect of monetary policy change on output and inflation in aggregate terms. While sectoral output effects of monetary policy have also been investigated (see Ibrahim (2005)), there is however a lack in the study on the effect of policy change on disaggregated inflation. This paper attempts to examine the later issue by employing structural vector autoregressive (SVAR) model in non-recursive form. The model is used as it provides some theoretical backgrounds on the relationship between the variables under study. Furthermore, as suggested by Cushman & Zha (1997) and Kim & Roubini (2000), the non-recursive SVAR model might be able to solve empirical anomaly of price puzzle.

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1 See for example Kashyap (1995) and Levy et al. (1997).

The study on this issue will shed some lights to policy makers on how to tackle the inflation in aggregate as well as in disaggregate terms. Consequently, as inflation is regarded as the cause of the cost of living, knowing how the price reacts to a monetary policy shock would be advantageous both for policy makers and Malaysian consumers. If the effect of monetary policy shock on sub-group inflations are heterogenous, modification has to be made in implementing the monetary policy. Otherwise the policy undertaken would not be effective in controlling inflation in certain sub-groups. Consequently the goal to reduce the price increase in that groups would not be achieved. For consumers, information on the effect of monetary policy on sub-group inflations can be a guide for managing household expenditures. To reduce the cost of living, expenditure on certain groups of goods can be reduced proportionately to the degree the subgroups' prices decrease in response to a change in monetary policy.

The remainder of the paper is organized as follows. Next section briefly reviews the previous literature that considers the effects of monetary policy changes on relative prices. Section 3 explains the data and the estimation procedures, which include a small-open economy SVAR model. Section 4 presents the main empirical results, and finally, section 5 summarizes and concludes.

2. LITERATURE REVIEW

Most of the empirical studies relating to the effect of monetary policy shocks upon prices have focused on aggregate data, and found that the price level decreases in response to monetary policy tightening (an increase in interest rate). However, little attention has been given in investigating the effect of monetary policy shock upon disaggregated inflation either in developed or semi-developed countries. Several studies in the U.S. economy, for example Balke and Wynne (2007) find that there are substantial effects of monetary shocks upon relative prices. In the short run, nearly equal proportion of goods prices significantly increase and decrease in response to a contractionary shocks. Another study by Bils et al. (2003), who use the sticky price model find that in the short run, the relative prices effects of monetary shocks have the wrong sign (price puzzle). Monetary policy shocks seem to have persistence effects on both relative prices and relative quantities, rather than the transitory effects one would expect from differences in price flexibility across goods. Employing disagregated data in the U.S. economy, Boivin et al. (2007) find that most prices respond with a significant delay to identified monetary policy shocks, and show little evidence of a 'price puzzle'. In fact, prices in sectors with volatile idiosyncratic shocks reacts rapidly to aggregate monetary policy shocks.

In Malaysia context, studies relating to monetary policy analysis have focused upon the effect of monetary policy on aggregate output (for example, Azali and Matthews, 1999; Ibrahim, 2005; Tang, 2006; Karim and Karim, 2014). Azali and Matthews (1999) employs a closed economy SVAR model, and find that during the pre-liberalization period, the bank credit shock had more impact compared with money shock in explaining output variability. In contrast, after the post-liberalization period, money as well as credit innovations were significant in explaining output shocks. Using recursive VAR in closed economy, Ibrahim (2005) supports the real effects of monetary policy shocks across sub-sector of economy. In fact, the response of sub-sector output to monetary policy is heterogeneous, where the sectors that are very heavily dependent on bank loan are more sensitive to monetary policy shock. However, Azali and Matthews (1999) and Ibrahim (2005) do not discuss the effect of monetary policy on inflation in their study. In contrast, Tang (2006) employs an open economy recursive VAR model in examining the relative important of the monetary policy transmission channel. His findings conclude that, the interest rates channel plays a pivotal role in influencing output and inflation. In addition, the asset price channel is also relevant for explaining output variability, but for inflation, the exchange rate channel is more relevant than the asset price channel. Karim and Karim (2014) examines the implementation of monetary policy during interest rates targeting in Malaysia, and found that monetary policy plays a significant role in affecting macroeconomics variables, in which suggests that monetary policy has an important role as a stabilization policy.

Recent study by Zaidi and Fisher (2010) using non-recursive SVAR approach reveals that unanticipated monetary policy explains very little of the variability in output and inflation at all forecast horizons but does account for some short run variability in the real exchange rate. Most of the variability of output and inflation are explained by foreign variables, though domestic credit is important for output at the one quarter horizon. They conclude that foreign shocks are the dominant influence on the macroeconomic performance of Malaysia.

To our best knowledge, there is still a lack of empirical studies in Malaysia that examine the relative prices effects of monetary policy shocks. Therefore, this study provides a novel contribution to the existing literature by investigating the inflation behavior across sub-sector of CPI in response to monetary policy shocks.

3. DATA AND THE SVAR MODEL

3.1. Data

This study divides the variables into two blocks. The first block consists of two foreign variables; real commodity prices (LCP) and the real trade weighted gross domestic product of the US and Japan (LFY). The US and Japan are chosen to represent foreign sectors not only because both countries are Malaysian major trading partners, but they are also the two important countries that have affected many other countries economically and financially.[2] Commodity prices are included to capture the expectation of future inflation by the policy-maker and as a means of solving the price puzzle (see Sim, 1992; Christiano, Eichenbaum & Evans, 1999). In addition, inclusion of commodity prices is also important because Malaysia is a commodity exporting country.[3] Changes in commodity prices are expected to influence

2 Other studies which investigate the influence of US and Japan on a particular country or countries include Chua et al. (1999) for Korea and Malaysia, Ibrahim (2004) for Malaysia, Moon and Jain (1995) for Korea and Dungey and Fry (2003) for Australia.

3 Malaysia is still a leading world exporter of several tropical commodities such as palm oil, rubber, timber, cocoa and pepper even though the manufacturing goods have now been constituting a majority of the Malaysian total export. The use of commodity price as an indicator for expected inflation follows the recent study of Tang (2006) for the case of Malaysia. Furthermore the period of study in this thesis covers from 1980:2 until 2008:2. Thus, it includes the period where the commodity has been a significant part of the total export.

the value of Malaysian exports of the commodities and eventually the level of real income in the economy. Commodity prices are included in Tang's (2006) work on Malaysia. Some other studies (Kim & Roubini, 2000) use oil prices rather than commodity prices as a proxy for future inflation, however Malaysia is an oil producing country and the oil price in the domestic market is heavily regulated.[4]

The aggregate variables LFY is used instead of individual real GDP of the US or of Japan to try and account for the impact of both major trading partners in affecting the Malaysian economy.[5] Given that these two countries accounted for 35 percent of total Malaysian trade with the world, it is anticipated that they will be sufficient to capture real external factors affecting the Malaysian economy. Chua et al. (1999) and Ibrahim (2004) find that both the US and the Japanese economies have a significant impact on the Malaysian economy. SVAR studies for other small open economics (see Sims & Zha, 1995; Kim & Roubini, 2000; Dungey & Pagan, 2000 and Berkelmans, 2005) have included foreign variables and found their roles in the system to be quantitatively important.

The second block contains the domestic variables; real Malaysian GDP (LMY), the relative price inflation rate (INF), the interest rate (INT) (3-month interbank rate), real credit (LCR) (measured as total loans and advances from the banking system), a real asset price (LAP) (measured by the Kuala Lumpur Composite Index) and real effective exchange rate (LER). All variables (except the inflation rate and the interest rate) are transformed by taking logarithms. The interest rate is in nominal terms and is the policy variable used by the central bank.[6] The inflation rate is calculated as the quarter-on-quarter percentage change of the consumer price index (CPI). Nine disaggregated prices under study consist of 1) Food; 2) Beverages and tobacco; 3) Clothing and footwear; 4) Gross rent, fuel and power; 5) Furniture, furnishings and household equipment and operation; 6) Medical care and health expenses; 7) Transport and communication; 8) Recreation, entertainment, education and cultural services; 9) Miscellaneous goods and services

With the possible exception of inflation, all of the variables in used in the study are potentially non-stationary due to the presence of either deterministic or stochastic trends. This raises the question as to whether the SVAR model should be specified in first-differences rather than in levels. Ramaswamy and Slok (1998) discuss the trade-off between the loss of efficiency (when the VAR is estimated in levels, but without imposing any cointegrating relationships) and the loss of information (when the VAR is estimated in first-differences). In essence, they

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4 Only recently has the Malaysian government reduced the oil price subsidy, thus making the domestic oil price more sensitive to changes in the world oil price.

5 The weight for each country is calculated by dividing the value of imports and exports of Malaysia from/to each country by the total value of imports and exports of Malaysia with both the US and Japan. The average weight for each country is around 0.5. Malaysia traded more with Japan (the highest weight is 0.63) than with the US before 1998, but the reverse is true after that year. In order to create the trade weighted output Japanese GDP is converted to US dollars.

6 Although BNM only began to use interest rate as policy variable towards the mid 1990s, the use of interest rate to describe policy variable (instead of monetary aggregates) in this study for the sample period which begins from early 1980s is due to the fact that since 1978, the liberalization of interest rates has led to a more market oriented interest rate determination process and the interest rate has become more important in the monetary transmission mechanism (BNM, 1999).

recommend that in cases where there is no prior economic theory that can suggest either the number of long-run relationships or how they should be interpreted, it is reasonable not to impose cointegration restrictions on the VAR model. Their recommendation is followed in this chapter; the SVAR model is specified in levels.

The domestic variables include the key macroeconomic variables in the Malaysian economy. The use of real GDP and inflation are standard in VAR models and represent the primary target variables of monetary policy. The use of inflation rather than the price level has been used in other studies, for instance Dungey and Pagan (2000), Dungey and Fry (2003) and Berkelmans (2005) for Australian case and Garrat et al. (2003) for the UK. Tang (2006) also employs inflation in his model of Malaysia. The real credit, real asset price and real effective exchange rate variables are used to represent the credit channel, the asset price channel and the exchange rate channel of monetary policy respectively.

The appropriate choice of interest rate for our sample period is less clear cut as the BNM has made several changes to the rate used to implement monetary policy. The policy rate currently used is the overnight policy rate (OPR), however this is only available from 2004 onwards. There are other few options available. Azali and Matthews (1999) use the 3-month Treasury bill, Fung (2002) and Tang (2006) utilize the 3-month interbank rate, while Ibrahim (2005) uses the overnight interbank rate. In this analysis the 3-month interbank rate (INT) is employed as the policy variable for a number of reasons: first it is available for the full sample period; it was used as the policy rate for the period 1995 to 1998 and finally it has been most commonly used in previous studies to reflect the BNM policy rate. As the interest rate captures the behaviour of monetary policy, a positive shock to the interest rate will indicate a contractionary of monetary policy (and vice versa).

For the credit variable, total loans and advances from the banking institutions is used. These include loans from commercial banks, finance companies and merchant banks. The commercial banks alone constitute about 75 percent of total loans given by the banking and financial system as a whole. The remainder are from merchant banks and finance companies. Total loans offered by the last two institutions have gradually been decreasing (especially after 2000) when more finance companies have merged with the larger commercial banks. The choice of the Kuala Lumpur composite index of share prices to represent the asset price channel is driven by the fact that it is the only measure of asset prices that is available throughout the full sample period. An alternative measure of asset prices such as the property price index only begins in the late 1990s.

For the exchange rate variable, the real effective exchange rate is used. It reflects the aggregate behaviour of the major currencies of Malaysia's main trading partners. As defined, an increase in the exchange rate means that the domestic currency which is the Ringgit Malaysia (RM) appreciates relative to the currencies of its major trading partners. A similar variable has been used by Domac (1999); however Ibrahim (2005) uses the nominal effective exchange rate, while Tang (2006) uses the nominal bilateral RM/USD exchange rate.

Data are collected from various issues of the Monthly Statistical Bulletin of the Bank Negara Malaysia, DataStream and the International Financial Statistics (IFS) online database. The sample period covers 1982:2 to 2008:1, taking into account the effects of an economic recession in 1985-1986, the Asian financial crisis of 1997-1998 and the period of exchange control implemented by Malaysian government (as well as the earlier period of economic liberalization and deregulation). Data which are not seasonally adjusted by the original sources are adjusted using the X11 method. Data are until 2008:1 to exclude from the effect of current economic crisis.

Two dummy variables are defined to capture both the effects of the 1985-86 economic recession (DEC) and the 1997-98 Asian financial crisis (DAC). Specifically, DEC takes on the value of one from 1985:2 until 1986:2 and zero otherwise while DAC takes on the value of one from 1997:4 until 1998:4 and zero otherwise. Since during recessions, a policy change is deemed to be significant and can affect the behaviour of an agent as postulated by the Lucas critique, the use of dummy variables to account for the economic recessions is important as this will allow only the modest policy change by the Bank Negara to be investigated (see Leeper and Zha, 2003). Nevertheless, using the dummy variables may affect the model's results as the economic recession episodes are dummied out from the model analysis. Secondly, the inclusion of the dummy variables accounts for the mean shift (downward) that occurred in GDP growth over the two recessions. It is a simple way to account for a mean shift in GDP growth over the two recessions. Inclusion of the two dummy variables improves the results from the diagnostic tests on the reduced form residuals.

3.2. SVAR models

In the SVAR approach the dynamic relationship for the selected economic variables is given by the following equation;

$$BY_t = C + (\Gamma_1 L + \Gamma_2 L^2 + \ldots + \Gamma_k L^k)Y_t + \varepsilon_t \tag{1}$$

where B is a square matrix that captures the structural contemporaneous relationships among the economic variables, Y_t is n x 1 vector of macroeconomics variables, C is a vector of deterministic variables, $\Gamma(L)$ is a kth order matrix polynomial in lag operator, L and ε_t is a vector of structural innovations that satisfies the conditions that $E(\varepsilon_t) = 0$, $E(\varepsilon_t \varepsilon_s) = \Sigma_\varepsilon$, for all $t = s$ and $E(\varepsilon_t \varepsilon_s) = 0$ otherwise.

Pre-multiplying equation [1] with B^{-1}, yields a reduced form VAR equation

$$Y_t = B^{-1}C + B^{-1}(\Gamma_1 L + \Gamma_2 L^2 + \ldots + \Gamma_k L^k)Y_t + B^{-1}\varepsilon_t \tag{2}$$

where $e_t = B^{-1}\varepsilon_t$ is a reduced form VAR residual which satisfies the conditions that $E(e_t) = 0$, $E(e_t e_s^{'}) = \Sigma_e$. Σ_e is a (nxn) symmetric, positive definite matrix which can be estimated from the data.

The relationship between the variance-covariance matrix of the estimated residuals, Σ_e and the variance-covariance matrix of the structural innovations, Σ_ε is such that

$$\begin{aligned}\Sigma_\varepsilon &= E(\varepsilon_t \varepsilon_t^{'}) \\ &= E(Be_t e_t^{'} B^{'}) = BE(e_t e_t^{'})B^{'} \\ &= B\Sigma_e B'\end{aligned} \tag{3}$$

In order for the system to be identified, sufficient restrictions must be imposed so as to recover all structural innovations from the reduced form VAR residuals, e_t. Thus for (nxn) symmetric matrix Σ_e, there are $(n^2 + n)/2$ unknowns and hence $(n^2 - n)/2$ additional restrictions need to be imposed to exactly identify the system.

(a) The structural model

The relationship between the structural innovations ε_t and the reduced-form residuals e_t is given by $Be_t = \varepsilon_t$. In a purely recursive SVAR model, the elements in B above the diagonal of the matrix are all set equal to zero. When a recursive identification scheme is used on the Malaysian data, the model produces both a price puzzle and an exchange rate puzzle to "monetary policy" shocks. To address these problems, a number of non-recursive identification schemes are considered.

Equation [4] indicates the set of restrictions that are imposed on of the contemporaneous parameters of the SVAR model of the Malaysian macroeconomy. The coefficient β_{ij} indicates how variable j affects variable i, contemporaneously. The coefficients on the diagonal are normalized to unity, while the number of zero restrictions on the coefficients is 28, so the model is exactly identified.

$$BY_t \equiv \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_{31} & \beta_{32} & 1 & 0 & \beta_{35} & \beta_{36} & 0 & 0 \\ \beta_{41} & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ \beta_{51} & 0 & 0 & \beta_{54} & 1 & \beta_{56} & 0 & \beta_{58} \\ \beta_{61} & \beta_{62} & \beta_{63} & \beta_{64} & \beta_{65} & 1 & 0 & 0 \\ \beta_{71} & \beta_{72} & \beta_{73} & \beta_{74} & \beta_{75} & \beta_{76} & 1 & 0 \\ \beta_{81} & \beta_{82} & \beta_{83} & \beta_{84} & \beta_{85} & \beta_{86} & \beta_{87} & 1 \end{bmatrix} \begin{bmatrix} LCP_t \\ LFY_t \\ LMY_t \\ INF_t \\ INT_t \\ LCR_t \\ LAP_t \\ LER_t \end{bmatrix} \tag{4}$$

The two foreign variables - commodity prices and foreign GDP - are assumed to contemporaneously affect most of the domestic variables. The only exceptions are that foreign GDP does not contemporaneously affect domestic inflation and the policy interest rate. The first zero restriction reflects the assumption of price rigidity (in this case inflation inertia), so that Malaysian inflation does not respond in the same quarter to a foreign output shock. The second zero restriction is based on the assumption that policy-makers in the BNM do not observe contemporaneous values of US and Japanese GDP. This type of identifying assumption has been widely used in SVAR models; see Kim and Roubini (2000) for its application to the G7 economies and Berkelmans (2005) for the case of Australia. Domestic variables are assumed not to contemporaneously affect the foreign variables (the restriction is also imposed on lagged values of the domestic variables) due to the fact that Malaysian economy is relatively small in size and therefore unlikely to have much impact on foreign variables.

Restrictions in equation [4] indicate that all financial variables (the interest rate, credit, asset prices and the exchange rate) respond contemporaneously to inflation shocks. Since the ultimate goal of monetary policy is to have low and stable inflation, a shock in inflation will require policy-makers to respond immediately by adjusting the policy rate. In [4] it assumed that policy-makers in the BMN respond more rapidly to an inflation shock than they do to a shock to domestic output. This treats the policy rate in a manner that is symmetric to all of the other financial variables in the SVAR model.

Since the model is estimated on quarterly data, it is assumed that a shock in the interest rate will have a contemporaneous effect on the domestic output.[7] The reasonableness of this assumption is supported by the fact that interest rate pass-through - from the policy rate to the retail rate - has been high in speed and magnitude over the past several years.[8] The contemporaneous effect of interest rate on output is also used by Sims (1992) in his six variable VAR model and by Kassim and Abdul Manap (2008) for Malaysia.[9]

The credit variable is assumed to have a contemporaneous effect on real output. The reason is quite straightforward as households and private firms are assumed to spend or invest immediately they get their loans. This in turn will quickly increase the aggregate demand. A similar assumption is used by Safaei and Cameron (2003) and Berkelmans (2005) in the case of Canada and Australia respectively.

Finally the exchange rate only affects the interest rate contemporaneously. The interdependence of the exchange rate and the interest rate has been assumed in Kim and Roubini (2000) and Brischetto and Voss (1999) as it helps solve the exchange rate puzzle. It is known from Tang's (2006) study of Malaysia that when this structure is not assumed there is an exchange rate puzzle. As in other VAR studies, the exchange rate responds contemporaneously to all variables in the model. Even though some variables do not affect the others contemporaneously, lagged

[7] Walsh (2003) argues that whether an interest rate shock has a contemporaneous effect on output will depend on the frequency of the data observations. For example it would be more plausible to assume a contemporaneous effect when using monthly data as opposed to using annual data.

[8] According to Kuang (2008), the greater speed and magnitude of interest rate pass-through is a result of the significant improvements in the level of efficiency in the banking system, led by the changes in the financial infrastructure and policy framework during the past several years.

9 Sims (1992) orders the interest rate variable first, followed by a monetary aggregate, a consumer price index, an industrial production index, an exchange rate index and a commodity price index for each model of the five developed countries under study. The innovations to the interest rate variable (as a measure of monetary policy) are assumed to affect all other variables contemporaneously but not vice versa.

effects among variables are unrestricted, except that the foreign and domestic sectors are assumed to be block exogenous.

(b) Estimation of the reduced form

Equation [5] shows the reduced-form for the SVAR model. Following the approach of Cushman and Zha (1997), Dungey and Pagan (2000), Berkelmans (2005) and Tang (2006) the two foreign variables are placed first in the VAR model. They are followed then by domestic variables. Since Malaysia is a small open economy, it is assumed that the domestic variables do not influence the foreign variables either contemporaneously or with a lag.

The vector C in [1] contains of the intercept and dummy variables.[10] The commodity price equation and the foreign GDP equation are only functions of lagged commodity prices and foreign GDP. All of the domestic variables depend on lags of both foreign and domestic variables.

$$\begin{bmatrix} LCP_t \\ LFY_t \\ LMY_t \\ INF_t \\ INT_t \\ LCR_t \\ LAP_t \\ LER_t \end{bmatrix} = \begin{bmatrix} \delta_{11} & \delta_{12} & \delta_{13} \\ \delta_{21} & \delta_{22} & \delta_{23} \\ \delta_{31} & \delta_{32} & \delta_{33} \\ \delta_{41} & \delta_{42} & \delta_{43} \\ \delta_{51} & \delta_{52} & \delta_{53} \\ \delta_{61} & \delta_{62} & \delta_{63} \\ \delta_{71} & \delta_{72} & \delta_{73} \\ \delta_{81} & \delta_{82} & \delta_{83} \end{bmatrix} \begin{bmatrix} 1 \\ dac \\ dec \end{bmatrix} + \begin{bmatrix} \theta_{11} & \theta_{12} & 0 & 0 & 0 & 0 & 0 & 0 \\ \theta_{21} & \theta_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ \theta_{31} & \theta_{32} & \theta_{33} & \theta_{34} & \theta_{35} & \theta_{36} & \theta_{37} & \theta_{38} \\ \theta_{41} & \theta_{42} & \theta_{43} & \theta_{44} & \theta_{45} & \theta_{46} & \theta_{47} & \theta_{48} \\ \theta_{51} & \theta_{52} & \theta_{53} & \theta_{54} & \theta_{55} & \theta_{56} & \theta_{57} & \theta_{58} \\ \theta_{61} & \theta_{62} & \theta_{63} & \theta_{64} & \theta_{65} & \theta_{66} & \theta_{67} & \theta_{68} \\ \theta_{71} & \theta_{72} & \theta_{73} & \theta_{74} & \theta_{75} & \theta_{76} & \theta_{77} & \theta_{78} \\ \theta_{81} & \theta_{82} & \theta_{83} & \theta_{84} & \theta_{85} & \theta_{86} & \theta_{87} & \theta_{88} \end{bmatrix} \begin{bmatrix} LCP_{t-1} \\ LFY_{t-1} \\ LMY_{t-1} \\ INF_{t-1} \\ INT_{t-1} \\ LCR_{t-1} \\ LAP_{t-1} \\ LER_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} \psi_{11} & \psi_{12} & 0 & 0 & 0 & 0 & 0 & 0 \\ \psi_{21} & \psi_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ \psi_{31} & \psi_{32} & \psi_{33} & \psi_{34} & \psi_{35} & \psi_{36} & \psi_{37} & \psi_{38} \\ \psi_{41} & \psi_{42} & \psi_{43} & \psi_{44} & \psi_{45} & \psi_{46} & \psi_{47} & \psi_{48} \\ \psi_{51} & \psi_{52} & \psi_{53} & \psi_{54} & \psi_{55} & \psi_{56} & \psi_{57} & \psi_{58} \\ \psi_{61} & \psi_{62} & \psi_{63} & \psi_{64} & \psi_{65} & \psi_{66} & \psi_{67} & \psi_{68} \\ \psi_{71} & \psi_{72} & \psi_{73} & \psi_{74} & \psi_{75} & \psi_{76} & \psi_{77} & \psi_{78} \\ \psi_{81} & \psi_{82} & \psi_{83} & \psi_{84} & \psi_{85} & \psi_{86} & \psi_{87} & \psi_{88} \end{bmatrix} \begin{bmatrix} LCP_{t-2} \\ LFY_{t-2} \\ LMY_{t-2} \\ INF_{t-2} \\ INT_{t-2} \\ LCR_{t-2} \\ LAP_{t-2} \\ LER_{t-2} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \\ e_{6t} \\ e_{7t} \\ e_{8t} \end{bmatrix} \qquad (5)$$

Since a block-exogeneity assumption is imposed between the foreign and domestic variables (so that not all equations have the identical right-hand side variables) seemingly unrelated regression (SUR) is used to estimate the reduced form VAR. According to Enders (2003), using SUR in this situation will increase the efficiency of the estimates.

In order to estimate the SVAR parameters, this study follows a two-step procedure suggested by Bernanke (1986). First, from the reduced form VAR estimates, the residuals, e_t and the

[10] The reduced-form in equation [5] employs two lags of each equation for ease of presentation. The exact number of lags is chosen based on residual diagnostics and information criteria.

variance-covariance matrix, Σ_e are calculated. Second, through the sample estimates of the contemporaneous matrix B is estimated. In this study, B is estimated using maximum likelihood.[11]

In choosing a appropriate lag length for the VAR model the residuals from each equation are tested for evidence of serial correlation (AR(1) and AR(4) models are utilized). In addition, information criteria for the full system of equations are considered, viz, Akaike's (1973) Information Criterion (AIC) and Schwarz (1978) Bayesian Criterion (SBC). As a simple indicator of model stability test, the eigenvalues of the companion matrix of the VAR model are calculated. If all the eigenvalues are inside the unit circle, the model is stable (see Lutkepohl, 1993).

From the SVAR model, standard impulse response functions are produced. The impulse response functions describe the direction of response of a variable of interest (e.g. the Malaysian GDP) to an exogenous shock (e.g. interest rate shock), One standard error confidence bands for the impulse response are generated via a bootstrapping technique.[12]

4. RESULTS

In this section, we focus only on the responses of relative price inflation to a monetary policy shock. We also do not show the results of the diagnostic tests to conserve space.[13] In essence, the diagnostic tests' results indicate that the optimum lag length is two when using AIC and one when using BSC for almost all estimations on relative price models. Thus we use two lag lengths for our models as it is sufficient enough to capture the dynamic of the models as well as it does not involve the loss of too many degrees of freedom. Furthermore the absolute values of the eigenvalues of the VAR companion matrix are all less then unity. This provides some evidence that the estimated VAR(2) model is stationary and the models estimated are stable.

Figure I indicates the results of the impulse response function of inflation to a monetary policy shock. The solid line represents the estimated responses; meanwhile the two dashed lines represent the confident bands or error bands.

As shown, there is a short run fall in aggregate inflation following a shock to monetary policy variable (one standard deviation increase in the interest rate). Similar patterns are also observed for inflation in 1) Food; 3) Clothing and footwear; 6) Medical care and health expenses; and 8) Recreation, entertainment, education and cultural services. Inflation in product groups of 2) Beverages and tobacco; 5) Furniture, and 7) Transport and communication; however tend to fall after few quarters. These delayed responses of inflation suggest that the inflation in that sub-group of products respond sluggishly to a monetary policy shock. There is nevertheless

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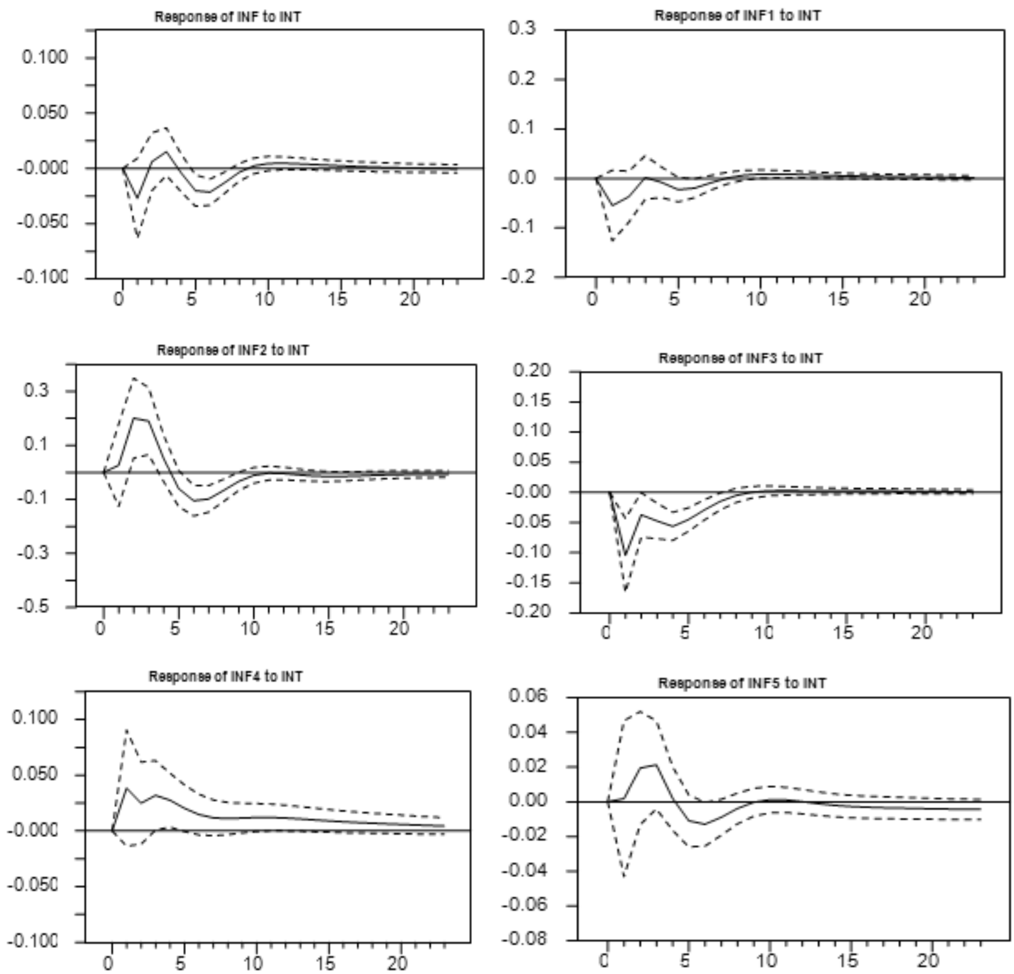
[11] In RATS, B is estimated using the Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm. The initial starting values for B are found using the genetic method.

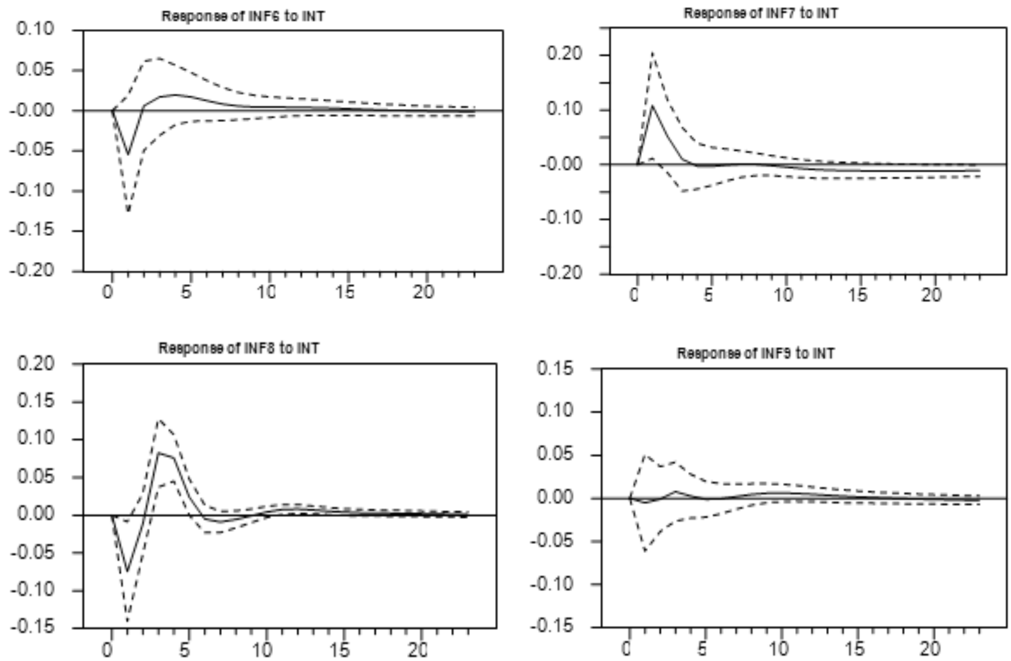
[12] 2500 random samples (with replacement) are drawn from the original sample data.

[13] Results are available upon request.

persistence positive response of inflation in the sub-group product of 4) Gross rent, fuel and power. As postulated by Barth and Ramey (2001), this might suggest that an interest rate shock has affected firms cost and the prices that they can offer. They suggested that because of the financial market frictions, a contractionary monetary policy shocks acts like a cost shocks. Firms that must borrow working capital from the banking system will see their operating costs rise as interest rates rise, and they will response by charging higher price to the consumers.

Figure 1: Relative Responses of Sub-group Inflation to Interest Rate Shock





5. SUMMARY AND CONCLUSIONS

Using non recursive SVAR model in open economy, we examine the effects of monetary policy shocks upon the disaggregated inflation of Malaysia sub-group of CPI. The Monetary policy shock is identified by assuming that the BNM sets the current level of policy rates after observing the current level of commodity price, inflation rate, real credit, and real exchange rate. Having estimated nine models for each sub-group of CPI and also for a base aggregate model, we conclude that a modest monetary policy shock in Malaysia results in varying degree of responses in disaggregated inflation. In other words, some subsector inflation react instantly while others respond sluggishly to a monetary policy shock. In contrast to aggregate inflation response, there are also evidence of price puzzles. As mentioned, price puzzles have also been captured by previous studies (see Bils et al. (2003), and Balke and Wynne (2007)).

The results from this study highlight several significant indications for monetary policy and price control in Malaysian economy. First, in general the BNM can influence the aggregate and some disaggregate price levels through the monetary policy variable (the interest rate). The findings indicate that a monetary policy tightening (an increase in the interest rate) is capable to stabilize the aggregate and some disaggregated price levels by influencing the aggregate demand. Second, since the effects of a monetary policy shock on sub-group inflations are heterogenous, the monetary authority, in particular the BNM has to consider some variations in implementing their policy. For example, beside the standard monetary policy, an additional moral suasion can be conducted for certain sub-group sectors, so that the intended price change can be achieved. Third, for consumers to significantly reduce their cost of living, expenditure on certain groups of goods can be reduced proportionately to the degree the subgroups' prices decrease in response to a contraction of monetary policy.

Finally, the heterogeneity of the effects of monetary policy explains why price puzzle occurs in some previous studies. Since the aggregate inflation depends on the distribution of relative price changes, if the weight of a sub-group price which has sluggish negative price response is bigger than the other subgroups which have instant negative price response, the possibility to have price puzzle to a monetary policy shock would be bigger and vise versa.

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