Monetary Policy Transmission Mechanism in Malaysia: An Empirical and Methodological Exploration

TANG Hsiao Chink
Declaration

Unless otherwise indicated this thesis is my own work.

TANG Hsiao Chink
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Acknowledgements

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May the wisdoms accrued be shared with all sentient beings. May all beings move from light to light.
Abstract

This thesis attempts to answer two questions: the relative strength of the main monetary transmission channels (interest rate, exchange rate, asset price/wealth and credit) in Malaysia; and whether the VAR methodology can adequately approximate the true economy. In examining the first question, an open-economy VAR model is built and estimated over the sample period from 1981:1 to 2004:1. The absence of past empirical work on Malaysia, the lack of theoretical guidance in estimating a structural VAR of this nature and the need to let the data speak for themselves motivate the use of the recursive identifying restriction.

With little previous empirical VAR work done on Malaysia, the development of the VAR model has to start from the ground-up, where the normally straightforward choices as to what variables to control for inflationary expectations and to proxy for the monetary policy stance have to be explored beforehand. In this context, the commodity price index, as opposed to the oil price index, is found to be helpful in controlling for inflationary expectations, particularly when M1 is used as an indicator of the monetary policy stance. Besides M1, the 3-month interbank interest rate is also found to be an important monetary policy indicator.

The relative contribution of a monetary policy transmission channel is determined by comparing the impulse response when the channel is shutdown with the baseline impulse response when all channels are operating. Overall, of the four channels studied, the interest rate channel is found to be the most important conduit in influencing output and inflation at the short-horizon of less than eight quarters. Beyond this period, the credit channel appears to be the most relevant. In terms of the channel of secondary importance at the short-horizon, the asset price/wealth channel is important in affecting output and the exchange rate channel in affecting inflation. These results are consistent when either M1 or the 3-month interbank interest rate is used as the monetary policy
indicator. Nonetheless, the overall impulse responses are sensitive to choice of ordering, particularly when the target variables (inflation and output) are placed at the end of the order.

The second part of the thesis attempts to answer the question of whether a monetary transmission VAR model is capable of approximating the "true" monetary policy transmission mechanism. To examine this, the G-Cubed model is chosen as a proxy for the underlying data generating process of the Malaysian economy and, pseudo data are generated from the model. A monetary transmission VAR model is then estimated based on the pseudo data and its impulse responses compared with the G-Cubed impulse responses. For convenience of focusing on the monetary policy transmission mechanism issue, a monetary transmission VAR model is used as a basis of approximation to the G-Cubed economy. This model is only similar to the actual monetary transmission VAR model for Malaysia as far as the selection of variables is concerned, for the approximation methodology by Kapetanios, Pagan and Scott (2005) assumes the identifying restriction is given by the representative model (G-Cubed). As such, findings from the second question have implications for the VAR methodology in general, rather than specific to the actual Malaysian VAR model.

To generate the pseudo data, shocks that hit the actual Malaysian economy are assumed to be the same shocks that hit the G-Cubed economy. These shocks can be summarised by the covariance-variance matrix of the estimated reduced form VAR errors – one that comes from a VAR estimated on the actual Malaysian data. However, an immediate problem encountered is that G-Cubed is an annual model, whereas the actual Malaysian VAR model is quarterly. To overcome such a mismatch, the actual quarterly Malaysian VAR model is taken to be the data generating process of the actual data. It is then used to generate new quarterly simulated observations. With about 30,000 to 50,000 simulated quarterly observations, the simulated data are found to exhibit near identical covariance-variance matrix and impulse responses as the actual quarterly data. By appropriate transformations of these simulated quarterly observations, a VAR
on the annual simulated data can be estimated to obtain the covariance-variance matrix of errors, which can then be used to generate the pseudo data.

The overall results show the VAR model estimated on the pseudo data does not match the G-Cubed impulse responses very well at typical lag orders suggested by the standard information criteria. Only at a lag order of 50, does the VAR closely approximate the G-Cubed impulse responses. Invoking the open-economy approach appears to have enhanced the matching capability – having more (US) variables in the VAR seem helpful. Interestingly, even in the G-Cubed world, the interest rate channel is found to be the most important channel in influencing output and inflation. In terms of the channel of secondary importance, because of the inherent theoretical properties of G-Cubed, the exchange rate channel is found to be more important than the asset price channel.

Obtained from examining the relative importance of the different transmission channels in the G-Cubed economy, the latter result represents a potential use of the Kapetanios et al. approach in bringing theory and data closer together. This is in the context that a more flexible technique like VAR can then be applied to some artificial data (having the properties of a structural model and the actual data) to study issues of interest.
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Chapter 1
Introduction

The first objective of this thesis is to study the monetary policy transmission mechanism in Malaysia. In particular, it aims to uncover the relative importance of the different transmission channels of monetary policy. It is a study not just about whether monetary policy affects economic activity, but more importantly about which transmission channels are more relevant. Four transmission channels are studied: the interest rate, credit, exchange rate, and asset price/wealth channels, based on their particular merits in Malaysia. As Bank Negara Malaysia (BNM), the central bank of Malaysia has increasingly shifted towards the use of indirect monetary instruments, the interest rate channel should gain greater prominence. Since the banking sector has been the traditional source of funding for firms and individuals, the credit channel is also expected to play an important role. The exchange rate channel should also be significant especially given Malaysia is a small and highly open economy with total trade double that of GNP. The increased popularity of the stock market as an alternative saving/investment avenue, understandably since the stock market is the most developed segment of the capital market, makes the asset price channel another interesting conduit to be included in the study.

A long list of studies has looked at the monetary policy transmission mechanism using the vector autoregression (VAR) methodology. Some examples include Sims (1980, 1992), Bernanke and Blinder (1992), Ramaswamy and Sloek (1997), Christiano, Eichenbaum and Evans (1999), and Morsink and Bayoumi (2001). Nonetheless, none of these studies focus on the issue of the relative

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1 Strictly speaking, the credit channel can be categorised into the bank lending channel and the balance sheet channel. For simplicity, the term, credit channel, is used. There has been a growing literature attempting to distinguish the presence of the bank lending channel versus the balance sheet channel through the use of bank or firm-level (micro) data. For example, see Oliner and Rudebusch (1995, 1996) and Kashyap and Stein (2000). The focus of this thesis will be on the use of macro data as the lack of micro-level data for Malaysia precludes detailed analysis separating the bank lending and the balance sheet channels.
strength of the transmission channels. The approach adopted in this thesis builds on this literature and also the shutdown methodology found in Ramey (1993) and Ludvigson, Steindel and Lettau (2002), among others. The approach involves shutting down or muting one channel at a time and comparing that with the baseline impulse response when all channels are operating. In addition, particular attention is also devoted to modelling Malaysia as a small and open economy. This involves invoking the open economy framework in VAR modelling, whereby the US is taken as representative of the world economy e.g. Cushman and Zha (1997) and Dungey and Pagan (2000).

A VAR model has the distinct advantage of being small and easily computable. In an unrestricted case, ordinary least squares can be used to estimate a system of equations, equation by equation, to give consistent estimates, and by assuming normality in the errors, the estimates are also efficient. More importantly, as Sims (1980) puts it, a VAR avoids the "incredible" identifying restrictions commonly associated with large macroeconometric models. Nonetheless, the VAR methodology has had its fair share of criticisms; for a summary, see Canova (1995). Conceptually, from a modelling perspective, being small with a handful of variables, the overriding concern is whether a VAR has the capability to actually reveal the true dynamics of the underlying economy, or at least, reveal the true dynamics of the variables of interest. Therefore, the second objective of this thesis is to investigate whether a monetary transmission VAR model can reasonably approximate the "true" monetary transmission mechanism. This entails simulating a detailed structural model of the Malaysian economy to generate a large data set and then estimating a VAR model on this pseudo data set. The structural model and the VAR representation can then be compared on the basis of their impulse responses. It should be stressed from the outset that this is not a test of whether the VAR on the actual data for Malaysia can uncover the true data generating process, since the issue of how well the large structural model actually represents the Malaysian economy is not explored. However, from a methodological point of view, it is still worthwhile to examine how well the VAR approach performs when the data generating process from the structural model of the "Malaysian" economy is known.

An earlier application of this methodology can be found in Helliwell and Higgins (1976).
The rest of the chapter is structured as follows. Section 1.1 outlines the motivation and governing thoughts behind the study of monetary policy transmission mechanism in Malaysia, specifically on the investigation of the relative importance of the different transmission channels. Section 1.2 does the same for the second objective of assessing the usefulness of the VAR methodology in approximating the underlying economy. Section 1.3 outlines the structure of the forthcoming chapters. Section 1.4 concludes by summarising the key questions and issues to be explored in each chapter.

1.1 Motivation I: Monetary Policy Transmission Mechanism

Ever since the pioneering work by Friedman and Schwartz (1963) who found a close correlation between monetary variables and output, there has been unceasing interest in the role money plays in influencing business-cycle fluctuations. It is now generally accepted by nearly all economists that money’s impact in the long-run falls entirely on prices with little impact on real variables. Most economists would also agree that monetary disturbances have important short-term effects on economic activity such as output (Taylor 1997). Nonetheless, when it comes to the precise nature in which monetary policy actions are transmitted throughout the economy, there appears to be a genuine lack of consensus. Indeed, the monetary policy transmission mechanism has been aptly called the “black box” by Bernanke and Gertler (1995). It is with this interest in mind that the thesis attempts to shed some light on the “black box” of monetary policy transmission mechanism in Malaysia, specifically to reveal the relative strength of the different channels of monetary transmission. Surprisingly, little published work has been done focusing on the latter, and none in the context of a developing country like Malaysia.³ It is therefore hoped that in answering the first objective, this thesis will make valuable contributions to the literature on monetary policy transmission mechanism in Malaysia.

For central banks, knowledge about the relative importance of the transmission channels provides useful policy information and suggestions. First, a more

³ The few studies on Malaysia will be reviewed in greater detail in Chapter 3.
accurate assessment of the nature of monetary conditions can be gleaned. For example, if the interest rate channel is not the main conduit, then the short-term real interest rate cannot be a good indicator of the monetary policy stance (Walsh 2003). In other words, it would be incorrect to associate a rise in short-term interest rates with a tightening of monetary policy and a decline with a loosening of monetary policy. On the other hand, if the exchange rate channel is important, even if domestic interest rates are low, having a strong Malaysian ringgit may actually be associated with a contractionary monetary policy. Viewed in the context of being highly open, a strong ringgit could potentially be an effective strategy to ward-off inflationary pressures from abroad and cool an overheating economy.

Similarly, if the credit channel is important, loan activity is another important signal to watch. A case in point was Malaysia’s experience in the early part of the 1990s amidst a period of relatively high interest rates which coincided with high loan growth, particularly for the purchase of properties and shares. To judge from interest rates alone, monetary policy would have been inaccurately interpreted as sufficiently contractionary. In reality, the period was connected with the stock market bull-run, where investors’ “irrational exuberance” precipitated a borrowing binge as investors believed any potential upside gains would more than offset the exorbitant cost of borrowing. From a holistic viewpoint, it is precisely because other channels of monetary transmission may also be important, or because it is unclear which channel is more important, some US investment banks have constructed their own indicators of monetary policy stance taking into account, besides interest rates, information on the exchange rate, stock prices and property prices.

Second, the presence of other transmission channels provides practical insights into monetary policy strategies when the main channel becomes benign. Two recent episodes from the US provide examples: during the 2001/2002 period, when the US economy was on its downward slide even as the Federal Funds Rate was nearing the zero percent level; and in the middle of 2003, when the economy was hit with deflationary fears. In the first case, the concern was, should the economy continue to worsen, the interest rate channel would be impotent because the Federal Funds Rate could not be reduced below zero
percent. In the second case, because nominal rates could not fall below zero percent, with deflation, real interest rates would actually rise, and this would further derail the US economic recovery, and by extension, the nascent world economic recovery. Fortunately, neither happened. Even if they did occur, the presence of other transmission channels would assure all was not lost. Chief amongst these strategies is quantitative monetary easing by pumping liquidity into the system to raise expectations in general price levels and to halt the deflationary slide. Policymakers can also reflate other asset prices such as stocks and properties, thereby boosting individual wealth to stimulate aggregate demand (Mishkin 1996). 4 The message remains that there are alternative measures that can be implemented for there exist other transmission channels in addition to the interest rate channel. Knowing which is more relevant provides valuable additional information to policymakers for enhanced monetary policy effectiveness.

Another important motivation which relates to the existence of the credit channel is twofold. First, the credit channel has a different distributional impact on firms, particularly small firms which seem to bear the brunt of monetary policy shocks (Gertler and Gilchrist 1994, Kashyap, Lamont and Stein 1994). In addition, smaller banks seem to be more severely affected, especially those with a less liquid balance sheet (Kashyap and Stein 2000) and lower capital-to-leverage ratio (Kishan and Opiela 2000). These findings suggest that on occasions when the long-term health of an economy is being jeopardised, policymakers should take appropriate measures to facilitate continued financing to smaller firms (Bank of Korea 1998). Thus, closer monitoring of loan data by type and size of customers and across different sectors is essential. The initial condition or financial health of individuals and companies must be appropriately accounted for in policy decision making. Similarly, because of the more adverse effects of policy on smaller banks, closer coordination of regulatory and stabilisation policy should not be overlooked.

4 There has been some interesting policy debate on ending deflation in Japan. For example, Bernanke (2003), inter alia, proposes a tax cut funded by the Bank of Japan which addresses many of the concerns the authorities have with the existing policies, some of which are mentioned here.
Second, the dominance of the credit channel also means policymakers must be cognisant of how the dynamics of financial innovations, liberalisation, deregulation and technological advancement, affect the credit channel. The increasing maturity of the private debt securities market, the setting-up of a junk bond market, and the increasing popularity of alternative forms of investment vehicles, such as unit trust funds and property trust funds, are factors affecting the traditional role played by banks and how firms and individuals borrow and invest. These factors ultimately have implications for the efficacy of the credit channel. Efforts to build a more resilient banking system by beefing up capital requirements may lead to sound banking intermediation, but it may also contribute to a less responsive monetary policy as transmitted through the credit channel (Kishan and Opiela 2000).

The existence of other transmission channels also means monetary policy is more potent – a small change in interest rates will have a larger impact on the economy than would otherwise be the case if the central bank were to be solely dependent on the interest rate channel. Bernanke and Gertler (1995) state the credit channel "can amplify and propagate conventional interest rate effects" (page 28). If other channels, such as the exchange rate and asset price channels are also relevant, the potency of monetary policy will be further enhanced. For instance, the presence of the exchange rate channel in a small open economy like Malaysia, provides policymakers with a flexible and powerful policy option to boost the country's competitiveness should this be deemed necessary. As such, knowing which channel is relatively important can provide a better indication of the likely impact of monetary policy shocks on the real economy.

1.2 Motivation II: Modelling Strategies – Approximating the Economy

A useful way of thinking about the current frontier in model building is shown in Figure 1.1 based on Pagan (2003a). Invariably, model building involves a trade-off between theoretical richness and empirical richness. Having more theory or greater theoretical coherence means "the model outcome can be [better] explained by reference to some agreed-upon conception of the way in which the economy is
thought to function", while greater empirical coherence implies the ability of the model to better explain the "history of the economy" (page 9).

At the far end of the x-axis, there is the VAR model, well-known for its fitting capability or some would argue as a purely statistical model, but devoid of much theory, where the outcomes can be difficult to interpret. At the other extreme, are the dynamic stochastic general equilibrium (DSGE) models such as those in Monacelli (2005) and Smets and Wouters (2003). Both of these belong to the class of New Keynesian Policy models (see Allsopp and Vines 2000) with features such as intertemporal optimising households and firms with rational expectations, nominal rigidities in prices and wages following a staggered Calvo mechanism, and real rigidities in capital and labour adjustment costs. Through the nominal and real rigidities, monetary policy has an impact in the short-run, while the adjustment path to steady state occurs over time. Richer propagation of shocks is also incorporated via partial indexation of wages and prices, and persistence in consumption via external habit formation. The model is normally closed by way of the monetary authority following the Henderson-McKibbin-Taylor type rule (Henderson and McKibbin 1993). The DSGE models are particularly attractive as they provide the analytical framework on the consequence of shocks in a rather stylised setting, albeit in Smets and Wouters, they attempt to bring the theory closer to the data. An intuitive but admittedly simplified way of thinking about DSGE models is that they are like the IS-LM and
AS-AD models and the Mundell-Fleming-Dornbusch model, but re-expressed with a microeconomics foundation and where shocks and expectations take centre stage.

Moving down from the DSGE models, the incomplete DSGE (IDSGE) models represent attempts to better match the data. This usually involves calibrating the model parameters such that the response of the economy to shocks follow some priors policymakers have in mind, instead of being solely estimated through econometric techniques. In spite of this, their theoretical foundation is still very much grounded in the mould of the DSGE models. The other distinguishing feature of the IDSGE models is that the shocks are usually viewed as being temporary or permanent, rather than being fully specified as in the DSGE models. Thus, shocks in the latter have both the temporary and permanent elements.\(^5\) IDSGE models are also usually larger and more disaggregated to encompass many more variables and issues of interest to policymakers. Some examples of IDSGE models are: the Bank of England Quarterly Model (BEQM), Harrison et al. (2005); the Reserve Bank of New Zealand’s Forecasting and Policy System (FPS), Black et al. (1997); the Bank of Canada’s Quarterly Projection Model (QPM), Coletti et al. (1996); and G-Cubed, McKibbin and Wilcoxen (1999). The latter, apart from not being built within a central bank, is actually a multi-sector global model.

Moving down the curve are the hybrid models. These models are built on the basis of two platforms: one that outlines a path along which the economy is to be evolving – the steady-state component; and the other involves stipulating the economy’s adjustment around the path – the dynamic component. The main difference between the Type I and II models is that the latter has an explicit long-run equilibrium, which is only implicit in the former. Unlike the above models, the hybrid models rely heavily on the econometric technique based on the idea of co-integration; what Pagan terms as the “equilibrium correction mechanism”. Some examples of Type I models are: European Central Bank’s

\(^5\) Shocks \((u_t)\) in many DSGE models can be expressed (in matrix form) as: \(u_t = \Phi u_{t-1} + \eta_t\). If \(\Phi = 0\) or \(I\), then the shocks are equivalent to the permanent or temporary shocks in IDSGE models (Kapetanios, Pagan and Scott 2005).
Area-Wide Model (AWM), Fagan et al. (2001); and Reserve Bank of Australia’s Economic Group Model (EGM), Beechey et al. (2000); and Type II models: the Murphy Model, Powell and Murphy (1995), and New Zealand Treasury Model, Szeto (2002). Type I models, however, are not in the current frontier, but can be enhanced to achieve the same level of empirical coherence with greater theoretical structure.

Further down the curve are the SVAR and VAR models. The former is differentiated from the latter by being more “theoretically” founded, albeit only loosely. In the sense that some theory is used to impose identifying restrictions – to give shocks in the VAR model an economic interpretation or what is known in the VAR parlance as “identification”. This commonly involves the imposition of either short-run or long-run restrictions. The short-run restrictions can follow a recursive structure _a la_ Cholesky factorisation based on information delays or inelastic restrictions based on some assessment that say, for instance, monetary policy does not affect real output for certain quarters. In models identified with long-run restrictions, only certain shocks are allowed to have a long-run impact on particular variables. For example, a supply shock has a long-run impact on output growth, but not a demand shock (Blanchard and Quah 1989), or a technology shock has a long-run impact on labour productivity, but not a non-technology shock (Gali 1999).6 One rare study that adopts a combination of both types of restriction is Gerlach and Smets (1995), where the monetary policy shock is restricted to have no within the quarter and long-run impact on real output.7

Studies on monetary policy transmission mechanism as cited above have tended to follow a recursive identifying structure. The same approach is adopted here. There are other reasons. It appears no previous studies have compared so many transmission channels alongside each other. In addition, the difficulty is

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6 For an example of the application of Blanchard and Quah’s long-run restriction to the study of monetary union in Asia, see Tang (2003).

7 Interestingly, this also resolves the price puzzle (that is a rise in interest rates leads to higher prices, instead of lower prices) as commonly found in VAR models. The authors acknowledge that the combination of short and long-run identifying restriction has not been popular, possibly because the solution involves a complicated system of non-linear equations. Their SVAR model comprises only three variables (output, prices and short-term interest rate), and does not delve into the relative importance of different transmission channels which is of interest to this thesis.
compounded by the lack of guidance from the theory on monetary policy transmission mechanism. Hence, it appears investigation on the relative importance of the different channels has more of an empirical slant than a theoretical one. It is therefore useful to allow the data to “do the talking” instead of imposing weakly founded zero restrictions for the sake of making it more structural than the recursive assumption. In actual fact, the imposition of a recursive structure may not be as arbitrary as it seems. It still has to be guided by some logical reasoning or conception about how the real world works. For example, intuitively, it would be reasonable to assume financial prices will change sooner than bank lending rate or bank loans following a monetary policy shock. This suggests that variables representing the transmission channels should be placed after the monetary policy stance indicator. Chapter 3 will discuss this issue in greater detail.

As alluded to above, the relative simplicity of the VAR methodology makes it an attractive tool well-suited to the study of the monetary transmission mechanism. Moreover, compared with the large scale macroeconometric models popular in the 1960s and early 1970s, VAR models impose few a priori restrictions, such as restrictions on the potential explanatory variables to be excluded, the choice of exogenous variables, and the lag structure. In this respect, VAR models are able to capture the rich dynamics of multiple time-series data. These are obvious advantages when economic theory reveals very little about the “black box” nature of monetary transmission mechanism and, when the main focus is to distinguish the relative strength of the various transmission channels. Perhaps, this is why the VAR approach has been the preferred methodology in this area of research, instead of, say, the DSGE route. Researchers in the latter would very quickly point out the non-trivial task of incorporating four different transmission channels into a DSGE framework; especially when the current literature is still very much preoccupied with developing a relatively small, focused and robust macro model. The VAR methodology also comes with

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8 For example, Smets and Wouters only work with seven macro variables. See also Erceg, Henderson and Levin (2000) and Christiano, Eichenbaum and Evans (2005). On the other hand, some studies relating to monetary policy transmission mechanism have used other models with a specific theoretical structure, but not necessarily DSGE models. For example, Claus (2005) uses a dynamic equilibrium open economy model parameterised to the New Zealand economy to study whether firms' borrowings from
several convenient tools like impulse response functions, forecast error variance decompositions and historical decompositions, which are helpful in analysing the impact of shocks and their role and relevance in specific historical periods.

On the other hand, it is not unexpected that the relatively loose way in which theory is being imposed to give the shocks in VARs an economic interpretation has received wide criticism. In a VAR with $k$ variables, there are $k!$ factorial ways in ordering the variables recursively. It is a well-known problem that different ordering schemes are likely to give different results. Cooley and LeRoy (1985) point out that the recursive identifying restriction is hardly observed in a general equilibrium setting. Keating (1990) criticises the zero restrictions placed on the covariance matrix of structural shocks as being inconsistent with rational expectations models. Canova and Pina (2004) show that for a typical DSGE model, zero restrictions are hardly compatible in identifying monetary shocks in SVAR models. Cooley and Dwyer (1998) highlight that long-run restrictions may not be able to properly separate permanent and temporary elements in shocks. Faust and Leeper (1997) demonstrate the futility of long-run restrictions even when the structural shocks may be uncorrelated in continuous time, but in discrete time, this is unlikely to be the case. Pagan and Robertson (1998) show that the problem of weak instrument associated with long-run restrictions can lead to multi-modal and non-normal density functions of model estimates even with a sample size considered to be large. An important assumption in both the short and long-run restrictions is that the structural shocks have to be independent (orthogonal) to each other. If in fact the structural shocks are not orthogonal, a misspecification error is committed which leads to inconsistent parameter estimates, and in turn contributes to biased impulse response estimators. Using a miniature New Keynesian policy model, Giordani (2004) demonstrates that if output instead of output gap is used in VAR models, such misspecification will occur and can contribute to the observed price puzzle found in many VAR studies. Even the more recent identification technique based on sign restrictions, where identifying restrictions are determined by the signs/shapes of a theoretical model, has its limitations. One such problem highlighted by Fry and Pagan (2005) as in the case of long-run restrictions is financial intermediaries or from the bond market entail differing impacts on economic activity.
due to the technique's reliance on weak information, which tends to provide weak estimates.

In sum, it is quite clear that in attempting to put more theory into VARs, the current approaches have notable weaknesses. In contrast to models up the curve, where restrictions appear in the structural form and then trickle down to the reduced form, the VAR methodology starts off from the reduced form estimation and "theory" is then imposed to move it up the curve to become structural. Amidst all these criticisms, it is timely to pause and contemplate whether the bottom-up approach of VAR is actually a reasonable modelling strategy. Essentially, this is what motivates the second core objective of this thesis. One which seeks to answer whether a VAR model can reasonably approximate the underlying economy. The methodology that does this follows from Kapetanios, Pagan and Scott (2005). It involves choosing a theoretical consistent model representative of an economy, generate some pseudo data from the model and estimate a VAR on the pseudo data. The impulse responses of the VAR on the pseudo data can then be used to compare with the impulse responses of the representative model of the underlying economy. This approach has a notable strength in that it avoids the problem of identification by assuming the structure of the VAR model is known and given by the theoretical model.

So, what will this representative economic model be? Unlike the central banks' IDSGE models that can be used to represent the respective economies (as shown in Figure 1.1), BNM does not have such a model, nor for that matter does Malaysia's Ministry of Finance. There are also no equivalents of the Type I and II hybrid models for Malaysia. Consequently, the search narrows down to one model: G-Cubed (McKibbin and Wilcoxen 1999). The G-Cubed model is particularly attractive because of its dimensionality and coverage. Above all, it is a fully articulated theoretical model. It is a multi-country, multi-sector dynamic intertemporal general equilibrium model of the world economy. Its long-run path is defined by the Solow-Swan neoclassical growth model with exogenous

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9 It is understood that BNM is currently in the midst of developing a macro model of the Malaysian economy. I am unaware whether the Ministry of Finance has any model that is made available to external parties.
technical progress and population growth. However, the short-run dynamics towards the long-run path are determined by some Keynesian type rigidities in the labour and goods markets. Households and firms maximise their intertemporal utility and profit functions respectively, subject to intertemporal budget constraints. In the short-run, however, some of them follow an optimal rule of thumb (meaning some of them are backward-looking and some are forward-looking), instead of recalculating the whole intertemporal equilibrium of the model. Wages are assumed to adjust gradually to clear labour markets depending on the institutional characteristics of labour markets in different countries. Countries and regions are linked intertemporally and temporally via trade and financial markets. Intertemporal budget constraints ensure all outstanding stocks of assets must be serviced, and asset markets are efficient in terms of being determined by a mix of intertemporal budget conditions and rational expectations.

The particular version of G-Cubed chosen is the Asia-Pacific G-Cubed (McKibbin 1998a) version 60n (for brevity, it shall be called G-Cubed hereafter). The main interest is on the Malaysian component of the model, as well as the US component, since the focus here is to estimate an open economy VAR as outlined above. There are nonetheless several methodological issues that require attention. First, G-Cubed is an annual model, whereas the analyses that will be performed to study the transmission mechanisms are based on quarterly data. It may not be a good idea to estimate a VAR with annual data since there are only about 40 years of historical data available in a system of interest of about 12 variables. Of course, the Malaysian economy of 40 years ago was quite different from that in the more recent times. Meanwhile, because of its sheer size and complexity, it is not a straightforward task to convert G-Cubed into a quarterly model. Second, G-Cubed does not explicitly model the banking sector, just like the rest of the IDSGE models mentioned above. Harrison et al. make the point that BEQM is not directly useful to study financial intermediation issues, such as collateral effects or financial accelerator phenomena, if these are believed to be quintessential. To do that, they rely on other specialised models. This means the credit channel has to be abstracted from the analysis. Nonetheless, this is unlikely to impede the main goal of approximating the VAR to the underlying economy (in this case, the G-Cubed economy of Malaysia).
1.3 Thesis Structure

This thesis is made up of nine chapters. Following Chapter 1 which motivates the research objectives, Chapter 2 provides a background to the Malaysian economy and brings to light the various aspects of monetary policy which have particular relevance to the research area. It will be evident that Malaysia’s remarkable economic performance has been largely attributed to macroeconomic orthodoxy plus a large dosage of pragmatism, amidst the desire to ensure a more equitable distribution of income among its multi-ethnic population. Not atypical of other central banks in previous decades, BNM’s conduct was very much shrouded in secrecy and unexpected or surprise actions were the *modus operandi* of the day. As such, it would not be unexpected that even if the central bank claimed to be doing one thing, it could actually be doing another. A case in point was the adoption of a monetary targeting framework. If indeed such a claim was incorrect this would have important implications for the choice of monetary policy stance indicator.

Table 1.1 Main Thesis Structure

<table>
<thead>
<tr>
<th>Chapter(s)</th>
<th>Brief Description</th>
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<tbody>
<tr>
<td><strong>Monetary Transmission:</strong></td>
<td></td>
</tr>
<tr>
<td>3 &amp; 4. A VAR Model for Malaysia</td>
<td>Builds a quarterly monetary policy transmission mechanism VAR model for Malaysia.</td>
</tr>
<tr>
<td>5. Transmission Channels: A Contest</td>
<td>Examines the relative strength of different transmission channels.</td>
</tr>
<tr>
<td><strong>VAR Approximation:</strong></td>
<td></td>
</tr>
<tr>
<td>6. Malaysia in G-Cubed</td>
<td>Highlights key properties of G-Cubed by examining the monetary policy transmission mechanism in the model’s representation of Malaysia.</td>
</tr>
<tr>
<td>7. Simulated Data</td>
<td>Uses the quarterly VAR model in Chapter 4 to generate new data (called simulated data) in order to estimate a simulated annual VAR.</td>
</tr>
<tr>
<td>8. Pseudo data VAR</td>
<td>Uses the covariance matrix of the simulated annual VAR (from Chapter 7) to generate new data based on G-Cubed (called pseudo data). Estimates a new VAR based on the pseudo data to compare with G-Cubed’s impulse responses.</td>
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Table 1.1 outlines the main thesis structure. Chapters 2 to 5 deal with the monetary policy transmission issue, while Chapters 6 to 8 on the VAR approximation issue. The main focus of Chapter 3 is on building an open economy monetary policy transmission mechanism VAR model for Malaysia. The theory of the different transmission channels and the VAR methodology will be reviewed. The issue on identification will also be examined as it represents a key input on the part of a researcher in building a VAR model. Chapter 4 builds on the materials in Chapter 3 and presents the empirical results in identifying a suitable VAR model for Malaysia. While Chapter 4 shows the results of monetary policy transmission mechanisms in general, Chapter 5 pits the different transmission channels against each other to gauge their relative importance. Various robustness checks are also undertaken. Results here provide the answers for the first objective of this thesis. It must be stressed that although the VAR model is of an open economy nature, the primary interest remains on Malaysia. As such, the impulse response functions pertaining to Malaysia receive most attention.

Chapter 6 introduces the G-Cubed model through a discussion on its theoretical foundations and also issues relating to parameterisation/calibration, baseline assumptions and model solution. The best way to understand the features of the model is via simulation exercises. This is done under two regimes: floating ringgit exchange rate and mobile capital flows (open capital account); and fixed ringgit exchange rate and immobile capital flows (closed capital account). For each regime, four types of temporary and permanent shocks are applied: interest rate, exchange rate risk premium, equity risk premium and augmented labour productivity. These results represent another perspective in which the monetary policy transmission mechanism issue can be studied. In particular, by leveraging on the model’s strength in performing counterfactual experiments, shifts in the monetary policy transmission mechanism can be analysed and better understood.

Chapters 7 bridges the gap between the quarterly VAR used in Chapters 4 and 5 with that of the annual G-Cubed model in Chapters 6 and 8. The key question is how to estimate an annual VAR given that one is working with actual quarterly series. The annual VAR is necessary in order to generate pseudo data from G-
Cubed. The methodology employed uses the reduced form VAR estimated in Chapter 4 as a vehicle to capture the data generating process of the actual quarterly variables, and to generate literally as many quarterly observations as possible. These newly generated quarterly observations, which shall be called simulated data, can then be easily transformed to obtain the annual simulated data. With the annual simulated data, an annual VAR can then be estimated.

The major reason for an annual VAR model is because G-Cubed is an annual model and the method prescribed by Kapetanios et al. to generate G-Cubed based pseudo data requires a key input from the annual VAR model, specifically the covariance matrix of the reduced form errors. This means shocks that hit the actual Malaysian economy are assumed to be the same as those that hit the G-Cubed economy. Since G-Cubed is chosen to represent the Malaysian economy it must have data to represent its economy. These data are called pseudo data. They will eventually be used as input into a new VAR to see how well the VAR can approximate the underlying (G-Cubed) economy. The VAR approximation proper is covered in Chapter 8, including a detailed discussion on the methodology used to generate the pseudo data. Finally, Chapter 9 concludes with a summary of the main findings and discussion on policy considerations and possible future research areas.

1.4 Questions and Issues to be Explored

Each chapter in this thesis will attempt to answer a host of questions and issues. A summary of the main ones are as follows:

Chapter 2 Malaysia: Macroeconomic Performance and Policies
i. What are the key motivations behind Malaysia’s macroeconomic policies?
ii. How has the Malaysian economy been transformed since independence?
iii. What is the philosophy behind capital account liberalisation/control and the exchange rate policy? Has the exchange rate been used to boost competitiveness?
iv. BNM’s monetary policy objective is to ensure sustainable economic growth with price stability. There seems to be an inherent trade-off in this. How does the central bank balance these two elements?

v. Was a monetary targeting framework ever adopted? This has important implications for the choice of indicator for the monetary policy stance.

Chapters 3 and 4 A VAR Model for Malaysia

i. What are the variables to include in the US and Malaysian blocks, particularly the proxy for inflationary expectations?

ii. What is the appropriate ordering scheme and lag order?

iii. How should the Asian financial crisis be dealt with?

iv. If the data are non-stationary and co-integrated, can the estimation be carried out at levels instead of via the vector error correction route?

v. Given that BNM has never formally announced its monetary policy stance, what would be the appropriate monetary policy stance indicator?

vi. If the price and exchange rate puzzles exist, can they be a result of the Asian financial crisis?

vii. How robust are the overall results to alternative variable ordering schemes and different specifications of the foreign block?

viii. What are the impacts of each transmission channel on monetary policy targeted goals under the various alternative ordering schemes?

ix. Does the inclusion of the output gap variable instead of real output, resolve the price puzzle?

Chapter 5 Transmission Channels: A Contest

i. What is the relative strength of the different transmission channels in relation to their impacts on the target variables (output and inflation) based on the original ordering scheme versus the best of the alternative ordering scheme, and under different choice of monetary policy instruments?

ii. How robust are the results under different model specifications: full-sample versus a) pre-Asian crisis sample, b) full-sample with interaction dummies to account for the pegging of the ringgit to the
US dollar, and c) full-sample with the pegged ringgit interaction dummies and also by invoking complete block exogeneity?

Chapter 6 Malaysia in G-Cubed

i. What are the key features of G-Cubed?

ii. Elucidate G-Cubed's theoretical structure which encompasses: firm's problem; household's problem; labour market rigidities; government's role; interactions between flows of goods and assets (financial markets and balance of payments); monetary authority's reaction function (the Henderson-McKibbin-Taylor rule);

iii. Discuss model calibration, assumptions for baseline projections, and model solutions; and

iv. Inspect theoretical richness of G-Cubed via model simulations based on permanent and temporary (interest rate, exchange rate risk premium, equity risk premium and augmented labour productivity) shocks under two alternative regimes: floating exchange rate and open capital account; and fixed exchange rate and closed capital account.

Chapter 7 Simulated Data

i. How are the simulated data generated via the reduced form VAR?

ii. How many simulated observations (and number of draws) are required to match the covariance-variance matrix of the reduced form errors of the actual quarterly VAR?

iii. Similarly, how many simulated observations (and number of draws) are required for the simulated VAR impulse responses to match those of the actual VAR?

iv. Would the impulse responses of the simulated annual data VAR transformed from the simulated quarterly data continue to resemble the qualitative properties of its quarterly counterpart?

v. What is the relative strength of the different transmission channels based on the simulated annual VAR model when bank loans are excluded (without the credit channel)?
Chapter 8 Pseudo data VAR

i. To generate pseudo data based on G-Cubed, apart from the input from the annual simulated VAR, what are the type and size of exogenous shocks to apply in G-Cubed?

ii. What identifying restriction to use in estimating a VAR on the pseudo data? Why is it important to use the contemporaneous impulse function of G-Cubed?

iii. What is the appropriate choice of lag length based on the Akaike Information Criterion (AIC) and Schwarz Criterion (SC)?

iv. Does the pseudo data VAR match the true impulse responses better with larger sample size, higher lag orders and greater number of variables?

v. Can the contemporaneous impulse response function of G-Cubed and the recursive structure be used as identifying restrictions?

vi. What does the pseudo data VAR say about the relative strength of the different transmission channels?

Chapter 9 Conclusions

i. Discuss main findings;

ii. Identify possible future research areas; and

iii. Discuss policy considerations.
Chapter 2

Malaysia: Macroeconomic Performance and Policies

The Malaysian economy has expanded considerably since independence and can be characterised as having an impressive development record. In 1993, a World Bank publication dubbed Malaysia a "miracle economy", and it has also variously received the accolade of the new "Asian Tiger" or "tiger cub", mimicking the economic achievements of the four Asian Tigers. 1 Malaysia's remarkable economic performance has also been compared with other countries which share the same initial conditions, such as Ghana, another former British colony which gained independence in the same year as Malaysia (Asare and Wong 2004). Malaysia's economic success has been contributed by some notable factors such as social harmony, political stability, a well-functioned institutional framework and legal system, the absence of severe natural disasters, and the Government's pragmatism and commitment to liberal and open door policies in trade and investment. In the latter, the approach adopted by the Government is best epitomised as gradualism - opening up and liberalising in a way that best suits the state of development of the country. This is the essence in which the Government remains in control to steer domestic social and economic policies to achieve the goal of economic growth with national unity. Nonetheless, these policies have come under increasing scrutiny and criticisms for being distortionary and favouring certain groups (Jomo 2004, Ritchie 2005).

The pragmatic, gradualist and economic-growth-with-more-equal-distribution philosophy permeates all facets of policymaking, even in the central bank. This is evident from the central bank's pursuit of broad objectives, monetary policy deliberations that tend to favour economic growth over price stability, the rather

1 See http://en.wikipedia.org/wiki/East_Asian_Tigers
unconventional monetary policy operations framework, and the myriad instruments the central bank uses.

This chapter serves as a background on the Malaysian economy. It aims to provide the policy context in which macroeconomic decision makings are made; an overview of the country’s economic performance; its approach towards capital account liberalisation/control; its stance on the ringgit exchange rate; and the monetary policy trade-offs and the framework within which monetary policy operates. The chapter will be structured as follows. Section 2.1 provides a brief geographical, historical and political background. Section 2.2 discusses policy motivations and policy environment. Section 2.3 highlights the transformation of the country’s economic structure and its economic performance. Section 2.4 delves into the thinking behind capital account liberation and re-regulation. Section 2.5 discusses the objective of the exchange rate which many claim to have been geared towards boosting the country’s competitiveness. Section 2.6 reviews the environment of monetary policy decision making. It focuses on the trade-offs of monetary policy arising mainly from the need to meet multiple objectives. It also examines the choice of monetary policy instrument in the context of a monetary policy operations framework. It is worth emphasising that although the central bank claimed it had once operated under a monetary targeting framework, closer inspection suggests this was unlikely to be the case. In other words, the choice of base money as a unique monetary policy instrument is questionable. In fact, its role should be no different from other measures of money. Finally, some concluding remarks are contained in Section 2.7.

2.1 Country Background

Malaysia is part of Southeast Asia, located between Thailand, in the north, and Singapore and Indonesia, in the south. With a land area of about 330,000 square kilometres, the country consists of two main regions: Peninsular Malaysia (West Malaysia) and the states of Sabah and Sarawak (East Malaysia) on the island of Borneo. The two geographical regions are separated by the South China Sea. Together with Singapore, the latter two states joined the
Federation of Malaya (which gained independence from Britain in 1957) and formed “Malaysia” in 1963. Singapore, however, separated from Malaysia and became an independent state two years later in August 1965. Malaysia now has 13 states and three Federal Territories, and is headed by a constitutional monarch (referred to as the “King”) rotated on a five-year term among the nine hereditary rulers or “Sultans”. The Federal legislative power is vested in the Parliament, while its executive power lies with the Prime Minister and his cabinet. Since its inception, the country has been governed by the same coalition party known as the “National Front” – comprising the United Malays National Organisation (UMNO), the Malaysian Chinese Association (MCA), the Malaysian Indian Congress (MCA) and a number of smaller political parties. This has been a crucial factor that enables the implementation of uninterrupted social and economic policies over the years.

Malaysia has a population of about 25.6 million people, with three main ethnic groups - Bumiputera (consisting of Malays and other indigenous people) who account for some 62% of the total; Chinese, 24% and Indians, 7%. Indians and Chinese immigrated to Malaya during the end of the 19th and early-20th century, thus laying the foundation for the modern multi-ethnic state. The Chinese came to escape from hardship and poverty in China and mostly settled in towns and became involved in trade and commerce. The Indians were brought in by the British to work on the rubber plantations, whilst the Malays were mainly involved in small-scale agriculture. This laissez-faire urban-based economy was the way the country was run during the colonial-era and the early period following independence.

2.2 Policy Environment

A turning point in Malaysia’s history occurred in May 1969, when the frustrations of the Malays, who held political power saw the country’s economic wealth continued to be amassed by the Chinese, boiled over into rioting and clashes with the Chinese. This was felt to be a result of the uneven distribution of income among the different ethnic groups and a failure of the laissez-faire model.

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2 Department of Statistics (DOS), Malaysia: http://www.statistics.gov.my.
Consequently, in 1970, the 20-year National Economic Policy (NEP) was launched with the aim of eradicating poverty through economic growth regardless of race and restructuring the economy through the removal of the identification of ethnicity with economic function. This was considered paramount for the attainment of national unity. Upon expiring in 1990, the NEP was replaced by the National Development Policy (NDP), which covered the period from 1991 to 2000, and the National Vision Policy (NVP), which encompasses 2001 to 2010, both of which continue to carry forth the goals of the NEP.

Figure 2.1 Development Policy Framework

<table>
<thead>
<tr>
<th>Longer-term Plan/Policy</th>
<th>Mid-term Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-70</td>
<td>First Malaysia Plan (1966-70)</td>
</tr>
<tr>
<td>Pre-NEP</td>
<td>Second to Fifth Malaysia Plans (1971-75, 1976-80, 1981-85, and 1986-90 respectively)</td>
</tr>
<tr>
<td>1971-90 OPP1, NEP</td>
<td>Sixth and Seventh Malaysia Plans (1991-95 and 1996-2000 respectively)</td>
</tr>
<tr>
<td>1991-2000 OPP2, NDP</td>
<td>Eighth Malaysia Plan (2001-05)</td>
</tr>
<tr>
<td>2001-10 OPP3, NVP</td>
<td></td>
</tr>
</tbody>
</table>


While the national development philosophy is enshrined in the NEP, Malaysia’s development policies are outlined in the 10-year Outline Perspective Plans (OPP) and the five-year Malaysia plans (see Figure 2.1). The underlying theme maintains that economic growth should not be pursued as an end in itself. What is chief is that higher income is desirable if it can benefit all races in an equitable manner. Incorporating such a growth philosophy with equitable distribution, the macroeconomic policies of the past few decades have sought to achieve sustainable growth with price stability. As an open and export-oriented economy,

the growth strategies are therefore to diversify the production and export base, and enhance its international competitiveness.

A case in point of the balance between economic policy and the consideration of maintaining a harmonious ethnic mix is demonstrated by the events surrounding the 1997/98 Asian financial crisis. Having tried but failed to achieve the desired stability with various orthodox adjustment measures, Malaysia eventually resorted to the introduction of capital controls in September 1998. While it was understandable that capital controls could be useful to reflate the economy by allowing forceful spending without the destabilising external influences, many feared the country was backtracking in its commitment to liberalisation and openness. However, what is not obvious was that the authorities were clearly concerned about the potential danger of a collapsed economy that could lead to ethnic unrest, which incidentally was already evident in Indonesia. Therefore, there was an urgent need to avoid further contraction in the economy, and measures however unorthodox had to be implemented to preserve the ethnic balance.

Undoubtedly, the NEP measures have achieved the targets of reducing poverty and, by and large, of increasing the Bumiputera share of ownership in the corporate sector (see Jomo 2004, Lucas and Verry 1999). Nonetheless, they have also had their fair share of criticism. Poverty reduction efforts have been seen to largely benefit the Bumipteras, the Malays in particular, instead of all ethnicities. Within the Bumiputera ownership of wealth, the lion's share is in the hands of a few. (For more detailed discussion, and other repercussions of the NEP affirmative action programs, see Jomo (2001, 2004) and Khoo (2004)). Ritchie (2005) criticises Malaysia's social and economic policies as designed to benefit coalition interests, which have retarded the country's technological development and left it "mired in mediocrity". Indeed, his arguments should provide fruit for frank and honest assessment within the country's policymaking circle. For instance, there should be greater recognition that any policy implemented involves trade-offs. Even though a policy might have worked in certain times under certain circumstances, yet to insist on keeping the same policy that clearly benefits only certain groups, at the expense of others, even when the entire country and global surroundings have changed, will only bring
much detriment and unnecessary hardship to the nation as a whole. It could even condemn the country to eternal sub-optimality.

2.3 Economic Structure and Performance

Malaysia started as a narrowly based economy which relied mainly on two primary commodities (natural rubber and tin) for growth. As far back as half a century, Malaysia was the one of largest producers and exporters of these two commodities. The agriculture sector single handedly accounted for a significant 40% of output (BNM 1989). However, with a multi-phased industrialisation policy, the economy has evolved from one that is commodity-based to one that is led by the manufacturing sector. The manufacturing sector has also progressed from simple assembly to higher value-added and higher-end technology based export-oriented industry. Broadly, the industrial policy has been implemented through three phases: import-substitution industrialisation during 1958-68; selective export-led industrialisation during 1969-80; and broad-based export-led industrialisation since 1981 (see Figure 2.2).

Figure 2.2 Economic Structure and Industrial Policy

<table>
<thead>
<tr>
<th>Economic Structure</th>
<th>Industrial Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960s: Reliance on rubber and tin</td>
<td>Phase I: Import-substitution industrialisation (1958-68)</td>
</tr>
<tr>
<td>1970s: Labour intensive industries</td>
<td>Phase II: Selective export-led industrialisation (1969-80)</td>
</tr>
<tr>
<td>Early 1980s: Heavy industries</td>
<td>Phase III: Broad-based export-led industrialisation (since 1981)</td>
</tr>
<tr>
<td>Mid-1985: Export-led manufactures</td>
<td></td>
</tr>
<tr>
<td>Since 1990s: Higher-end manufacturing and services sector</td>
<td></td>
</tr>
</tbody>
</table>

Source: BNM (2001)
The services sector has also been actively promoted due to its strong linkages with other sectors in the economy and its great potential as a foreign exchange earner. Yet, as will be evident later, much remains to be done in this area. In tandem with the changed economic structure and comparative advantage edge, the Government has also introduced measures with the aim of transforming Malaysia into a knowledge-based economy with state-of-the-art technology and a skilled workforce. To spearhead the investment and development towards this end, the Government launched the Multimedia Super Corridor in 1996 and introduced the Knowledge-Economy Master Plan in 2000.

Taking a snapshot of every decade since 1970 (see Table 2.1), Malaysia’s economic performance has indeed been quite a “miracle”. To name but a few key measures: almost full-employment since the early 1990s; real output growth of roughly 7%; low inflation rate of 3%; transformation from a rural to industry-based economy; high national savings; moderate external debt level, and a prudent fiscal position.

In terms of the transformation of the economic structure, since the late 1980s, the manufacturing sector has taken the lead role in the economy on various fronts: production, exports and employment. An outward-orientation trade policy has made Malaysia one of the most open economies, with total trade amounting to twice GNP. Such openness has brought prosperity, but has also rendered the country more vulnerable to global boom and bust, particularly those emanating from its major trading partners (the US, Singapore, the European Union and Japan). Various brief derailments from the long-term growth path have to a large extent been attributed to world business cycles, rather than to any self-inflicted downturn.

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4 For more details, see BNM (1999), pages 12-13.
Table 2.1 Key Macroeconomic Indicators

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (million persons)</td>
<td>10.4</td>
<td>13.7</td>
<td>17.8</td>
<td>23.5</td>
<td>25.6</td>
</tr>
<tr>
<td>Labour force (million persons)</td>
<td>n.a</td>
<td>n.a</td>
<td>7.0</td>
<td>9.6</td>
<td>10.6</td>
</tr>
<tr>
<td>Unemployment rate (% of labour force)</td>
<td>7.7</td>
<td>5.6</td>
<td>5.1</td>
<td>3.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Real GDP (% change)</td>
<td>5.0</td>
<td>7.4</td>
<td>9.0</td>
<td>8.9</td>
<td>7.1</td>
</tr>
<tr>
<td>Composition of GDP (% share)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>32.1</td>
<td>22.9</td>
<td>16.3</td>
<td>8.9</td>
<td>8.5</td>
</tr>
<tr>
<td>Mining</td>
<td>6.6</td>
<td>10.1</td>
<td>9.4</td>
<td>7.3</td>
<td>7.0</td>
</tr>
<tr>
<td>Construction</td>
<td>4.0</td>
<td>4.6</td>
<td>3.5</td>
<td>3.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>14.0</td>
<td>19.6</td>
<td>24.6</td>
<td>31.9</td>
<td>31.6</td>
</tr>
<tr>
<td>Services</td>
<td>43.3</td>
<td>42.8</td>
<td>46.2</td>
<td>48.6</td>
<td>50.0</td>
</tr>
<tr>
<td>Per capita GNP (RM)</td>
<td>1,071</td>
<td>3,734</td>
<td>6,206</td>
<td>13,333</td>
<td>16,538</td>
</tr>
<tr>
<td>Inflation rate (%)</td>
<td>1.9</td>
<td>6.7</td>
<td>3.1</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Gross National Saving (% of GNP)</td>
<td>18.0</td>
<td>30.4</td>
<td>31.6</td>
<td>40.1</td>
<td>37.1</td>
</tr>
<tr>
<td>Gross Domestic Investment (% of GNP)</td>
<td>17.8</td>
<td>31.6</td>
<td>33.8</td>
<td>29.8</td>
<td>23.8</td>
</tr>
<tr>
<td>Trade balance (RM million)</td>
<td>875</td>
<td>4721</td>
<td>527</td>
<td>61,812</td>
<td>81,073</td>
</tr>
<tr>
<td>Total trade (% of GNP)</td>
<td>81.2</td>
<td>100.5</td>
<td>139.2</td>
<td>217.9</td>
<td>208.1</td>
</tr>
<tr>
<td>Current account balance (% of GNP)</td>
<td>0.2</td>
<td>-1.2</td>
<td>-2.2</td>
<td>10.3</td>
<td>13.4</td>
</tr>
<tr>
<td>Total external debt (% of GNP)</td>
<td>n.a</td>
<td>n.a</td>
<td>40.3</td>
<td>51.2</td>
<td>46.6</td>
</tr>
<tr>
<td>External debt service ratio (% of exports of goods and services)</td>
<td>1.7²</td>
<td>4.3</td>
<td>8.3</td>
<td>5.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Federal Government overall balance (% of GNP)</td>
<td>-4.1</td>
<td>-7.2</td>
<td>-3.0</td>
<td>-6.3</td>
<td>-4.3</td>
</tr>
<tr>
<td>BNM net international reserves (as months of retained imports)</td>
<td>6.3</td>
<td>5.4</td>
<td>4.1</td>
<td>4.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Exchange rate (RM/US$, end of period)</td>
<td>3.0775</td>
<td>2.2175</td>
<td>2.6980</td>
<td>3.8000³</td>
<td>3.8000³</td>
</tr>
</tbody>
</table>

Notes:
1. Include adjustment for import duties and bank service charges. Services sector comprises transport and communication, financial services, utilities, wholesale and retail trade, government services and other services.
3. Ringgit Malaysia (RM) was pegged to US$1= RM3.80 between 2 September 1998 to 21 July 2005.
2.3.1 Output Growth

Malaysia's economic growth is portrayed by strong and sustained high growth in an environment of low inflation. Overall real GDP grew by about 5% in 1961-70 and about 6.8% in the period from 1971 to 2004. Significantly, the economy grew by 9.3% per year for a decade until 1997. A few brief periods of disruption were evident as shown in Figure 2.3. By and large, they were mostly triggered by external factors.

Figure 2.3 Real GDP Growth (% p.a.)

The first blip in economic growth was in 1975, following contraction in the world economy due to the first oil shock. The growth rate though almost flat remained in positive territory. The first economic recession occurred in 1985. Prior to that, in the early 1980s, the economy was still experiencing sustained strong growth despite the global recession. This was in part due to the Government's deliberate counter-cyclical prime pumping policy. In 1982, the slump in commodity prices and hence the worsening of terms of trade took its toll on the economy with the onset of twin deficits in the fiscal and current accounts. Cognisant of the potential destabilising effects of such developments, the Government undertook a voluntary adjustment program, which involved, among other things, a significant cut in operating and development expenditure,
consolidation of the financial position of non-financial public enterprises, and postponement of public projects. The role of Government in the economy was also significantly downsized. While both deficits were substantially reduced by 1985, the prolonged and untimely collapse of commodity prices pushed the economy into recession.

**Figure 2.4 Composition of GDP (% share)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Services (incl. adjustments)</th>
<th>Manufacturing</th>
<th>Agriculture</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>43.3%</td>
<td>14.0%</td>
<td>32.1%</td>
<td>6.6%</td>
</tr>
<tr>
<td>1988</td>
<td>44.4%</td>
<td>21.1%</td>
<td>18.6%</td>
<td>12.7%</td>
</tr>
</tbody>
</table>

Sources: BNM (1999, 2001), author's calculations

While the specialisation in primary commodities, though narrowly based on two resources, served the economy well since independence, fluctuations in prices were a major source of disruption to growth. To reduce the country's vulnerability to movements in world commodity prices, the Government embarked on aggressive policy reform immediately after the 1985 recession. Through the provision of a more conducive environment and a more liberal policy towards foreign direct investments (FDI), the private sector has flourished to become the main driver of the economy. The manufacturing sector has also
been groomed to take over the lead role from the agriculture sector. Its share to GDP had overtaken that of agriculture by the late 1980s. As shown in Figure 2.4, the agriculture sector accounted for 32.1% of GDP in 1970, while the manufacturing sector was 14% in the same period. In 1988, the latter overtook the former, for the first time, to become the single largest sector driving economic growth. This marked the turning point of the Malaysian economy towards industrialisation. Nonetheless, the manufacturing sector has yet to become more broad-based and continues to rely largely on electronics and electrical (E&E) products. As a result, the economy remains susceptible to global business cycles, in particular global electronics cycle.

In the aftermath of the mid-1980s recession, Malaysia staged a strong recovery and recorded a decade of uninterrupted strong economic growth until the outbreak of the Asian financial crisis. Indeed, by the mid-1990s, the Government and the central bank were already attempting to engineer a soft-landing arising from the extended period of rapid growth. However, the initiatives were a bit too late and Malaysia was not spared from the crisis. The crisis brought about the worst ever disruption to the Malaysian economy in various ways, including a substantial depreciation of the currency and resultant sharp contraction in economy activities leading to a loss of wealth. To address the crisis, the Government adopted a number of policy responses, which were fine-tuned along the way in tandem with the changing domestic and external economic environment. Thanks to the economic recovery measures together with the capital controls and the fixing of the exchange rate, the economy has recovered since the beginning of 1999.

2.3.2 Inflation

Malaysia has never really had any periods of high inflation (see Figure 2.5). Strong fiscal discipline, particularly resistance by the Government to seek deficit financing through the monetary system, means a major cause of hyperinflation that befalls many countries has always been absent. Because of its openness, it is hardly surprising that the periods of relatively higher inflation, just like lower economic growth, have largely been triggered by adverse external events. Against this backdrop, one could conjecture policymakers' tendency to favour
higher growth over lower inflation as long as the fiscal spending remains judicious (for more details see Section 2.6.1).

Figure 2.5 Consumer Price Inflation (% p.a.)

2.3.3 Saving-Investment Gap

By international standards, Malaysia can be considered as having a high saving rate. Over the last 35 years, gross national saving (GNS) has been on a rising trend, averaging 30.9% of GNP (see Table 2.2). Several factors have contributed to this trend. Rising income in a low inflationary environment and a relatively well-developed financial system with a wide range of savings products have been helpful. Above all, there is national compulsory savings through monthly contributions to the Employees Provident Fund, where employees are required to set aside 9% of their monthly salary into this fund, matched by 12% from employers.

Uniquely, this high level of domestic saving has not always been able to match the rapid investment growth. The rate of gross domestic investment (GDI) over GNP averaged 32.1% during 1970-1997 (see Table 2.2). Nonetheless, at times when the external environment was less desirable and external sources of funding less forthcoming, domestic saving was very much at the fore to finance
economic activity. The root cause of the strong investment activities previously was a series of massive privatised infrastructure projects and the private sector’s capacity expansion-related investments, that started as early as 1987 and continued throughout the 1990s, until the lead-up to the Asian crisis. In essence, these were carried out in response to the rapid domestic demand expansion and the worsening supply bottleneck arising from the prolonged robust economic growth.

<table>
<thead>
<tr>
<th>1970-79</th>
<th>GNS/GNP</th>
<th>24.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-89</td>
<td>GNS/GNP</td>
<td>29.2</td>
</tr>
<tr>
<td>1990-97</td>
<td>GNS/GNP</td>
<td>35.1</td>
</tr>
<tr>
<td>1998-2004</td>
<td>GNS/GNP</td>
<td>38.1</td>
</tr>
</tbody>
</table>

**Table 2.2 Saving and Investment (% of GNP)**

**Source:** BNM (1994, 2001a, 2005a), author's calculations

The gap between saving and investment was reflected in a persistent current account deficit for most years, particularly in the first half of the 1980s and 1990s, respectively, from a negligible position prior to that (see Figure 2.6). In the first period, the current account deficit peaked at 14.1% of GNP in 1982, due primarily to the decline in export earnings from falling world commodity prices, and massive federal development outlays to pump-prime the economy amidst the global downturn. The situation improved in the second-half of the 1980s, following adjustment measures undertaken to address the twin deficits in the fiscal and current accounts. In the latter period, the gap again turned negative in the face of a domestic private demand boom driving up imports. This pattern was broken with the onset of the Asian crisis causing a sharp slowdown in investment and, at the same time, a massive depreciation of ringgit boosted exports. Since then, the recovery in investment has remained tentative, but saving has picked up considerably, as reflected by a notable current account surplus of 13.4% in 2004.
2.3.4 Current Account

Overall, the deficit in the current account of the balance of payments has largely been caused by deficits in the services and income accounts, which outstripped surpluses in the merchandise/trade account. The deficits in the services and income accounts stem mainly from structural weaknesses in the economy. In particular, there has been heavy reliance on foreign freighters and foreign human resources. In addition, a high-level of foreign participation in the economy shows up in the large transfers of profits and dividends abroad.
Earnings from gross exports of goods exceeded that of gross imports for most years, except in 1982 and a few years in the 1990s. With a deliberate diversification policy, the composition of exports and imports shifted with the changed economic structure (see Figure 2.7). On the exports front, the turning point was in 1986, when exports of manufactured goods overtook the dominance of primary commodities for the first time to account for 43.5% of total export earnings. Since then, manufactured goods have been the major foreign exchange earner. Within manufactured exports, E&E have been dominant (see Figure 2.8). Meanwhile, the structure of imports has experienced similar changes in tandem with the industrialisation policy. Imports of intermediate goods have gained importance, while imports of consumption goods have shrunk.

**Figure 2.8 Gross Exports in 2004 (% Share)**

- **Minerals (8.6%)**: Of which, crude oil 52%, LNG 42%
- **Agriculture (7.5%)**: Of which, palm oil 56%, rubber 14%
- **Manufactured goods (81.2%)**: Of which E&E, 66% of total manufactured exports; and electronics 73% of the total E&E exports

Total Exports: RM480.7b

Sources: BNM 2005 and author's calculation

The authorities are well-aware of the frailty of the economy as exposed by the current account. They fretted about the trade deficit from 1994 to 1997 as being due to over-dependence on E&E exports, caused by the slowdown in the global demand for electronics, and the perennial deficit in the services and income accounts. Efforts have been made to encourage foreign multinationals to move up the value-chain in the E&E sector. But the China factor has proved a major snag. Instead, to reduce over-reliance on this sector, there has been renewed
vigour to explore and develop new growth areas in resource-based industries leveraging on the country’s position as leading producer in palm oil/palm-oil related products and rubber. There has also been an increased recognition that the services sector in itself is a vital engine of growth and an export earner, not merely an industry that supports the manufacturing sector. In terms of export potential, Malaysia’s relatively cheap cost of living and safe environment, its language and cultural diversity, and proximity to large markets, make it an attractive destination for the promotion of education and tourism. In addition, areas such as transportation, consultation and management, and computer and information services are other new sources of foreign exchange income.

2.3.5 Capital Account

The financing of the current account deficit can be separated into three distinct periods reflecting the different economic landscapes. Prior to 1987, official foreign capital inflows were dominant. But, since 1987, private flows notably foreign direct investment (FDI) became important as the private sector became the leading engine of growth. For instance, between 1991 and 1997, the country received around RM10-14 billion per annum in FDI mainly channelled to the manufacturing sector (about 65%). The pull factors for these inflows owed largely to generous fiscal incentives, relaxation of rules on foreign investment, a conducive pro-business environment and growing domestic demand. In the early 1990s (or more specifically, 1991-93 and 1995-96) parallel to the strong inflows of long-term capital, Malaysia also experienced a surge in short-term capital inflows (see Figure 2.9). Most of these inflows were intermediated through the banking system to finance private sector activities, particularly for investment in the manufacturing sector and the purchase of properties. A notable portion also came in as portfolio investments in the stock market. This surge in foreign funds was instrumental in bringing about the 1993 stock market bull-run, that has yet to be surpassed.

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5 For a detailed account of FDI developments, see pages 54-58, Annual Report 2000, (BNM 2001a).
2.3.6 External Debt

Malaysia’s exposure to external debt has been moderate and concentrated at the medium to longer end. In the 1970s, much of the financing was sourced locally. In the early 1980s, as a consequence of the public spending splurge, the external debt outstanding rose noticeably. In 1987, it peaked at 76% of GNP following the Plaza Accord. Until 1996, owing to a prudent borrowing strategy, the external debt hovered around a rather comfortable level of around 40% of GNP (see Figure 2.10). Nevertheless, it rose again during the Asian crisis, when the massive depreciation of the ringgit increased the debt exposure to more than 60% of GNP. In 2004, it stood at 46.6%, which is considered "moderately indebted" based on the World Bank’s classification. In terms of composition, short-term debt, for most years, accounted for less than a quarter of the total external debt. Nonetheless, it surged visibly in the run up to the Asian crisis due to inflows into the stock and property markets.

Stringent rules and regulations have been important in maintaining the moderate external debt exposure. External borrowings by the Government are limited to a ceiling provided in the External Loans Act 1963, while that of the private sector are governed by the Exchange Control Act 1953 and subsidiary legislation administered by the central bank (BNM 1999). For example, one such rule
requires foreign borrowing by residents companies or individuals above permitted limits to obtain approval from the central bank. In fact, this was a vital element contributing to the relatively low level of Malaysia's external debt exposure vis-à-vis the other Asian crisis affected countries, and one that shielded Malaysia from the more severe shockwaves during the crisis. In addition, there is an approval criterion requiring applicants to show that the currency composition of their debt matches their foreign earnings. On the other hand, it has also been the policy of the public sector, to prepay and refinance, where possible, its external borrowing to contain the debt level, to avoid bunching and to reduce the servicing burden.

**Figure 2.10 External Debt**

![Graph showing external debt levels](image)

**Note:** Prior to 1998, refers to medium and long-term debt only.  
**Source:** BNM (2005b)

### 2.3.7 Federal Government Finance

The financial position of the Federal Government is a mirror image of its involvement in the economy. In the 1960s, the Government was very much a bystander trying to understand its own power and the affairs of the economy after independence. As such, the budget/fiscal position was either in balance or surplus. In the 1970s, the Government became more active in pursuing the goals set out in the NEP. In the early 1980s, the counter-cyclical fiscal policy

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6 Resident companies and individuals may obtain credit facilities in foreign currency up to the equivalent of RM50 million and RM10 million in aggregate, respectively, from licensed onshore banks, licensed merchant banks and non-residents. Where the aggregate amount exceeds the equivalent of RM1 million and up to the permitted limit, the resident is required to register the credit facility with the central bank, prior to drawing down on the facility (BNM 2004, Annex, p.3).
measures amidst sluggish revenue growth led to a record overall budget deficit of 17.5% of GNP in 1982 (see Figure 2.11). At the same time, the current account deficit peaked at 14.1% of GNP. Gradually, following a fiscal austerity drive and higher tax revenue amidst increased economic activity, the Federal Government’s financial position began to strengthen culminating in five consecutive years of surpluses just prior to the outbreak of the Asian crisis. This was short-lived as the recovery measures instituted to revive the economy saw the Government’s financial position returned to deficit. What is notable is that the absence of a large and runaway deficit remains an important ingredient of prudent macro management, one that has contributed to Malaysia’s low inflation record, even by the standard of developed countries.

Figure 2.11 Federal Government Fiscal Account (% of GNP)

![Graph showing Federal Government Fiscal Account (% of GNP)]

Sources: BNM (1994, 2005b)

2.4 Capital Account Liberalisation/Control

Malaysia has generally had a fairly open capital account. It has adopted a gradual approach to the liberalisation of capital movements after the floating of the ringgit in 1973. Financial system deregulation also followed suit in the late 1980s after the Government implemented multi-year structural adjustment

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7 Pages 275-296 of BNM (1999) provides a very good account of the exchange control system over the years.
measures. On the whole, the liberalisation process has often been carefully designed and tailored to suit the prevailing economic conditions and developments. It has involved structural deregulations and prudential regulations; the central bank has at times employed unconventional measures as long as the desired objective could be met. On the flip side, however, the central bank is also often quick to dismantle those measures when prevailing circumstances become more congenial.

In 1973, the exchange control regulations ceased to discriminate between countries. Regulations on current and capital transactions were liberalised and funds were allowed to flow freely in and out of the country. Only some prudential rules on capital outflows remained. Further major liberalisation was implemented on the capital account in 1987-89 together with deregulation of the financial system, and again in 1994-96. However, the gradual liberalisation process was halted in two instances: in 1993-94 due to the substantial short-term capital inflows simulated by the strong economic growth and the interest rate differentials favouring Malaysia; and in 1998-99 due to massive capital outflows arising from speculative attacks on the ringgit.

Malaysia's policy response to the destabilising capital inflows in 1993-94 included the initial sterilised interventions, the raising of the Statutory Reserve Requirement, and subsequently the introduction of temporary administrative controls on short-term flows when the inflows were too substantial. The latter included a prohibition on residents' selling money market securities to non-residents, commercial banks' engagement in non-trade related swap and outright forward contracts with non-residents, and the imposition of a ceiling on banks' net foreign exchange open positions. They were rescinded in less than a year when the objective was achieved. From 1994-96, Malaysia again embarked on a liberalisation process.

Between 1997 and early 1998, Malaysia suffered massive capital outflows as portfolio investors fled the region in the wake of the Asian financial crisis. After numerous policy responses failed to stabilise persistent depreciation of the ringgit, the Government finally resorted to capital controls. The unorthodox measures were introduced on 1 September 1998 and the ringgit was pegged to
the US dollar at 3.80 on the next day. From the outset, the case for capital controls was made very clear as to insulate the economy from the external volatility of short-term capital flows and speculative activities, and to provide a breathing space for the economy to be restructured and revitalised (BNM 1998). As a testament to the commitment to full current account convertibility, trade flows and foreign direct investment were not affected. The rules have gradually been relaxed as external conditions return to greater normalcy.

The use of capital controls in the case of Malaysia has always been part of an overall policy package. It has been implemented flexibly, pragmatically and temporarily, even though it may appear to be going against the tide of greater liberalisation. Malaysia’s experience suggests policymakers have to be practical, realistic and honest about the circumstances they face, and think outside the box rather than be constrained by certain preconceived pro-market rhetoric. Although, the jury may still be out as to whether the September 1998 capital controls have brought much benefit to the economy, it would be fair to say that at the very least they have not done the country any harm. Instead, confounding the assessment of many, they have allowed fiscal and monetary policies, and the restructuring of banks and companies to be pursued more vigorously and successfully compared with other affected countries. To a large extent, the growing acceptance of the use of capital controls in specific circumstances, even among unexpected quarters like the IMF and The Economist, vindicates Malaysia’s introduction of capital controls during the Asian crisis (IMF 1999, The Economist 2003).

2.5 Currency and Exchange Rate Policy

The unit of currency in Malaysia is the ringgit Malaysia or RM. Prior to independence, the ringgit, then known as the Malayan dollar, was tied to pound sterling. In June 1972, Malaysia adopted the US dollar as the intervention currency and the Malaysian dollar was linked to the US dollar with a certain margin of fluctuations in the effective rate. In June 1973, a managed floating

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8 For two opposing assessments, see Kaplan and Rodrik (2002) and Dornbusch (2002).
9 For a more in depth analysis of these and other factors, see Chapter 8 of Athukorala (2001).
exchange rate system was adopted due to the uncertainty in the international foreign exchange market. In 1975, Malaysia entered a new exchange rate regime, whereby the Malaysian dollar was officially renamed the ringgit and its value determined by a basket of representative major currencies weighted based on the composition of trading partners' currencies and settlements. This arrangement formed the basis of Malaysia's exchange rate policy until 2 September 1998.

Prior to September 1998, Malaysia had a relatively open foreign exchange regime. The official exchange rate policy of the central bank was to smooth the day-to-day fluctuations of the ringgit and not to affect its underlying trend (BNM 1999). Even today, the motivation remains to ensure stability in the ringgit against its trading partners to facilitate trade and investment. The Bank has repeatedly iterated that the exchange rate has never been relied on to maintain export competitiveness, e.g., Zeti (2003, 2004) and Cheong (2001). However, this is not what many believe. For example, after the 1985 recession, between 1986 to 1993, there was a 25% real ringgit depreciation which would have supported the export-oriented industries (page 212, Corden 2002).

Admittedly, the infamous loss of the central bank during the ERM (Exchange Rate Mechanism) crisis in 1992 suggests a sometimes overzealous attitude towards its reserve management. After successfully rejuvenating the economy from the slump in 1985, the Bank seemed to have regained confidence in its ability and conviction in managing its affairs. The then Governor had this to say (page 383, Jaafar 1989):

"I basically took the stance that risk-taking in reserves management included not only the risk of losses, but also the risk of falling behind inflation, of not earning as much with our scarce resources as we could. The primary motivation is still to preserve and conserve the value of what we have. But, these days, trading profits can make a difference between lackluster earnings and good results."

10 Like the classification of its exchange rate regime before the Asian crisis as managed floating, many often interpreted it as de facto pegging to the US dollar (Athukorala 2001, and Reinhart and Rogoff 2002).
If this enthusiasm was the only thing to go by, it would not be too far-off to extend it to the Bank’s exchange rate policy – one that perceived the ringgit could be managed to achieve higher growth spurred by cheaper exports.

The truth of the matter remains in the difficulty to disentangle whether the Bank’s policy has actually been to smooth day-to-day fluctuations to ensure ringgit stability or to enhance the country’s export competitiveness. By de facto pegging to the US dollar, the Bank is perhaps leaning more towards the objective of maintaining ringgit stability than enhancing competitiveness. Yet if the ringgit remains stable or appreciates slightly, this does not mean it is not controlled for competitiveness reasons, because lack of control suggests even greater appreciation. Nonetheless, there is evidence to suggest maintaining ringgit stability has been an objective at certain times. Athukorala (page 54, 2001) notes that between mid-1994 to mid-1997, the RM/USD rate remained very stable as the central bank was using it as a tool to address domestic inflationary pressures, switching from the policy of maintaining a slight nominal depreciation. Another case in point is the fixing of the ringgit to the US dollar at 3.80 which could have easily been set higher (more depreciated) if the external competitiveness consideration was predominant. (Daily exchange rates prior to 2 September were hovering above RM4.00/USD).

Taking a more holistic view, the exchange rate is only one factor among a whole host of factors that determine the country’s competitiveness. There are other factors which are equally or more important: an open and liberal trade regime; low-costs in doing business; overall macroeconomic stability; special incentives to attract quality foreign direct investment; high quality physical infrastructure; good institutional quality; an experienced labour force proficient in English; flexible labour migration; an efficient functioning financial system; and social and political stability.\textsuperscript{11} Accordingly, there may have been occasions where the exchange rate has been influenced either to improve competitiveness or to avoid wide fluctuations. There is reason to believe the central bank realises the exchange rate cannot be used indefinitely for a competitiveness reason as it is essentially a short-term solution for a longer-term structural/supply-side issue.

\textsuperscript{11} See Hill (2005) for a succinct and favourable comparative discussion on Malaysian economic developments in relation to other ASEAN countries.
Ultimately, perhaps it is an empirical issue which this thesis will be able to shed some light on.

2.6 Monetary Policy

2.6.1 Objectives/Trade-Offs

Bank Negara Malaysia (BNM), the central bank of Malaysia was established in 1959 under the Central Bank of Malaya Ordinance, 1958. The ordinance was revised in 1994 to become the Central Bank of Malaysia Act 1958 (Revised 1994). The Act defines the objectives of the Bank as:

i. "To issue currency and keep the reserves safeguarding the value of the currency;
ii. To act as a banker and adviser to the Government;
iii. To promote monetary stability and a sound financial structure; and
iv. To influence the credit situation to the advantage of Malaysia".

In meeting these objectives, the Bank regulates and supervises the banking industry and maintains the payments system. More importantly, it is responsible for the country's monetary policy. Although, the Act is silent on the explicit objective of monetary policy, this has often been interpreted to mean the attainment of sustainable economic growth with price stability. This objective seems pretty clear cut but in the actual decision making process, it often involves trade-offs against the Bank's other objectives. The current Governor attributes this as a consequence of a broader mandate placed on central banks in emerging countries unlike those in developed countries (Zeti 2003).

A lax monetary policy, at least in the short-term, can lead to higher output growth with relatively stable prices. Anecdotal evidence seems to suggest the Bank weighs more heavily on the side of output growth than price stability. This

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12 The Bank also regulates and supervises the insurance industry, and part of the bond market. The latter is attributed to its responsibility as agent of the Government in administering the Government's bonds issuance as well as its role in providing the infrastructure for bonds trading and registering. The Securities Commission is the regulator of the country's capital and derivatives markets.
is quite understandable as Malaysia's inflation track record has always been very good. Even when inflation was high, it was due to external factors, which were beyond the direct influence of the Bank. Therefore, as expected, when a decision is called for to balance the need to support growth or to reduce inflation, it is usually made in favour of higher output growth. An example of this trade-off is clearly demonstrated by the following excerpt dealing with the second oil crisis (pages 240-241, Annual Report 1990, BNM (1991):

".... three major factors governed the conduct of economic policy. The first was the persistently unfavourable international environment, characterised by slow growth, higher unemployment and inflation in the major industrial countries. Second, the renewed inflationary pressure as global inflation persisted at a high level, amidst sustained expansion of domestic demand pressures emanating from imported inflation. Finally, the progressive weakening of the nation's external payments position. In the face of these, reliance was on domestic demand, particularly private spending, to provide the stimulus for sustained economic expansion. On the fiscal policy side, the Government maintained its counter-cyclical stance aimed at stimulating the expansion of the country's productive capacity and dampening inflationary pressures. The monetary policy implemented was to provide sufficient liquidity to finance real economic activity without adding to price pressure. The policies during this period were to moderate the growth in money supply and establish conditions conducive for restraining inflation. It was designed to maintain orderly conditions in the financial system, while ensuring that bank liquidity was adequate to generate sufficient credit for investment and other productive purposes. In order to check destabilising capital flows and protect the balance of payments, the Central Bank had to ensure that the domestic level of interest rates was not out of line with the international level".

Notice the emphasis on monetary policy to provide sufficient liquidity especially to productive sectors, even though a circumstance of high inflation would normally warrant a tightening of monetary policy across the board. Also note the emphasis on having interest rates at levels commensurate to international interest rates for fear of fuelling greater volatility in capital flows and to "protect the balance of payments". These interplays of the need for a good output growth number, while ensuring an acceptable level of inflation rate, without an overly strong currency, and interest rates which are not out of line with the rest of the world, continue to feature prominently as trade-offs in policy decision making.

The episode of the recent Asian crisis further illustrates the workings of these and other trade-offs. During the speculative attacks, Malaysia responded like
other affected countries by raising interest rates, but the rise in interest rates was never really very high or kept high for a long period because of the fear it might jeopardise economic activity. Subsequently, when it was apparent the crisis would lead to a protracted downturn, counter-cyclical measures were implemented. However, interest rates could not be reduced drastically as this would have led to greater capital outflows and depreciation of the currency, thus further exacerbating an already fragile market sentiment. Because of the need to "regain the control over the interest rate lever", selective capital controls were introduced and the ringgit was pegged to the US dollar. Soon after, interest rates were quickly brought down, but not consistently across all markets. The reduction in lending rates, which was largely dictated by BNM's policy rate, was kept significantly higher than the underlying interbank rates. At the same time, deposit rates fell to only slightly higher than the interbank rates because of the need to ensure a positive real rate of return to savers. This was done by specifying a minimum interest rate for fixed deposits at the 1-month and 12-month maturities. Interest rates at other maturities were allowed to be freely determined by the banking institutions. As would have been expected because of the underlying lower interest rate environment, the uncontrolled rates fell close to the 1-month rate and resulted in a kinked or L-shaped term structure of deposits rates. The fallout from all this was the creation of three distinct and disjointed segments of interest rates in the market, viz. one for the lending rates, one for the deposits rates and the third for the market determined interbank rates.

It was clear that by including the Intervention Rate in the BLR formula, BNM attempted to reduce lending rates as rapidly as possible to accelerate economic recovery. But the fact that the Intervention Rate, which was based on the 3-month interbank rate when it was first introduced, was not allowed to fall to the level of the 3-month interbank rate was also quite clearly a strategy to cushion the balance sheet of banking institutions - to prevent further deterioration in the financial positions of the banking system and also market sentiment. On top of

\[13\] BNM was able to directly influence the lending rates of the banking institutions since it changed the formula for calculating the base lending rate (BLR) to the one based on its policy signal (the Intervention Rate) as opposed to the one based on the market 3-month interbank rate. The motivation for including the Intervention Rate in the formula was to ensure lending rates could be reduced fast enough to facilitate economic recovery. Previous experience has shown that lending rates tend to be sticky downwards.
that with the additional objective of ensuring savers would continue to earn sufficient income from their deposits, deposit rates were kept artificially high. In other words, to ensure savers were not adversely affected, the Intervention Rate had to be artificially propped up as well, so as to ensure banks' profit margins remained adequate and they would not be forced to lower deposit rates. These decisions were made with the inflationary consideration very much in the background despite its steady rise from 2.2% in June 1997 to a peak of 6.2% in June 1998, primarily because the main source of pressure was external (due to the depreciation of the ringgit), and domestic demand was already contracting. The overriding objective and focus at that time was clearly to bolster the economy.

In a nutshell, the policy deliberations during the Asian crisis further demonstrate the considerations and trade-offs weighed by BNM. In contrast, a country with a specific mandate such as, price stability, would have had a more straightforward policy response. Because of the multiple demands expected of the Bank, a move towards a single objective of targeting, say, the inflation rate, is unlikely to materialise in the foreseeable future. And to meet these multiple demands, the Bank has to rely on a myriad of tools in its conduct of monetary policy. Table 2.3 describes the tools and circumstances in which they have been used.

### Table 2.3 BNM Monetary Policy Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description / Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct borrowing and lending</td>
<td>Uncollateralised borrowing and lending by the Bank through tender at either fixed or variable rates. The former is most useful in signalling monetary policy stance. Flexible in terms of amount and tenure which the Bank can operate. Most popular especially in managing the day-to-day liquidity conditions.</td>
</tr>
<tr>
<td>Open market operations</td>
<td>Withdrawal or injection of liquidity from the system via the direct selling or buying of government papers, or indirectly via repurchase agreements/reverse repos. It has the same advantages as direct borrowing and lending, plus the benefit of further deepening the money market. However, the lack of government papers impinges the more active use of this instrument.</td>
</tr>
<tr>
<td>Reserve requirement</td>
<td>Altering the amount of cash reserves banking institutions need to keep with the central bank by changing the ratio of required reserves to eligible liabilities (comprise all conventional deposits and</td>
</tr>
<tr>
<td>Instrument</td>
<td>Description / Use</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Centralisation of deposits of Federal Government and the Employees Provident Fund with BNM</td>
<td>Address the liquidity situation at source by managing the deposits of the Federal Government and the Employees Provident Fund with the Bank so that they are consistent with the monetary policy stance. For example, in the early 1990s, it was used extensively to ensure the market was not flushed with an even larger amount of liquidity, in addition to the massive capital inflows. Deposits are remunerated at market rates.</td>
</tr>
<tr>
<td>Guidelines on lending to the priority sectors, and selective credit and administrative measures</td>
<td>These measures are targeted at specific sectors of the economy. Lending to priority sectors comprises lending to the Bumiputera, the indigenous community, small and medium-scale enterprises, and for the purchase of low and medium-cost houses, in order to meet the economic and social objectives of the nation. The guidelines specify a ceiling interest rate and a portion of total lending which banking institutions must channel to these sectors. Selective credit and administrative measures are widely used to complement other monetary instruments to address the imbalances that exist in specific areas of the economy during a specific point in time. For example, in March 1997, several months before the Asian crisis hit, they were used to address excessive lending in the property sector, and for the purchase of stocks and shares. Both took the form of limiting the share of lending to these sectors as a proportion of total loans outstanding. Another popular tool to restrict speculative activities on the ringgit is to impose a swap limit on non-commercial (non-trade related) transactions between banks and foreign customers. These measures are only meant for short-term use as they can potentially misallocate resources.</td>
</tr>
<tr>
<td>Moral suasion</td>
<td>The oldest form of monetary instrument. It involves persuading banking institutions to respond voluntarily in line with overall monetary policy stance. The credibility of the central bank, and the confidence which the public has in the bank, that its actions are for their own interests and the betterment of the country, are essential to ensure the success of moral suasion (BNM 1994).</td>
</tr>
</tbody>
</table>

Sources: BNM (1999) and BIS (1999).
2.6.2 Monetary Policy Framework

The above discussion has shown the trade-offs in monetary policy decision making and the relative importance BNM places on output growth over price stability. In this section, the single and easily the most often misunderstood element of monetary policy operations will be clarified. It is to do with the role of base money in monetary policy whether central banks have complete control over it and whether it is the most appropriate monetary policy stance indicator especially in a monetary targeting setting. The answer is “no” to both questions, and this is not specific to BNM, but in fact a common reality for many central banks. Having a clear understanding of this will help identify the appropriate monetary policy indicator in later chapters.

Figure 2.12 Stylised (Textbook View of) Monetary Policy Framework

For ease of exposition and as illustrated in Figure 2.12, a monetary policy framework can be divided into three components: an operating target, an intermediate target and a final target. The diagram depicts a textbook representation of a monetary targeting framework and an interest rate/inflation targeting framework. (These are highlighted because they have direct relevance to the Malaysian case). In a monetary targeting framework, base money is treated as the operating target, something which central banks “directly” control, so that it can affect money supply (intermediate target) and in turn inflation rate and/or real GDP growth (final objective). Hence, to identify an appropriate policy signal for monetary policy stance in a monetary targeting framework, reserve or base money is the obvious choice. Alternatively, one of the intermediate targets,
namely other monetary aggregates, such as M1, M2 or M3, can also be used since they are related to base money via the money multiplier. However, in practice the choice of base money is less obvious because this is not the way monetary policy is conducted even as central banks openly declare themselves as following a monetary targeting framework. In essence, the problem is that central banks do not normally have complete control over base money. As Goodhart (page 293, 1989) put it:

"Central bank practitioners, almost always, view themselves as unable to deny the banks the reserve base that the banking system requires, and see themselves as setting the level of interest rates, at which such reserve requirements are met, with the quantity of money then simultaneously determined by the portfolio preferences of private sector banks and non-banks"

One way to look at this is to realise a central bank is trying to perform two functions: as a monopoly supplier of liquidity (base money), it supplies the currency the public holds and the transaction balances banks require, what is called liquidity management; and the other is to influence banks’ balance sheets to affect economic activity – what is known as monetary policy (Grenville 2005). The snag is that the central bank is unable to perform these two functions simultaneously given just one instrument. There are large exogenous variations in the demand/supply balance for base money, and the role of a central bank’s open market operations is to smooth these fluctuations. Any move to influence banks’ balance sheets will confuse banks as they will be unsure whether, say, the extra liquidity left-over in the system is a failed central bank attempt to mop-up liquidity, or whether it is a signal for them to expand their balance sheets.

Another way to look at this is to note that base money is basically composed of two components: currency-in-circulation, and banks’ reserves. The problem here is that a central bank has no direct short-term control over currency-in-circulation. For instance, during festivities, when there is a greater demand for goods and services, there will be additional demand for currency from the public. Now, consider the possibility where the central bank refuses the public’s requests for extra notes and coins because doing so will violate the monetary growth target. Surely such a refusal will make headline news and create a panic in the system. Interest rates will also periodically shoot-up during this period. In a developed
financial system, the share of currency-in-circulation over total base money is large (about 90% in the US, 84% in Australia vis-à-vis 56% in Malaysia).\textsuperscript{14} This very size and its demand-determined nature, makes it extremely difficult for a central bank to directly influence base money, let alone target a set monetary growth.

No convincing evidence has shown that central banks have actually adopted a monetary targeting framework in practice. Even in the heydays of monetary targeting in the 1970s and 1980s, countries which officially called themselves monetary targeters did not strictly adhere to the operating procedure of a constant-money growth-rate path as advocated by the monetarists. Goodhart (1995) provides evidence from Germany and the UK. In Germany, the monetary base was used as an indicator to assist subsequent discretionary adjustments in interest rates, or by a rule, for example, if base money deviates by x%, interest rates are varied by y%. There was actually no attempt made to change or control base money directly. The UK’s experience was a classic lip-service. After having overshot the monetary targets which led to the high inflationary episode of the late 1970s, the British Government drew-up the Medium-Term Financial Strategy which stipulated a gradual decline in M3 growth. Nonetheless, soon after that, financial innovations began to wreak havoc on the relationship between M3 and output, which eventually led to the abandonment of M3. As a result, M0 became the target. Like before, the base money target was not taken seriously and discretionary adjustments in interest rates continued to be used as the control mechanism. What the experience in these countries shows is that in actual practice, central banks never really followed a monetary targeting framework, despite calling themselves monetary targeters. This implies that as an indicator of monetary policy stance, contrary to the textbook view, base money holds no unique role vis-à-vis other intermediate targets of money. Since base money is not directly controlled by central banks, it does not necessarily mean it is the best indicator of policy stance in a “monetary targeting” framework.

\textsuperscript{14} The data are obtained from Grenville (2005); Reserve Bank of Australia’s \textit{Bulletin} Statistical Table D3, Monetary Aggregates as at March 2005; and BNM’s \textit{Monthly Statistical Bulletin}, Table II.1 Reserve Money as at April 2005.
In Malaysia's case, the same observations can be noted. In fact, there is clearer evidence to suggest BNM was never really a monetary targeter, certainly not to the extent practiced by the Bank of England, which in itself was short of that advocated by the monetarists. BNM never indicated it was a monetary targeter until an official publication in 1999. "Prior to the mid-1990s, the monetary policy strategy had been based on targeting monetary aggregates. This was an internal strategy and was not formally announced to the public" (page 139, BNM 1999). The publication goes on to mention that prior to 1987, M1 was the main policy target, but subsequent to that in the midst of financial liberalisations and innovations, greater emphasis was placed on M3. It is unclear whether M1 or M3 was an operating target or an intermediate target. Using the stylised monetary framework above as a guide suggests it was more of an intermediate target. In other words, M1 and M3 could not be the operating target as they were not directly controlled by BNM, but were goals which the Bank aimed at, because by meeting the intermediate targets, BNM would achieve its final objectives. So, effectively both could be an indicator of monetary policy stance. Of course, the ideal choice would still be the operating target because it would be better controlled by BNM and so should more closely reflect changes in monetary policy stance. As hinted above, there was actually no formal announcement of the conduct of monetary policy based on a monetary targeting framework when BNM was supposedly operating under that framework throughout the 1980s and early 1990s. Only recently, it was mentioned that BNM had followed a monetary targeting framework. Even then, there was no mention of an operating target. Further investigation suggests the Bank was unlikely to be controlling base money alone, and in fact, was likely to have also smoothed interest rates throughout this period. In the Bank's Money and Banking publications released at five-year intervals, the 1989 and 1999 editions, pages 421 and 434, respectively, state that "[b]riefly, monetary policy operates mainly through affecting the volume of bank reserves. In addition, the Central Bank can directly affect bank interest rates and whenever appropriate, directly control the volume of bank credit or the direction of credit through selective monetary measures". What is obvious is the absence of singling out of the control on base money alone.
Another important factor highlighted by Goodhart (1989, 1995)\textsuperscript{15}, which also applies to Malaysia, pertains to the operational difficulty in having complete control over base money, i.e., why base money cannot be the sole operating target even in a monetary targeting context. In a mandatory required reserve system as in Malaysia, where the maintenance of required reserves is based on the previous period deposit base, banks which experience a short-fall in their required reserves will have to borrow to meet the requirements. They can do so by borrowing from the market but this is likely to put upward pressure on interest rates. If this happens on a regular basis, interest rates will tend to spike-up periodically, and this will be extremely disturbing. As such, BNM has to ensure sufficient liquidity is available in the market so that such disturbances do not happen on a regular basis. If some banks are still short at the end of the day, they will have to borrow from BNM at an interest rate specified by BNM. Either way, this means BNM must revert back to a discretionary choice of interest rates i.e., conduct monetary policy by setting interest rates.

### Table 2.4 Volatility of Money Growth and Interest Rates (1981:1 to 1994:4)

<table>
<thead>
<tr>
<th></th>
<th>M0</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>Overnight Interbank</th>
<th>3-month Interbank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatility$^1$</td>
<td>10.2</td>
<td>8.9</td>
<td>5.2</td>
<td>5.3</td>
<td>1.9</td>
<td>2.2</td>
</tr>
<tr>
<td>F-value$^2$</td>
<td>28.0*</td>
<td>21.3*</td>
<td>7.2*</td>
<td>7.5*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. Standard deviation. For monetary aggregates, volatility is calculated based on the growth rate (quarter-on-quarter percentage change).
2. Calculated as $s_v/s_o$ where the numerator refers to the variance of the variable with a larger variance and the denominator of a smaller variance. The number of degrees of freedom is 56 at both the numerator and denominator. * Indicates the null hypothesis of equal variance between each measure of money and overnight interbank rate is rejected at the 1% level. The results do not change when the overnight interbank rate is replaced with 3-month interbank rate as well.

If BNM was actually targeting money, there should have been greater volatility in interest rates during the period up to the mid-1990s, when the monetary targeting framework was allegedly being adopted, compared with the volatility of monetary growth. Table 2.4 shows that from 1981:1 to 1994:4, contrary to

\textsuperscript{15} Although this is not a study of the failure of the monetary targeting framework, interested readers are strongly urged to refer to these papers for a discussion on the real world challenges facing a monetary targeter. Goodhart (1977) is also another essential reference, particularly pages 129-136, which look at the conceptual problems associated with the money multiplier.
expectations, the volatility of all measures of money was larger than that of interest rates. Statistical tests on the equality of variance between different monetary aggregates and interest rates overwhelmingly reject they are of equal variance.

In short, the above discussion lends support to two salient points. First, there is a lack of evidence to substantiate BNM was actually a monetary targeter. This is further underlined by the author's private discussions with staff from the Investment Operations and Financial Market Department, the people in-charge of monetary operations in the Bank, which often ended-up with a verdict that in practice the Bank had never operated to achieve a set monetary growth target. Second, theoretically base money should have a unique role to play in a monetary targeting setting because it is within the immediate ambit of central banks – it should best reflect changes in monetary policy stance. In practice, however, its role is no different from other intermediate targets, which essentially is just another indicator of monetary policy stance. In fact, since it is not directly controlled by central banks, there is no reason to believe it would be more superior to other money aggregates, or for that matter, a short-term interbank rate.

With regard to the interest rate/inflation targeting framework, again, in practice, there is generally no specific variable that is used as an intermediate target. Subsequent to the abandonment of "monetary targeting" in Malaysia in the mid-1990s, BNM moved towards an interest rate targeting setting. As in the preceding environment, no official operating or intermediate target was revealed. Nonetheless, the market generally took the 3-month interbank rate as the de facto operating target. This lasted until February 1998, when BNM announced the Intervention Rate as the official operating target. Since April 2004, under a new interest rate framework, the Overnight Policy Rate (OPR) based on the overnight interbank rate has become the official stance of monetary policy.

Before leaving this section, it is useful to briefly look at the US experience with monetary targeting as it encapsulates the issues highlighted above. In October 1979, two months after Paul Volcker became the Chairman of the US Federal Reserve, he announced a new monetary policy operating framework based on
targeting non-borrowed reserves (the portion of total reserves that is not borrowed by depository institutions through the discount window). Prior to that, the US Fed had operated on the basis of controlling the Fed Funds rate. Control of the Fed Funds rate was abandoned because adjustments in interest rates were often criticised as being "too little too late" and failed to control the inflationary tendencies in the 1970s. At the same time, the general uncertainty in economic decision making and political pressure against upward changes in interest rates did not help the Fed Reserve in operating flexibly and "independently". Nevertheless, the implementation of non-borrowed reserves targeting only prevailed for three years to October 1982. During this period, as would generally be expected, the Fed Funds rate became more volatile and was allowed to rise significantly. But, contrary to expectations, there were no signs that the Fed had better control over the rate of monetary growth which continued to increase during the period. The Fed missed its M1 target in all three years. Mishkin (2003) attributed these failures to the faster pace of financial innovation and liberalisation, such as the inclusion of NOW accounts to the measure of monetary aggregates; the introduction of credit controls by the Fed which restricted the growth of consumer and business lending; the consecutive recessions of 1980 and 1981/82; and the technical difficulty in controlling money in a lagged reserve requirement system. Many economists now believe the Fed was not concerned about the monetary target per se, but rather the monetary target was a veil to allow interest rates to rise sharply to eliminate, once and for all, persistent inflationary expectations in the economy (Goodhart 1989, Mishkin 2003). This veil, labelled by Grenville (2005) as "heat shield" allows central banks to raise interest rates indirectly without the political pressure, thereby deflecting the criticism on central banks as "taking away the punch bowl just when the party is getting to be fun" (page 9).

2.7 Conclusions

Malaysia's economic performance since independence is highly commendable. Real income growth has been robust and inflationary pressures have remained well-contained. The former is in no small part due to the highly open economy, and the latter to judicious handling of the fiscal purse. Nonetheless, being highly
open also comes with the cost of being more susceptible to adverse global shocks, not only in the traditional sense (terms of trade, oil price shocks) but also in the modern sense (herd instinct, contagion). Reassuringly, however, the way the impact of these shocks has been handled demonstrates the pragmatism, courage and discipline of the policymakers, which has often times quickly steered the economy back to an even keel. A classic example of this is the episode associated with the introduction of capital controls during the Asian crisis.

The way monetary policy is conducted is also based on a large dose of pragmatism – do what works – rather than be dictated by certain “flavour of the month”. When world central banks were abuzz with monetary targeting in the 1970s and 1980s, and also inflation targeting from the early 1990s, BNM continued to conduct monetary policy with what works, given the nature and circumstances of the financial development of the country and the problems in hand. It appears that what works is never close to what is advocated in a monetary targeting framework. Hence, it would be incorrect to assume base money has a unique role to play as an indicator of monetary policy stance vis-à-vis other measures of money. Instead, a more relevant and appropriate indicator appears to be interbank interest rates.

Nonetheless, pragmatism can be carried too far. There are expectations that the central bank has in its power the ability to influence the economy in many ways. This is evident from the lack of a clearly defined objective, and the use of various distortionary monetary policy tools right up to the present day. The central bank appears to have a tendency to favour economic growth over stable prices, despite the accepted wisdom of the reverse. Many of the policy tools used are clearly distortionary – they cloud the monetary policy signals, drive a wedge between markets/misallocate resources, and raise the cost of intermediation. Yet they remain handy as a means to meet the central bank’s various mandates. Going forward, if the central bank truly believes in a market-based system of monetary operations, as it has long advocated, it will have to approach this with greater determination, truthfulness and discipline and not be wilfully sidestepped by ancillary objectives and outside pressures.
Chapter 3
A VAR Model for Malaysia: Theory, Methodology and Estimation Issues

This chapter details the building of an open economy VAR model for Malaysia. What sets it apart from other more typical models of monetary policy transmission mechanism is that it includes four transmission channels viz. the interest rate, credit, exchange rate and asset prices/wealth channels. It also adopts the open-economy approach, which is often overlooked in the majority of empirical studies as they have tended to concentrate on the US, a large and relatively closed economy. The inclusion of the four monetary policy transmission channels is motivated by one of the core interests of this thesis, which is to study the relative importance of the different transmission channels. Invoking the open economy approach fits the profile of Malaysia’s economic structure where total trade to GNP is over 200%.

Unlike the developed countries in particular, little work has been done on the monetary policy transmission mechanism in Malaysia. This is largely due to a lack of sufficiently long time-series data, at least until recently. Empirical work involving micro or firm-level data remains non-existent for the same reason that there is virtually no comprehensive bank/firm-level database to allow any meaningful studies. Inevitably, more focused work to disentangle the different transmission channels, though not necessarily to examine their relative strength, has to be ignored.

Only a few studies on the monetary policy transmission mechanism in Malaysia have been published. Azali and Matthews (1999) examine the money and credit channels pre and post-liberalisation in the late 1990s, using Bernanke’s 1986 closed-economy contemporaneous SVAR model where the money channel is found to be more important in influencing output fluctuations post-liberalisation. Bernanke and Blinder (1992), who in their own study use a recursive VAR like here, criticise the results from the 1986 Bernanke model as “sensitive to choice of
specification and to the identifying assumptions" (page 902). Another study by Domac (1999) looks at the distributional consequences of monetary policy on small and large manufacturing firms. His main finding provides support that small firms are more severely affected by monetary policy. This finding is based on a thorough descriptive analysis of banking and bond yields statistics, as well as a simple closed form recursive VAR model. However, several comments are worth highlighting: it is fair to say that any analysis using bond yields in Malaysia must be interpreted with caution because of the distortions caused by the lack of breadth and depth of the bond market; further, the analysis based on the banking statistics appears to be broad-brush and reflects a lack of clear understanding about local banking conditions, particularly during the period of the Asian crisis; and the choice of overnight interbank interest rate as the policy instrument may not be appropriate. More recently, Ibrahim (2005) uses a recursive VAR to study the impact of monetary policy shocks on various economic sectors. Likewise, several remarks should be noted: the choice of the 3-month Treasury bill rate as the monetary instrument is less appropriate given the problems in the debt market;¹ and the source of the quarterly aggregate real output and sectoral data, which starts from 1978:1, is questionable. The author claims they are obtained from BNM, but, officially, quarterly total real GDP series only start in 1987, and sectoral breakdowns are only available from the early 1990s.²

The lack of previous studies or references throws up many challenges. The main challenge is that work must virtually start from ground zero, where some simple and basic questions must first be answered. For example, would a simple recursive VAR model perform well for the Malaysian economy? Would a closed economy VAR suffice or would an open economy version be better? What is the appropriate variable to use to represent BNM’s monetary policy stance? How would the price puzzle and exchange rate puzzle be dealt with if they were present? Would the inclusion of a certain variable to account for inflationary expectations be better than another? What would be a reasonable ordering scheme? This and the following chapters will attempt to answer these questions.

¹ See Section 3.3.1, for a discussion on the problems of the debt market.
² This fact was confirmed by officers from BNM.
This chapter discusses the building blocks of a VAR model for Malaysia, while the next chapter presents the empirical results in choosing a suitable model.

The rest of the chapter is structured as follows. Section 3.1 discusses the theoretical and practical underpinnings of the different channels of monetary transmission. Section 3.2 reviews the VAR methodology, with particular reference to the use of the Cholesky decomposition in identifying the model. Special attention is also paid to the derivation of the impulse response function since it is the single most important analytical tool used in this thesis. Section 3.3 delves into issues and rationales relating to the selection, construction and transformation of variables. Section 3.4 discusses estimation issues pertinent to the VAR methodology and the sample period chosen. These involve the ordering of variables in a VAR model, the choice of dummy variable to account for the Asian crisis period, the choice of lag structure, some diagnostic checks, and non-stationarity of variables. Section 3.5 concludes.

3.1 Theoretical and Practical Aspects of Monetary Policy Transmission Channels

Four transmission channels are examined: the interest rate channel, the credit channel, the exchange rate channel, and the asset price channel. The interest rate channel is included because it remains the most conventional mode of monetary transmission. The credit channel here refers not just to the bank lending channel but also to the financial accelerator effect as advanced by Bernanke, Gertler and Gilchrist (1996). It will be clearer later why the term credit channel has been chosen instead of bank lending or broad credit channel. The inclusion of the exchange rate channel is understandable because the extent of Malaysia's openness implies that the exchange rate is a vital price in the economy. The asset price channel is examined to gauge the wealth effects on consumers as well as its impact on investment spending by firms. The particular asset price used is the stock price since undoubtedly the stock market
represents the most significant component of Malaysia's capital markets. It is also by far the most active avenue of investment and speculation among the Malaysian public.

3.1.1 Interest Rate Channel

In modern central banks, changes in monetary policy stance are equivalent to changes in the target level of interest rates, normally a target overnight interbank interest rate. This rate in Australia is the Cash Rate; in the US, it is the Federal Funds Rate and in Malaysia, the Overnight Policy Rate. Actual overnight rates traded can be different from the target rate but they are ultimately guided by the target interest rate set by the central banks. The credibility of central banks and the mechanism of monetary operations in place ensure actual overnight rates stay within an acceptable band. One critical feature of this framework, for want of a better name called interest rate targeting in Malaysia, and inflation targeting in Australia, is that changes in monetary policy stance are not commensurate with the changes in open market operations. For instance, to tighten monetary policy, that is to increase the target level of the overnight rate, central banks need not necessarily sell government papers to mop-up liquidity to drive up the level of interest rate. Instead, announcement of a rise in the target interest rate would lead to a corresponding adjustment in the overnight market rate. To emphasise this point, the Reserve Bank of Australia (RBA 2003a) has categorically stated that open market operations are not "needed to 'move' the actual cash rate to the new target rate" (page 2). What open market operations do is simply a reflection of day-to-day liquidity management due to varying demand shocks, without which the cash rate will be extremely volatile. The US Federal

3 The house price index is also a popular variable to use to examine the wealth effect but this alternative is not feasible in Malaysia because of insufficient data. The quarterly house price index in Malaysia only starts from 1997, annual from 1988.
4 Not all countries have such mechanism installed. The US does not but there is in Australia, although it is not stated explicitly. In Malaysia, New Zealand and Canada, it is made known explicitly.
5 The day-to-day liquidity flows are movements of funds between financial institutions and a central bank. They involve federal government transactions handled by the central bank, since the central bank is also the banker of the government, transactions by the central bank on behalf of other foreign central banks, the central bank's own transactions, and financial institutions' proprietary transactions and transactions on behalf of their clients.
Reserve echoes this in one of its publications from a decade ago when it says "most purchases and sales of securities are not undertaken to adjust conditions in reserves markets as a result of a policy decision. Rather they are made to offset other influences on reserves" (page 37, Board of Governors of the Federal Reserve System 1994). This new approach has now come to be popularly and appropriately known as "open mouth operations".

On the theoretical front, the traditional Keynesian view says that changes in nominal interest rates affect real interest rates because prices are sticky in the short-run, which in turn influences real variables such as consumption and investment. Put plainly, given short-run price stickiness, when nominal interest rates rise, real rates also rise, and vice versa. It is well recognised that although short-term interest rates may change, medium to long-term interest rates may not, but the latter are what determine the spending of consumers and firms. Therefore, in order for short-term interest rates to affect long-term rates, the expectation hypothesis of the term structure of interest rates is assumed – the long-term rate is an average of future short-term rates. For example, if the short-term one year rate for the current year and the next four years is expected to be 5% per annum, then the five-year interest rate is just 5% per annum.

Using Mishkin’s (1996) famous schematic, the interest rate channel’s transmission can thus be depicted as follows:

\[ M \uparrow \Rightarrow r \downarrow \Rightarrow I, C \uparrow \Rightarrow Y \uparrow. \]

An easing of monetary policy (a rise in \( M \)), leads to a fall in nominal interest rates and, given price rigidity, a fall in real rates (\( r \)). A fall in real rates boosts investment (\( I \)) as the required rate of return from a project and the cost of borrowing decline. Similarly, consumption (\( C \)) also increases. With both investment and consumption increasing, aggregate demand rises and hence output (\( Y \)) rises.

It must be emphasised that a clear distinction is made between the interest rate channel and the money channel (the latter is not studied here). Some researchers still prefer to use the term interchangeably but clearly there is a
difference. The money channel should only be used for central banks operating under a monetary targeting framework, whereby open market operations are effected through changes in bank reserves and in turn money supply. Given price rigidity in the short-run, real money balances will change, hence real interest rates will also change which will in turn affect prices and output. In contrast, in an interest targeting framework, reserves and money supply do not change but nominal interest rates change when the monetary policy stance changes. The pursuit of a monetary targeting framework is largely based on the quantity theory of money \((MV=PY)\). By setting a desired level of future inflation rate \((P)\), estimating an underlying real output growth \((Y)\) and forecasting the likely velocity of money growth \((V)\), central banks then define a monetary growth target consistent with the final inflation target. The fulcrum of this framework lies in the predictability of the velocity of money which unfortunately has proven to be extremely tricky for countries going through rapid financial liberalisation and technological advancement. Over time this complexity becomes too onerous and has led to abandonment of monetary targeting in many countries.

### 3.1.2 Credit channel

The credit channel studied here encompasses both the bank lending channel and the broad credit (balance-sheet) channel because the variable used, that is, total outstanding loans in the banking system, incorporates the features of both the channels.

#### 3.1.2.1 Bank Lending Channel

The bank lending channel works through constraining the supply of bank loans to borrowers after a tightening of monetary policy. Again to be precise, the theoretical underpinning of this channel lies in the traditional view of conducting monetary policy based on the monetary targeting framework. One such model that incorporates the bank lending channel via an extension of the IS/LM model is due to Bernanke and Blinder (1988). Oliner and Rudebusch (1995) provide a simple and intuitive rendition of this by considering a simplified balance sheet of a bank where on the assets side there are only three items: reserves, loans and
securities; and on the liabilities side, there are only two items: time deposits, and demand deposits (see Figure 3.1).

**Figure 3.1 A Simplified Balance Sheet of a Bank**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserves</td>
<td>Demand Deposits</td>
</tr>
<tr>
<td>Loans</td>
<td>Time Deposits</td>
</tr>
<tr>
<td>Securities</td>
<td></td>
</tr>
</tbody>
</table>

They assume a fraction of demand deposits, $\mu$ has to be held as reserves, and there is no reserve requirement on time deposits. When monetary policy is tightened via the sale of securities by the central bank, this raises the holdings of securities by the private bank, which is matched by the decline in reserves. With the fractional reserve requirement in place, demand deposits must fall by $1/\mu$. To ensure total assets equal total liabilities, this implies either time deposits (the liability side) must rise or loans and securities (the asset side) must decline. This channel, which operates on the basis that changes in monetary policy are accompanied by changes in reserves, is clearly not the norm in the current framework of monetary policy. Nonetheless, for Malaysia, the bank lending channel has a role to play because of the frequent use of the statutory reserve requirement (SRR) ratio as a monetary policy tool by the central bank. Besides, the sample period examined in this thesis covers the era when the central bank claimed it was adopting a monetary targeting framework.

For the bank lending channel to work, two conditions must be satisfied: (i) banks cannot fully insulate the fall in deposits by issuing more of other deposits and/or selling their securities; and (ii) borrowers cannot fully insulate themselves by substituting for alternative sources of funding. On the first point, Romer and Romer's (1990) study of the US case highlights that because certificates of deposits are not subject to reserve requirements, more certificates of deposits can be issued to insulate the fall in reserves and therefore, loans supply does not have to decline as much or even at all. This feature, however, is less relevant in Malaysia because all forms of deposits are subject to SRR – Malaysian banks cannot easily insulate themselves by issuing other forms of
deposits, and hence the bank lending channel would still be relevant. In addition, selling off securities is not an attractive option when there is a shortage of government securities on offer and more generally when the bond market is not well developed. Also, the infancy of the domestic bond market supports the second condition because it hinders Malaysian companies from finding alternative sources of funds apart from going to the banks. The Malaysian ringgit bond market is relatively small. The total amount of bonds outstanding to GDP is only 81% (BNM 2004), compared with a developed market like the US of 163% (Bank for International Settlements (BIS) 2004) at end-2003. Nonetheless, going forward, the situation is expected to change for the better, as measures have been intensified to develop the ringgit bond market as an alternative funding source as well as an avenue for the diversification of risks away from the banking sector.

The bank lending channel can thus be depicted as follows:

\[ M \uparrow \Rightarrow L \uparrow \Rightarrow I, C \uparrow \Rightarrow Y \uparrow. \]

An easing of monetary policy increases reserves, and hence, loans (L). So spending by bank dependent borrowers rise to finance their investment and consumption, in turn aggregate demand rises and output rises.

### 3.1.2.2 Broad Credit (Balance Sheet) Channel

Unlike the bank lending channel, the broad credit channel transmits monetary policy shocks on the basis of how banks assess borrowers. It does not depend on whether central banks can control the supply of loans. The way banks assess

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6 Relative to other Asian countries, the Malaysian bond market is better developed, spearheaded by the establishment of the national mortgage corporation, Cagamas Berhad in 1986. Interestingly, its share to GDP is also higher than Australia’s 32% (RBA 2003b).

7 Many argued the almost non-existence of a domestic bond market was a key factor that exacerbated the Asian crisis as the bulk of the risks had to be borne by the banking sector. Cognisant of this, authorities in the region have individually re-examined with greater urgency the development of a domestic bond market. This sentiment is widely shared in the region. In 1993, it culminated in the launch of the Asian Bond Market Initiative, under the auspices of the ASEAN+3 Finance Ministers’ Forum, which aims to develop a deep, broad and liquid bond market within the region.
borrowers is based on the latter's net worth, defined as the sum of internal funds (liquid assets) and the collateral value of illiquid assets or simply the strength of borrowers' balance sheets (Bernanke and Gertler 1995) – hence, it is also popularly known as the balance sheet channel. Essentially, the broad credit channel works on the premise that there is a difference in the cost of funds borrowed externally (by issuing debt or equity) and obtained internally (from retained earnings). This difference in cost or the external finance premium comes about because lenders do not have complete information about borrowers. As a result, lenders have to collect, monitor and evaluate information, which entails costs that have to be borne by borrowers. Since borrowers naturally have more information about their prospects than lenders, they may at times act irresponsibly, that is, with moral hazard. To account for these downsides, higher costs have to be imputed and these are reflected in the external finance premium.

Unless external finance is fully-collateralised, internal finance will always be cheaper. Intuitively, unless borrowers are willing to fully compensate lenders who face incomplete information, lenders have no alternative but to charge more than the cost of internally generated funds. It follows that if borrowers are willing to provide more collateral, or if the value of the collateral increases, the external finance premium falls. Hence, higher net worth or a stronger balance sheet means a lower external finance premium. A subtle but essential relationship is that a policy induced tightening of monetary policy can cause a deterioration in borrowers' balance sheets, in addition to the common effect of higher market interest rates, which further amplifies the contraction in spending and production (the financial accelerator effect). Cecchetti (1995) adds that the broad credit channel therefore stresses both the distributional impact of monetary policy and why small changes in interest rates can have a large impact on investment. These results are shown by Bernanke, Gertler and Gilchrist (1996) using the principal-agent framework to credit markets.

When interest rates are raised, there are several ways in which balance sheets can deteriorate. Normally, companies finance their working capital with short-term floating rate borrowing such as an overdraft. So, higher interest rates increase their interest expense, reduce their cash flow, and weaken their
financial position. Higher interest rates are also usually associated with lower asset prices, which mean lower collateral value and a weaker balance sheet. This explains why banks tend to over-lend in the upswing when things are rosy and over-contract in the downswing when things turn gloomy. This is the amplification and propagating mechanism referred to by proponents of the broad credit channel. There is also an indirect impact because of the interconnectedness of companies and consumers in the economy. Any company is a buyer and producer of another company’s goods and services. So, higher interest rates can hit the balance sheet of one company and have a knock-on impact on other companies. All will spend and produce less as a result. The presence of highly geared agents further exacerbates this effect.

The broad credit channel can thus be depicted as follows:

\[ M \rightarrow i \rightarrow C_f \rightarrow P_a \rightarrow C_v \rightarrow L \rightarrow Y \]

An expansionary monetary policy reduces nominal interest rates \((i)\) and the debt service burden of companies and consumers. This improves their cash flow \((C_f)\). Perceiving this, banks become more willing to lend and aggregate demand and output rise. At the same time, asset prices \((P_a)\) rise, contributing to a rise in collateral value \((C_v)\), making it more attractive for banks to lend, leading to higher loans and a rise in aggregate demand and output. Mishkin (1996) interprets the broad credit channel via the notion of adverse selection and moral hazard. The key in his exposition lies in the inverse relationship between borrowers’ net worth and the severity of adverse selection and moral hazard. For instance, an expansionary monetary policy enhances the net worth of borrowers, and reduces the adverse selection and moral hazard problems, thus encouraging banks to lend leading to a rise in aggregate demand and output.

To recap, since this thesis uses bank loans to study the credit channel, it essentially incorporates both features of the bank lending channel and the broad credit channel. However, it is fair to argue that bank loans cannot actually separate the effects of the two channels. To do this, requires a different tack, one which uses micro-level or firm-level data. As mentioned above, owing to the
absence of adequate micro-level data for Malaysia, this possibility is ruled-out. In adopting the latter approach, closer investigations of the bank lending channel and the broad lending channel are possible. But the drawback is that they do not allow for comparisons between the relative importance of different transmission channels. It is not apparent whether any empirical studies using firm-level data have examined the relative importance of the bank lending channel versus the broad credit channel. The objective of these studies is normally not to compare their relative strength, but to examine whether a particular channel exists or otherwise.

A major criticism in using aggregated data to study the credit channel is that a rise in banking loans could potentially be caused by more buoyant economic activity, which boosts loan demand instead of the expected reverse causation of a higher loan supply boosting economic activity. This issue will be investigated but the result can only be suggestive. Cecchetti (1995) provides a critical examination of the weaknesses of many empirical studies in this area. He points out that even micro-level studies fail to discern a reduction in loans as being attributed to loan demand or supply. Any conclusion reached merely provides evidence supportive of capital market imperfections, where smaller and more agile companies bear a disproportionate burden of any adverse impact from a contractionary monetary policy. Accordingly, this has important distributional effects in the economy particularly because smaller companies form the backbone of many economies.

3.1.3 Exchange Rate Channel

The transmission of monetary policy through the exchange rate channel is mainly explained via net exports.\(^8\) But firstly how does the exchange rate respond to a change in interest rates? Mundell (1962) shows that with capital mobility, higher interest rates in one country attracts capital from another (so that the currency in the former appreciates relative to the latter), and this process continues until the expected return from investments in both countries are the same. The factor that equalises the expected returns in both countries is the expected change in the exchange rate i.e., the currency of the former is expected to depreciate in the future or the currency of the latter is expected to appreciate – the famous result of the uncovered interest rate parity (UIP). Thus, as a priori, a positive interest rate shock is expected to lead to an immediate rise or a nominal appreciation of the currency. Grilli and Roubini (1995) highlight that this result is consistent with a broad class of exchange rate models that include asset models of the exchange rate with sticky prices, à la Dornbusch’s model of exchange rate overshooting (see Appendix 3-1 for more details), portfolio models of exchange rate, and liquidity models with inertia in asset markets.

The exchange rate channel can thus be depicted as follows:

\[ M^\uparrow \Rightarrow r^\downarrow \Rightarrow E^\uparrow \Rightarrow X_n^\uparrow \Rightarrow Y^\uparrow. \]

An expansionary monetary policy leads to a decline in the domestic real interest rate assuming price stickiness, this leads to capital outflows and a depreciation in the value of the domestic currency (\(E^\uparrow\): in this study the exchange rate is defined as the value of the ringgit compared to one US dollar, RM/USD), resulting in cheaper domestic goods relative to foreign goods. Hence, exports increase due to the improvement in competitiveness, and imports decrease due to expenditure switching among residents. Therefore, net exports \((X_n)\) increase and aggregate demand and output rise.

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\(^8\) This is the conventional trade-linkages/expenditure-switching perspective. See McKibbin and Vines (2000) for an alternative explanation from the exchange rate risk premium/capital flows angle, which is also highlighted in Section 4.3, Chapter 4.
3.1.4 Asset Price Channel

The relationship between investment and asset prices can be referenced to the famous Tobin's $q$ theory (1969). Based on the value $q$, defined as the market value of a company divided by the replacement cost of capital, companies know when to undertake new investment or otherwise. The intuition is that when $q$ is above one, the market value of a company is high relative to the current cost to replace the capital; this means the company can get a better price in issuing shares to finance its capital expenditure – it is cheaper to buy new equipment and plant by issuing shares rather than to buy existing capital. Hence, investment in new equipment and plant will rise. On the other hand, when $q$ is less than one, the current market value of the company is less than the current cost to replace the capital, so there is now no incentive to issue shares to buy new equipment and plant. Instead, if the company chooses, it is better off buying old capital or another firm. Thus, new investment falls.

The value of a share can be simply thought of as the discounted value of the future stream of dividends. If dividend $(D)$ is assumed to grow indefinitely by $g$ percent per year and the discount rate or the required rate of return is $r$, percent per year forever, the current intrinsic value of a share $(P_0)$ now is:

$$P_0 = \frac{D}{1+r} + \frac{D(1+g)}{(1+r)^2} + \frac{D(1+g)^2}{(1+r)^3} + \ldots = \frac{D}{r-g}.$$  

Monetary policy affects the general level of interest rates which includes the required rate of return. Specifically, higher interest rates also translate to a higher required rate of return. So, a policy induced decline in interest rates means a lower discount rate and thus a higher current share valuation – share price $(P_s)$ rises. Cast in terms of Tobin's $q$, this implies an increase in $q$, and a rise in new investment and output. Thus, the asset price channel can be depicted as follows:

$$M \uparrow \Rightarrow P_s \uparrow \Rightarrow q \uparrow \Rightarrow I \uparrow \Rightarrow Y \uparrow.$$
A more familiar link between interest rates and stock prices can be interpreted from the Keynesian angle, where an expansionary monetary policy reduces interest rates making the holdings of bonds less attractive relative to shares, thereby increasing the demand for shares and pushing up share prices (Mishkin 1996).

The above discusses changes in asset prices as they influence firms. Changes in asset prices also have an important influence on individuals, many of whom own shares, bonds or houses, or at least invest in investment vehicles which own these assets. Note the popular commentary on the US economy, that the last recession would have been far worse had it not been cushioned by a strong housing market and, that the US Federal Reserve was applauded for engineering a soft-landing due to its aggressive reductions of interest rates. Although, the asset price used in this study is not the housing price, monetary policy still has an important influence on share prices as shown above. In particular, an expansionary monetary policy boosts share prices, making individuals wealthier. Richer individuals \((W)\) can better afford to spend, thereby boosting consumption, aggregate demand and output as depicted by the schematic below. This is why the asset price channel is also known as the wealth channel (this term will be used interchangeably in this thesis).

\[
M^\uparrow \Rightarrow P_s^\uparrow \Rightarrow W^\uparrow \Rightarrow C^\uparrow \Rightarrow Y^\uparrow.
\]

The mechanics of the wealth channel is consistent with Modigliani's life-cycle model, which he reiterated in his Nobel Prize winning speech in 1985, "[t]he fact that wealth enters .... in the short-run consumption function means that monetary policy can affect aggregate demand not only through the traditional channel of investment but also through the market value of assets and consumption" (page 310, 1986). Meltzer’s (1995) monetarist discussion on the burst of the property bubble in Japan in the early 1990s, which shaved-off a chunk of individuals' wealth and dealt a severe blow to the country’s consumption and output, further reinforces the wealth channel. This point is also emphasised by Mishkin (1996), where he adds that Tobin’s q-theory is also applicable to property investment (it also affects individuals’ wealth), whereby a contraction in monetary policy lowers the market value of a property relative to its replacement cost, resulting in a decline in q,
and thus leading to lower spending on properties. More recent anecdotal evidence comes from the sluggish property market in Hong Kong in the aftermath of the Asian crisis which had purportedly held back much of its growth vis-à-vis other Asian countries.

3.2 Methodology

Consider a SVAR model of $p$ lags as represented by:

$$B_0Y_t = K + B_1Y_{t-1} + \ldots + B_pY_{t-p} + U_t, \quad (3.1)$$

where $B_i$ is a $n \times n$ matrix of parameters of 0 to $p$ lags, $Y_t$ is a $n \times 1$ column vector of endogenous variables, $K$ is a $n \times 1$ column vector of constant terms, $Y_{t-i}$ is a $n \times 1$ column vector of $Y_t$ at different lags, and $U_t$ is a $n \times 1$ vector of structural innovations or shocks, having the white noise properties of zero mean, $E(U_t) = 0$, constant variance, $E(U_tU_t') = \sigma^2$, and shocks that are independent across time, $E(U_tU_s) = 0$ for $t \neq s^9$. Hence, the covariance-variance matrix of $U_t$, $\Sigma$, is essentially a diagonal matrix. In the VAR literature, when an innovation or a shock is referred to, it is usually referred to as a structural shock. The focus of the discussion in this section is motivated by the objective of finding structural shocks and the ability to generate the impulse response function (IRF), a standard tool used in VAR analysis.

The contemporaneous relationships between the endogenous variables are contained in matrix $B_0$, where the diagonal elements are restricted to be unity. This is useful because each structural shock can now be identified to a particular structural equation, which permits economic interpretations. An example of the simplest case of a two-variable model with a one-period lag looks like:

---

9 This last property implies each shock is serially uncorrelated – $\text{Cov}(U_{it}U_{is}) = 0$ for $i = 1 \ldots n$ shocks, and any two different shocks in the system are also uncorrelated with each other ($\text{Cov}(U_{it}U_{ij}) = 0$ for all $i \neq j$). In contrast, for the reduced form residuals, the second condition does not apply i.e., two different reduced form shocks can be correlated with each other, but each shock is still serially uncorrelated.
Nonetheless, doing this impinges the direct estimation of the equation because of the presence of the contemporaneous variables on the right-hand side. To estimate the model, Equation (3.1) must be expressed in reduced form. Premultiplying each term in Equation (3.1) with $B_0^{-1}$ yields the reduced form representation:

$$
\begin{bmatrix}
1 & b_{12}^0 \\
b_{21}^0 & 1
\end{bmatrix}
\begin{bmatrix}
y_{1t} \\
y_{2t}
\end{bmatrix}
= 
\begin{bmatrix}
k_1 \\
k_2
\end{bmatrix}
+ 
\begin{bmatrix}
b_{11}^1 & b_{12}^1 \\
b_{21}^1 & b_{22}^1
\end{bmatrix}
\begin{bmatrix}
y_{1t-1} \\
y_{2t-1}
\end{bmatrix}
+ 
\begin{bmatrix}
u_{1t} \\
u_{2t}
\end{bmatrix}.
\tag{3.2}
$$

Notice $U_t$ can now be retrieved from $\mathbf{\epsilon}_t = B_0^{-1} U_t$ or more specifically from the covariance-variance matrix of the reduced form residuals:

$$
\mathbf{\epsilon}_t = B_0^{-1} U_t,
\tag{3.3}
$$

Herein lies the famous identification problem in VAR models. A problem that arises because the number of parameters already estimated or known, on the left-hand side of Equation (3.4), is less than the number of unknown parameters, on the right-hand side. The most common method to solve this is to impose some restrictions by assigning a value of zero to some elements in the $B_0$ matrix — short-run/zero restrictions. From Equation (3.4), the left-hand side has $n(n+1)/2$ unique parameters (since elements on one side of the diagonal elements mirror the other), while on the right hand side, there are $(n^2-n) + n$ unknown parameters from $B_0^{-1}$ and $E(U_t U_t')$, respectively. (Recall that the $B_0$ matrix is assigned to having a value of unity on the diagonal elements, leaving $n^2-n$ unknown parameters that must be estimated. $E(U_t U_t')$ is $\mathbf{D}$ which is a diagonal matrix, so it only has $n$ unknown parameters that must be estimated). Therefore, the difference between the two (right-hand side minus left-hand side)
represents the number of additional restrictions that must be imposed for exact identification, which is \((n^2-n)+n - n(n+1)/2 = n(n-1)/2\).

One way to achieve this identification is to let \(B_0\) be a lower triangular matrix, i.e., that the elements on the top right side of the principal diagonal all be zero. From Equation (3.2), this means \(b^0_{12} = 0\) and the structural equation of \(y_{1t}\) will now only be explained by the lagged values of \(y_{1t}\) and \(y_{2t}\), but \(y_{2t}\) will be explained by the contemporaneous values of \(y_{1t}\) as well as the lagged values of \(y_{1t}\) and \(y_{2t}\). This hierarchical structure is also known as the Wold causal ordering. By letting \(B_0\) be lower triangular, the structural shocks can be retrieved as the linear combinations of the reduced form residuals, i.e., the structural shocks are now orthogonal to each other. Using the two-variable model as an example, and making use of \(U_t = B_0 e_t\) from Equation (3.3), yields \(u_{1t} = \&_1 t\) and \(u_{2t} = b^0_{21} \&_1 t + \&_2 t\). This gives the all important structural shocks which are of interest in VAR analysis.

In the above case, the orthogonalisation of the covariance-variance matrix of the residual form residuals, \(\Omega\), is done via the \(B_0\) matrix being lower triangular with unity on the principal diagonal. Alternatively, the popular, Cholesky decomposition can be used, whereby the transformation is made by having \(P = B_0^{-1}D^{1/2}\), where \(D^{1/2}\) is simply the square root of the covariance-variance matrix of the structural shocks. Hence, the reduced form residuals' covariance-variance matrix is:

\[
E(\varepsilon_t\varepsilon_t') = \Omega = PP'.
\]  

(3.5)

This is the famous result where the main diagonal elements of \(P\) are now the standard deviation of each structural shock as opposed to unity in the previous case, but \(P\) still remains lower triangular.\(^{10}\) Likewise, it can be shown that the structural shocks are orthogonal to each other:

\(^{10}\) Note that transformation of \(B_0\) above to a lower triangular matrix with unity on the principal diagonal is sometimes referred to as the Cholesky decomposition. However, others have followed Hamilton (1994) and called the \(P\) matrix the Cholesky matrix (\(P\) has the standard deviation of \(U_t\) along its principal diagonal instead of unity). The latter terminology is adopted here.
\[ E(U_t, U_t') = B_0 E(\varepsilon_t, \varepsilon_t') B_0' \]
\[ = B_0 \Omega B_0' \]
\[ = B_0' P P' B_0' \]
\[ = B_0 B_0^{-1} D_{1/2} D_{1/2} B_0' \]
\[ = D . \] (3.6)

With the structural shocks identified, the impulse response function can be estimated. The plot of impulse response is essentially a graphical representation of a shock to one endogenous variable on itself or any other endogenous variables over time, holding all other shocks constant. For instance, the impulse response of output to an interest rate shock depicts the dynamics of output over time due to a change in interest rate shock taking place at time \( t \). Alas, the impulse response function cannot be directly estimated from Equation (3.3). To do this, Equation (3.3) has to be expressed in the moving-average form, where the right-hand side variables comprise only structural shocks. First, rewrite Equation (3.3) as:

\[
(l - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^p) Y_t = C + \varepsilon_t \\
\Phi(L) Y_t = C + \varepsilon_t \\
Y_t = \Phi(L)^{-1} C + \Phi(L)^{-1} \varepsilon_t \\
= \mu + \Psi(L) \varepsilon_t \\
= \mu + (\Psi_0 + \Psi_1 L + \Psi_2 L^2 + \ldots) \varepsilon_t \\
= \mu + \Psi_0 \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \ldots \] (3.7)

Line 3 of Equation (3.7) is possible if \( \Phi(L) \) is invertible – its unit roots lie outside the unit circle, that is, it is known as a covariance stationary process.\(^{11}\) This condition ensures the model has a stable structure. Violation of this condition means the model is unstable. From a practical perspective, instability can be detected by plotting the impulse responses over many periods. An explosive

---

\(^{11}\) Why outside the unit circle and not inside, as in the stability condition required for a univariate difference equation? It is commonly known that stability in a univariate case is achieved when the roots (\( \lambda \)) of the characteristic equation, \( \lambda^n - a_1 \lambda^{n-1} - a_2 \lambda^{n-2} \ldots - a_n = 0 \), lie inside the unit circle. Notice however that line 1 of Equation (3.7), \((l - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^p) \) is the inverse of the usual representation of the characteristic equation. Therefore, it follows that in order for the system to be stable, its roots must lie outside the unit circle.
pattern indicates instability as opposed to impulses which revert to the horizontal axis if the model is stable.

Line 4 of Equation (3.7) simplifies the equation further, where $\mu = \Phi(L)^{-1}C$ and $\Phi(L)^{-1} = \Psi(L) = (\Psi_0 + \Psi_1 L + \Psi_2 L^2 + \ldots)$. Note that in the latter, $\Psi_i$ can be estimated from $\Phi(L)(\Psi_0 + \Psi_1 L + \Psi_2 L^2 + \ldots) = I$, specifically by letting the powers of the right and left-hand sides be equal. Consider the case of a one-lag VAR model, where $(I - \Phi L)(\Psi_0 + \Psi_1 L + \Psi_2 L^2 + \ldots) = I$. Multiplying both terms on the left hand side, and then grouping the power terms on the right and left equal to each other, give:

$$L^0 : \Psi_0 = 1,$$
$$L^1 : -\Phi_1 + \Psi_1 = 0 \Rightarrow \Psi_1 = \Phi_1,$$
$$L^2 : -\Phi_1 \Psi_1 + \Psi_2 = 0 \Rightarrow \Psi_2 = \Phi_1^2,$$
$$L^3 : -\Phi_1 \Psi_2 + \Psi_3 = 0 \Rightarrow \Psi_3 = \Phi_1^3.$$

Thus, $\Psi_j = \Phi_1^j$ where $j = 1, 2, 3, \ldots$. Of course, a similar procedure can be used for a VAR model with $p$-lag (see page 18, Lütkepohl 1993).

Finally, the last line of Equation (3.7) represents the reduced form equation in the moving average form, which is expressed in terms of all current and past values of the reduced form residuals. Since the interest is on structural shocks or structural residuals, this equation can be transformed by multiplying each term by $B_0^{-1}B_0$ and noting that $U_t = B_0 \varepsilon_t$, thus giving:

$$Y_t = \mu + \Psi_0 B_0^{-1}B_0 \varepsilon_t + \Psi_1 B_0^{-1}B_0 \varepsilon_{t-1} + \Psi_2 B_0^{-1}B_0 \varepsilon_{t-2} + \ldots$$
$$= \mu + \Psi_0 B_0^{-1}U_t + \Psi_1 B_0^{-1}U_{t-1} + \Psi_2 B_0^{-1}U_{t-2} + \ldots$$
$$= \mu + \Theta_0 U_t + \Theta_1 U_{t-1} + \Theta_2 U_{t-2} + \ldots,$$

(3.8)

where $\Theta_0 = B_0^{-1}$ since $\Psi_0 = I$, and $\Theta_j = \Psi_j B_0^{-1}$ (see Zivot 2005). Equation (3.8) is now the VAR in the structural moving average form and the impulse response function can be easily calculated as:
\[
\frac{\partial Y_{t+s,j}}{\partial U_{t,j}} = \Theta_{j,i,j} \\
= \Psi_s b_j ,
\]

(3.9)

where \( b_j \) is the \( j^{th} \) column vector of \( B_{0}^{-1} \). Essentially, Equation (3.9) is the partial derivative of the \( j^{th} \) component of the \( Y_t \) vector with respect to the shock to the \( j^{th} \) component of the \( U_t \) vector at time \( t \), for \( s=0,1,2,\ldots \). Thus, the plot of impulse response for an endogenous variable summarises the partial derivatives of a structural shock at time \( t \) on that variable at time \( t+s \) for different \( s \). When \( B_0 \) is lower triangular with unity on the principal diagonal elements, the impulse response function is estimated based on the size of one unit shock. On the other hand, using Cholesky decomposition, the size of shock is measured as one standard deviation, and the impulse response function is:

\[
\frac{\partial Y_{t+s,j}}{\partial U_{t,j}} = \Psi_s b_j d_{y}^{1/2} = \Psi_s p_j ,
\]

(3.10)

where \( b_j d_{y}^{1/2} \) is the \( j^{th} \) column of \( B_{0}^{-1}d^{1/2} \), which is the same as the \( j^{th} \) column of the Cholesky matrix, \( P_j \).

To place this in perspective, using the earlier example of a bi-variate VAR model, Equation (3.8) can be depicted as:

\[
\begin{bmatrix} Y_1t \\ Y_2t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \theta_{11}^0 & \theta_{12}^0 \\ \theta_{21}^0 & \theta_{22}^0 \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} + \begin{bmatrix} \theta_{11}^1 & \theta_{12}^1 \\ \theta_{21}^1 & \theta_{22}^1 \end{bmatrix} \begin{bmatrix} u_{1t-1} \\ u_{2t-2} \end{bmatrix} + \ldots \ldots
\]

(3.11)

It follows that at time \( t+s \), the above becomes:

\[
\begin{bmatrix} Y_{1t+s} \\ Y_{2t+s} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \theta_{11}^s & \theta_{12}^s \\ \theta_{21}^s & \theta_{22}^s \end{bmatrix} \begin{bmatrix} u_{1t+s} \\ u_{2t+s} \end{bmatrix} + \ldots + \begin{bmatrix} \theta_{11}^s & \theta_{12}^s \\ \theta_{21}^s & \theta_{22}^s \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} + \ldots \ldots
\]

(3.12)

Thus, if the interest is to calculate the impulse response function of the first endogenous variable due to the impact of the second structural shock, then:
\[
\frac{\partial y_{it+s}}{\partial u_{2t}} = \theta_{12}^s.
\]

In general, the plots of the impulse response function are just the graphs of \( \theta_{ij}^s \) versus \( s \) for \( ij = 1,2 \) and \( s = 0,1,2,3 \ldots \).

### 3.3 Data

#### 3.3.1 Choice and Rationale

The basic VAR model comprises 12 variables and can be divided into two blocks – foreign (four variables) and domestic (eight variables). The foreign block comprises the commodity price index (CP) or the oil price index (OP), the US consumer price index (PUS), the US real GDP (YUS), and the US Federal Funds Rate (RUS). The commodity price index/oil price index is included to account for inflationary expectations (Sims 1992), while the US variables represent the open-economy component of the model. The selection of US variables is motivated by the work done in Grilli and Roubini (1995), Fry (2001) and Suzuki (2003). Grilli and Roubini, for example, find the inclusion of these variables help to address the price puzzle and exchange rate puzzle commonly found in empirical results associated with estimating a closed-economy VAR on a small open economy.

#### 3.3.1.1 Foreign Block

Ideally, to estimate an open-economy model, the world’s CPI, GDP and interest rates would be preferred. As a proxy, however, the US economy is chosen. This appears reasonable for Malaysia. The US economy is Malaysia’s single largest trading partner accounting for 18.8% of total exports and 14.5% of total imports.
in 2004\textsuperscript{12}. The US has been Malaysia's largest trading partner for many years, although its importance was greater in the earlier years. For example, in 1995, the US accounted for 20.7\% of Malaysia's total exports. In terms of world interest rates, the US Federal Funds Rate is used as a proxy.

To account for inflationary expectations, by far the most common commodity price indicator chosen follows Sims (1992), which is the IMF's \textit{World Export Price Index - All Exports, excluding Fuels}. Studies using this index includes Bernanke and Gertler (1995) and Barran, Courdet and Mojon (1996). Some studies have also used the oil price index, e.g., Kim and Roubini (2000) and Brischetto and Voss (1999). Others have even used the industrial/producer price index, e.g., Lown and Morgan (2002). Christiano, Eichenbaum and Evans (1999) choose what they call "an index sensitive of commodity prices (a component in the Bureau of Economic Analysis' index of leading indicators)" (page 83). However, it is generally not clear why one particular index is preferred over another. There is a possibility this is due to countries being either oil-importers or oil-exporters. Kim and Roubini (2000) study the G-7 countries which comprise both oil importing and exporting countries, while Sims (1992) also looks at a similar group of countries using a different indicator. In order to shed some light on this issue, this chapter will compare results using the commodity price index and the oil price index. (For the producer price index, work within BNM has generally found it is a poor leading indicator of inflation in Malaysia).

\subsection*{3.3.1.2 Domestic Block}

The domestic block comprises two target variables of monetary policy: CPI (PMY) and real GDP (YMY); a policy instrument/indicator of monetary policy stance chosen from: the statutory reserve requirement ratio (SRR), the overnight interbank interest rate (RON), money supply (M0, M1, M2 or M3) or the 3-month interbank interest rate (R3M); and four intermediate transmission variables: the base lending rate (BLR) for the interest rate channel, the total banking system outstanding loans (L) for the lending channel, the ringgit/US dollar exchange

\textsuperscript{12} For more details, see page 48 of BNM (2005a). As a group, Malaysia's ASEAN neighbours accounted for the largest share, representing 25.1\% and 24\% of total exports and total imports, respectively, in 2004.
rate (ER) or the nominal effective exchange rate index (NEER) for the exchange rate channel, and the Kuala Lumpur Stock Exchange Composite Index (KLCI) for the wealth or asset price channel.

The objective of monetary policy in Malaysia is to ensure sustainable economic growth with price stability. Incidentally, this objective statement is very similar to that of the US Federal Reserve of "the attainment of [the] long-run goals of price stability and sustainable economic growth". Like the US, BNM makes no formal output growth or inflation rate target announcement. Thus, both consumer prices and real output are included as target variables. In addition, four options of policy instrument will be examined because hitherto BNM has never officially announced its policy instrument. Since April 2004, BNM has adopted a new interest rate framework, whereby the Overnight Policy Rate (OPR), based on the overnight interbank interest rate, has officially become the indicator of monetary policy stance. Prior to this, however, in 1998, BNM introduced the Intervention Rate as a policy indicator, mainly to guide market sentiment amidst the highly volatile interest rate environment during the crisis period as well as to facilitate a quick economic recovery. (The latter was achieved by including the Intervention Rate as part of the computation of the BLR). The Intervention Rate was based on the 3-month interbank rate, which was the unofficial monetary policy indicator before that. The SRR ratio, which currently stands at 4% of total eligible liabilities, is also a possible candidate, as it has always been used to mop-up liquidity on a permanent basis, particularly if the Bank’s assessment shows that such a condition could lead to persistently higher inflationary expectations or contraction in the economy. SRR is also often used to complement other indirect monetary instruments. For a developing country like Malaysia, this has always been useful because of the lack in the breadth and depth of its money and bond markets. Lastly, the different monetary aggregates will also be used as a proxy

---

14 This new framework is in many ways similar to that adopted in New Zealand and Canada, where the overnight rate is guided within a corridor or band around the OPR. For more details, see the press release in April 2004 entitled "BNM Introduces New Interest Rate Framework" at http://www.bnm.gov.my.
15 The eligible liabilities are total deposits, net amount due to other domestic financial institutions/Cagamas, net instruments discounted/rediscounted under the repurchase agreements, and net negotiable instruments of deposit. This means commercial banks, finance companies, merchant banks and Islamic banks are required to maintain 4% of their eligible liabilities in the form of cash reserves with BNM.
for the policy instrument, which can be important considering Malaysia was still said to be adopting a monetary targeting framework as late as the early 1990s. In fact, this framework was said to be adopted from the 1970s as an internal platform, but there was no formal and public announcement of a monetary target (BNM 1999).

The choice of intermediate transmission variable used to proxy the interest rate channel is very much constrained by the conditions of the domestic bond market. It would be better to use an interest rate of a medium or long-dated Government bond, such as the five or 10 years Malaysian Government Securities (MGS), which would better approximate agents' capital expenditure and investment horizons. Unfortunately, a sufficiently long series is unavailable – monthly MGS yields commence only from 1995. Moreover, the infrequent and small issuances of MGS are likely to distort their true yields, thus limiting their usefulness. As demand for MGS generally outstrips supply due to the tiny pool of outstanding MGS, most holders tend to buy and hold MGS, or just hold them if they have been successful in bidding for the securities in the primary market. This condition was most apparent before the Asian crisis when the Federal Government enjoyed a long-period of budget surpluses and had no strong desire to issue too many new MGS beyond rolling-over maturing papers.

The decision to use commercial banks' average BLR appears to be the next best option. The BLR is the quoted rate to the best customers or prime rate. It may not be the actual lending rate charged to customers, which normally will be higher depending on a customer's credit risk profile. The choice of using BLR is also motivated by the significant role played by the banking system in financing economic growth. Bank loans contributed about 50% of the economy's total financing annually over the last 20 years (calculated as a percentage of total debt including private and public debt, in ringgit and foreign currencies). Naturally, this implies a crucial role can be expected of the credit channel in Malaysia. To gauge the presence of the credit channel, total outstanding loans in the banking system, including Cagamas (the national mortgage corporation) and excluding Danaharta (the asset management company set-up during the crisis to acquire and manage non-performing loans) is used. This series includes mortgages loans which may subsequently be securitised, but excludes loans.
sold to Danaharta\textsuperscript{16}. This classification corresponds to the publicly available information.

In the case of the exchange rate channel, the ringgit/USD exchange rate is used: RM to USD1. As highlighted above, given the position of the US in Malaysia's trade profile, this appears to be a reasonable proxy. Moreover, a large part of Malaysia's total trade (exports plus imports) with other countries is also denominated in US dollars. Assuming all trade with the European Union is in euros and with Japan in yen, the share of US dollars to total trade was a substantial 75\% in 2003. As a comparison, the NEER index published in the *International Financial Statistics* by the IMF is also used. The benefit of this is that it continues to vary after the fixing of the ringgit in September 1998. Then again, the NEER index should not be used as a substitute for the RM/USD exchange rate because doing so assumes the exchange rate channel was still operating post-September 1998, which was clearly not the case.

3.3.2 Data Collection and Transformations

All monthly data are converted to quarterly data by taking the average of the three months in a quarter, except for real GDP which is already a quarterly series. This is to account for all activities that occurred during the quarter instead of the activities in the last month of a quarter, which would be obtained if end-month data were used to represent the quarterly series. The sample period starts from 1979:1 to 2004:1 giving a total of 101 observations. However, in specifications involving the 3-month interbank interest rate, the sample period starts from 1981:1, coinciding with the beginning of the 3-month interbank interest rate series, yielding a total of 93 observations. All variables are transformed into natural logarithms except for the interest rates and the inflation rate which remain in percentage terms. The inflation rate is calculated from the CPI as the quarter-on-quarter percentage change and not on a preceding quarter basis. This has the distinct advantage of handling seasonality in the

\textsuperscript{16} To give a perspective of the role played by Danaharta, the company completed the acquisition of NPL with loans rights from the banking system in 2001 amounting to RM39.8 billion. This represented about 40\% of total non-performing loans in the banking system at end-2001.
series. For comparative purposes, sensitivity of the measure of the inflation rate is also conducted whereby inflation is calculated as the preceding change, but the final results are qualitatively similar (see Appendix 5-1, Chapter 5, which presents the results of the relative strength of the different transmission channels). Nonetheless, for a start, the consumer price indexes or specifically the natural logarithm of that will be used, since they are commonly adopted in many studies. For a detailed description of the variables used in this paper, refer to Appendix 3-2. Table 3.1 presents the descriptive statistics of the variables in their original forms and units. Figure 3.2 to Figure 3.9 present the plots of the variables.

Table 3.1 Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Max.</th>
<th>Min.</th>
<th>Std. Dev.</th>
<th>Skewness²</th>
<th>Kurtosis³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Block</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP (Index)</td>
<td>82.04</td>
<td>80.85</td>
<td>103.00</td>
<td>65.00</td>
<td>9.40</td>
<td>0.44</td>
<td>2.44</td>
</tr>
<tr>
<td>OP (Index)</td>
<td>127.49</td>
<td>113.85</td>
<td>216.80</td>
<td>67.70</td>
<td>36.84</td>
<td>0.34</td>
<td>1.93</td>
</tr>
<tr>
<td>PUS (Index)</td>
<td>90.63</td>
<td>92.05</td>
<td>121.27</td>
<td>57.70</td>
<td>18.86</td>
<td>-0.04</td>
<td>1.72</td>
</tr>
<tr>
<td>YUS (US$ b)</td>
<td>7.605</td>
<td>7.334</td>
<td>10.600</td>
<td>5.177</td>
<td>1.597</td>
<td>0.21</td>
<td>1.89</td>
</tr>
<tr>
<td>RUS (%)</td>
<td>6.56</td>
<td>5.85</td>
<td>17.81</td>
<td>1.00</td>
<td>3.44</td>
<td>1.07</td>
<td>4.75</td>
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<tr>
<td>Domestic Block</td>
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<td></td>
<td></td>
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<tr>
<td>PMY (Index)</td>
<td>79.27</td>
<td>77.34</td>
<td>104.77</td>
<td>54.71</td>
<td>15.62</td>
<td>0.24</td>
<td>1.62</td>
</tr>
<tr>
<td>YMY (RM m)</td>
<td>4.037</td>
<td>31.573</td>
<td>60.296</td>
<td>4.871</td>
<td>14.181</td>
<td>0.23</td>
<td>1.55</td>
</tr>
<tr>
<td>M0 (RM m)</td>
<td>27.771</td>
<td>23.902</td>
<td>79.899</td>
<td>7.003</td>
<td>19.167</td>
<td>0.78</td>
<td>2.80</td>
</tr>
<tr>
<td>M1 (RM m)</td>
<td>38.471</td>
<td>28.043</td>
<td>99.356</td>
<td>10.281</td>
<td>25.906</td>
<td>0.59</td>
<td>2.04</td>
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<tr>
<td>M2 (RM m)</td>
<td>161.939</td>
<td>105.693</td>
<td>421.739</td>
<td>29.287</td>
<td>125.512</td>
<td>0.64</td>
<td>1.87</td>
</tr>
<tr>
<td>M3 (RM m)</td>
<td>215.335</td>
<td>147.655</td>
<td>546.184</td>
<td>34.153</td>
<td>166.054</td>
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<td>SRR (%)</td>
<td>6.37</td>
<td>5.00</td>
<td>13.50</td>
<td>3.50</td>
<td>3.12</td>
<td>1.18</td>
<td>3.02</td>
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<tr>
<td>RON (%)</td>
<td>5.50</td>
<td>5.88</td>
<td>10.83</td>
<td>2.19</td>
<td>2.19</td>
<td>0.09</td>
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<td>R3M (%)</td>
<td>6.45</td>
<td>7.03</td>
<td>12.04</td>
<td>2.73</td>
<td>2.54</td>
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<td>BLR (%)</td>
<td>8.45</td>
<td>8.22</td>
<td>12.25</td>
<td>6.00</td>
<td>1.70</td>
<td>0.61</td>
<td>2.30</td>
</tr>
<tr>
<td>L (RM m)</td>
<td>198.058</td>
<td>147.024</td>
<td>448.416</td>
<td>27.300</td>
<td>148.519</td>
<td>0.47</td>
<td>1.56</td>
</tr>
<tr>
<td>ER (RM/USD)</td>
<td>2.88</td>
<td>2.61</td>
<td>4.06</td>
<td>2.26</td>
<td>0.59</td>
<td>0.90</td>
<td>2.05</td>
</tr>
<tr>
<td>NEER (Index)</td>
<td>97.34</td>
<td>98.44</td>
<td>126.89</td>
<td>75.86</td>
<td>14.09</td>
<td>0.36</td>
<td>2.28</td>
</tr>
<tr>
<td>KLCI (Index)</td>
<td>602.04</td>
<td>573.24</td>
<td>1230.16</td>
<td>193.30</td>
<td>273.11</td>
<td>0.56</td>
<td>2.35</td>
</tr>
</tbody>
</table>

Notes:
1 For ease of comparison, the sample period starts from 1981:1 to 2004:1.
2 Positive skewness implies a distribution with long-right tail and negative skewness, long-left tail. Normal distribution has a skewness of nought.
3 Normal distribution has a kurtosis of 3. If kurtosis is greater than 3, the distribution has a higher peak, less than 3, a lower peak.
Figure 3.2 Malaysian Interbank Interest Rates and US Fed Funds Rates (%)

Figure 3.3 BLR and SRR (%)

Figure 3.4 RM/USD and NEER Index

Figure 3.5 CP and OP Indexes

Figure 3.6 Loans Outstanding and Monetary Aggregates (RM million)

Figure 3.7 Real GDP (RM million) and CPI
Most of the data used are already seasonally adjusted. The official Malaysian real GDP is not seasonally adjusted and is highly seasonal, especially in the fourth quarter due to major festivities and school holidays. To account for seasonality, two methods are considered: using seasonal dummies in the VAR estimation; or seasonally adjusting the series first via a filter based method such as the simple moving average or the popular Census-X11, before including it in the VAR estimation. Since most of the data are already seasonally adjusted, the second approach is adopted for practical convenience – this avoids the need to include only seasonal dummies in the real GDP equation, and not in other equations. Both the simple moving average method and the Census-X11 are tried and both give very similar results as can be seen in Figure 3.10. As such, the real GDP series used hereafter is based on seasonal adjustment via the latter method.

3.4 Estimation Issues

3.4.1 Choice of Ordering of Variables

The main estimation issue that relates to the use of the Cholesky decomposition is the choice of ordering of variables. Being a lower triangular matrix, the Cholesky decomposition imposes a strictly recursive contemporaneous structure on the VAR system. Put simply, if there are three variables in the system with the following ordering: PMY, YMY and R3M, this means R3M is contemporaneously influenced by PMY and YMY, while YMY is only contemporaneously influenced by PMY. All variables are influenced by the lags of the complete set of variables in the system. Thus, any impact of YMY and R3M on PMY would appear after one lag. The simplicity of this ordering, which solves the identification problem, is the main strength of the Cholesky method. It is of course also its main weakness as results may differ if different orderings are used as will be evident in the next section.

Attempts to improve this have involved imposing non-recursive zero restrictions based loosely on economic theory. Nonetheless, the Cholesky method remains popular because it is a method that literally lets the data do the talking, and with results that are largely consistent with economic predictions. Christiano, Eichenbaum and Evans (1999) comprehensively summarise the common agreements on the qualitative impact of an exogenous monetary policy shock on the US economy. The Cholesky method as applied to an open-economy is not as common as the one that applies to a closed-economy. Studies which estimate an open-economy model have often tended to follow a more structural approach, e.g., Cushman and Zha (1997), Kim and Roubini (2000), and Dungey and Pagan (2000). Eichenbaum and Evans (1995), Grilli and Roubini (1995), and Suzuki (2003) have used the recursive assumption on an open-economy model. Table 3.2 summarises the ordering schemes adopted by studies in their key VAR models with a recursive identification assumption.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Ordering</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernanke and Blinder (1992)</td>
<td>Fed Funds rate, unemployment, CPI, real deposits, real securities, and real loans.</td>
<td>To study the bank lending channel as per their 1988 model.</td>
</tr>
<tr>
<td>Sims (1992)</td>
<td>Interest rate, exchange rate, commodity price index, money, CPI and real GDP.</td>
<td>To examine the effects of monetary policy actions in France, Germany, Japan, the UK and the US.</td>
</tr>
<tr>
<td>Ramey (1993)</td>
<td>Industrial Production Index, M2 velocity, bank lending velocity and monetary policy indicator (Fed Fund and Boschen-Mills Index).</td>
<td>To study the relative importance of the bank lending channel versus the money channel.</td>
</tr>
<tr>
<td>Bernanke and Gertler (1995)</td>
<td>Real GDP, GDP deflator, commodity price index, and Fed Funds rate.</td>
<td>To provide evidence that the credit channel supplements the interest rate channel as the important conduit in transmitting monetary policy actions.</td>
</tr>
<tr>
<td>Eichenbaum and Evans (1995)</td>
<td>Real GDP, CPI, ratio of non-borrowed reserves to total reserves (policy indicator), the difference of foreign and domestic interest rates, and the real exchange rate.</td>
<td>To investigate US monetary policy shocks on exchange rates.</td>
</tr>
<tr>
<td>Grilli and Roubini (1995)</td>
<td>Domestic industrial production, domestic CPI, US industrial production, US short-term interest rate, domestic interest rate, money and exchange rate.</td>
<td>To study the liquidity effects in open economies particularly to examine the exchange rate puzzle in selected countries.</td>
</tr>
<tr>
<td>Barran, Courdet and Mojon (1996)</td>
<td>Real GDP, CPI, exchange rate, world export price index and interest rate (policy rate). When the intermediate transmission variables are included: real GDP, CPI, world price index, exchange rate, credit, long-term bond yield and interest rate.</td>
<td>To study the differences in monetary policy transmission across a group of European countries.</td>
</tr>
<tr>
<td>Levy and Halikias (1997)</td>
<td>Interest rate, nominal effective exchange rate, loans, bond yield, monetary aggregates, CPI and real GDP.</td>
<td>To examine the impact of monetary policy transmission in France, particularly the impact of the four key transmission variables of exchange rate, credit, long-term bond yield and monetary aggregates.</td>
</tr>
<tr>
<td>Ramaswamy and Sloek (1997)</td>
<td>Real GDP, CPI, short-term interest rate.</td>
<td>To study the impact of monetary policy shocks on a group of European countries.</td>
</tr>
<tr>
<td>Christiano, Eichenbaum and Evans (1999)</td>
<td>Real GDP, CPI, commodity price, Fed Funds rate, total reserves (TR), non-borrowed reserves</td>
<td>Among other objectives, to examine the impact of an exogenous monetary policy shock on the economy based</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Ordering</td>
<td>Objective</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Morsink and Bayoumi (2001)</td>
<td>(NBR) and money (M1 or M2). Two other ordering schemes are also examined: Same as above but with NBR becoming the policy instrument and ordered ahead of TR; and Same as above but with the ratio of NBR/TR being the policy instrument (NBR and TR do not exist on their own anymore).</td>
<td>To study the mechanics of monetary policy transmission in Japan.</td>
</tr>
<tr>
<td>Lown and Morgan (2002)</td>
<td>Private demand, CPI, interest rate and broad money.</td>
<td>To study the credit effects of the monetary policy transmission in terms of credit standards.</td>
</tr>
</tbody>
</table>

What can essentially be gleaned from the above is that there does not seem to be any consensus in the ordering of variables, which is understandable considering the different objectives different models are formulated to achieve. On the one hand, there is the Bernanke and Blinder (1992), and Sims' (1992) approach of putting interest rates and other financial variables ahead of the real variables. The rationale is that the information lags in real variables preclude policymakers from using real variables in the current period. For instance, if a central bank decides to hike the interest rate today, it cannot make a decision based on the present GDP number because this information is simply not available. This argument is less persuasive in studies using quarterly data, since policymakers are more likely to have a better idea of what the current quarter GDP is going to be (at least through some estimates) compared with studies using monthly data. Another rationale argued by Levy and Halikias (1997) is that since the objective is to study the impact of monetary policy shocks on the real variables via the intermediate transmission variables, the ordering should be to place the interest rate first, followed by the intermediate transmission variables and finally, the real target variables. On the other hand, there is another set of ordering which places interest rates last (Barran, Courdet and Mojon (1996)); the authors assume monetary policy decisions are made after taking into account the real variables.
account all the information contained in other variables in the model. They contend this can be justified on the grounds of “convex adjustment costs, building and delivery lags, menu costs and time dependent rules” (page 15) or in short, the effects of monetary policy actions take time to filter through the economy. The majority of the other studies place the interest rate or other policy instruments somewhere in between the two extremes.

Knowing where to place the policy instrument only solves one part of the problem. A further complication arises as to where to position the rest of the financial variables and the real variables within their own sub-groups. For example, should money come before the policy instrument or after; if the transmission variables are placed after the policy instrument, should the BLR be ordered before the exchange rate or after; should the CPI comes before the real GDP or after. Alas, none of the studies surveyed provide any details on how these decisions are made. Coincidentally, studies which have also tried different ordering schemes tend to provide evidence in favour of the results from their original ordering arrangements; qualitatively their overall results do not change even with a different ordering scheme. Morsink and Bayoumi (2001) reverse their initial ordering by placing the financial variable ahead of the real variables: money, interest rate, CPI and real GDP; and Grilli and Roubini (1995) place US related variables ahead of other domestic variables: US industrial production, US short-term interest rate, domestic industrial production, domestic CPI, domestic interest rate, money and exchange rate. Both conclude their findings do not differ much as a result of the different ordering.

The basic philosophy of ordering adopted here is in the spirit of Cushman and Zha (1997) and, later, by Dungey and Pagan (2000), Fry (2001) and Suzuki (2003) for an open-economy, which outline a foreign block influencing the domestic block contemporaneously but not the opposite – variables in the foreign block are ordered ahead of the variables in the domestic block. Strictly speaking, in the studies adopting a SVAR methodology, this means the domestic variables do not appear either contemporaneously or in lagged terms in the foreign block equations. In contrast, as in the recursive approach used here, variables in the domestic block do influence the foreign variables, but only
through the lags of the model. (The former is also estimated but the results are not vastly different (see Section 4.2.3, Chapter 4)).

For a start, the preliminary ordering scheme adopted is as follows:

![Figure 3.11 Preliminary Ordering Scheme](image)

<table>
<thead>
<tr>
<th>Foreign Block</th>
<th>Domestic Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, PUS, YUS, RUS</td>
<td>PMY, YMY, M3, R3M, ER, KLCI, BLR, L</td>
</tr>
</tbody>
</table>

The commodity price index (CP) is placed ahead of the rest with the view that it is contemporaneously exogenous to both US and Malaysian influences. Notice that in both blocks, interest rates are ordered after prices and real GDP, and after money, in the case of Malaysia. The rationale for this is to establish a simplified form of monetary feedback equation whereby the interest rate decision is made based on the contemporaneous availability of prices, real GDP and money information. The choice to order prices ahead of real GDP seems arbitrary. Suzuki (2003) justifies this on the basis that prices are assumed to be sluggish and hence should be placed ahead of other domestic variables – other variables only affect prices after a lag. Other studies (see Table 3.2) have tended to place real GDP ahead of prices. Encouragingly, reversing the order between the two does not qualitatively change the results.

The ordering of the intermediate transmission variables in the domestic block follows the information lags and institutional structure arguments. Exchange rate and stock prices should instantaneously react to monetary policy shocks because they are prices traded in large and liquid markets where up-to-the-minute price information is available. Because of institutional rigidity in the banking system, the base lending rate (BLR) is expected to react more slowly, and even more so for bank loans (L). Placing the exchange rate (ER) ahead of the stock prices (KLCI) is justified on the grounds that the foreign exchange market is basically a 24-hour market, while trading in Malaysian stocks is not, which means the ringgit exchange rate is practically obtainable at any time.
throughout the day. Nonetheless, it is still interesting to compare the results for the case where BLR and L are ordered ahead of ER and KLCI.

As alluded to above, several changes to the preliminary ordering scheme will be investigated in the next chapter. These include:

i. To compare the importance of CP vis-à-vis OP;

ii. To compare the difference between ER and NEER, which will be particularly interesting since the former has been fixed since September 1998;

iii. To compare the importance of other candidates for policy instruments namely, SRR, RON and the various monetary aggregates;

iv. To check for robustness in the ordering of the domestic block when the order is completely reversed, and when only the order among the intermediate transmission variables is reversed; and

v. To check whether a scaled-down open economy model is adequate.

### 3.4.2 Crisis Dummy

To account for the Asian crisis and a possible structural break during the period, a dummy is initially used for the four quarters in 1998, the year when the full brunt of the crisis was felt by the real economy. However, the addition of the crisis dummy in the VAR system as an exogenous variable resulted in the model being unstable — the plots of the impulse responses become explosive. These results are quite unexpected because the Chow test performed on individual series at two separate dates, 1998:1 and 1998:4, conclusively support the presence of structural breaks in all variables (the results are not presented). These tests are based on regressing each variable on a constant term and a time trend. In addition, dummy variables for the above two dates and for the whole of 1998 are each separately included into the above specification, and t-tests based on the Newey-West corrected standard errors are performed on the dummy variables. Again, the results are supportive of structural breaks at 1998:1, 1998:4 and the whole of 1998, except for real GDP. However, the seasonised real GDP do exhibit structural breaks at 1998:1 and 1998:4.
Since the model is unstable, an alternative crisis dummy has to be identified. One possibility is to choose a new dummy that covers the period from the start of the crisis until the introduction of the capital controls, that is, from 1997:3, to 1998:3. The selection of this period appears reasonable because it encompasses the adjustments in both the faster-moving financial variables as well the slower-moving real variables. Taking the exchange rate as an example of a fast-moving financial variable, the first large depreciation of the ringgit occurred in 1997:3, and this continued into the rest of the year. By 1998:1, the ringgit had stabilised somewhat, but true stability was only achieved subsequent to its pegging in 1998:3. In contrast, real GDP, a slow-moving real variable, only fell most noticeably in the first three quarters of 1998. Using this new dummy, labelled CRISIS97, the plots of impulse responses show the system is stable. Therefore, in all subsequent estimations, CRISIS97 will be included as an explanatory variable.

3.4.3 Lag Order Selection

Typically, reliance is placed on the information criteria of Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQC), these being the most popular model selection criteria. This chapter adopts these criteria to choose between alternative VAR specifications of the Malaysian economy. Table 3.3 shows the lag order selection results for lag specifications of up to four lags. Both the SIC and HQC recommend a one-period lag, while the AIC recommends a four-period lag. Examining the plots of the impulse responses of all other variables to the interest rate shock highlights that there is more variability in the case of the four-period lag model exhibit an explosive oscillating path, thus ruling out the four-period lag model. In addition, many of its impulse responses do not conform to economic predictions (see Appendix 3-3).

As such, the one-period lag order seems to be a reasonable choice. Moreover, it is consistent with the work done by Ivanov and Killian (2003) who advocate the use of SIC for quarterly data of less than 120 observations. Nonetheless, on a practical note, a one-period lag is unlikely to account for much of the dynamics of the variables, and evidently the impulse responses of the one-period model
are much smoother. Diagnostic checks on the one-period lag VAR reveal the reduced form residuals are autocorrelated at one, two and three lags at the 5% level of significance, but they are homoscedastic.\textsuperscript{18} With a two-period lag model, the system is only autocorrelated at the first lag, and continues to be homoscedastic. On the basis of these findings, the VAR models estimated hereafter will be made up of two lags.

\begin{table}[h]
\centering
\begin{tabular}{llll}
\hline
Lag & AIC & SC & HQC \\
\hline
0 & -17.98 & -17.31 & -17.71 \\
1 & -47.52 & -42.82* & -45.63* \\
2 & -48.27 & -39.54 & -44.75 \\
3 & -48.79 & -36.04 & -43.65 \\
4 & -51.17* & -34.38 & -44.40 \\
\hline
\end{tabular}
\end{table}

Notes:
* Indicates the lag order selected by the criterion. The criteria are based on Chapter 4, Lütkepohl (1993).

\textbf{3.4.4 Non-stationarity}

Most students in time-series econometrics learn when variables in a VAR model are found to be non-stationary and cointegrated, the model should be estimated as a vector error correction model (VECM) rather than at levels. And if the variables are only non-stationary but not cointegrated, then first differences would suffice. Nonetheless, in this thesis, the VAR models are estimated at levels, in the spirit of other studies focusing on the same issue of monetary policy transmission mechanism. In fact, it is not entirely wrong to do so. As Engle and Granger (page 259, 1987) point out:

\textit{"[VARs] estimated with co-integrated data will be misspecified if the data are differenced, and will have omitted important constraints if the data are used in levels. Of course, these constraints will be satisfied asymptotically but efficiency and improved multistep forecasts may be achieved by imposing them."}

\textsuperscript{18} The tests used are the Autocorrelation LM Test and the White Heteroscedasticity Test (with no cross terms), respectively. The results for the two-lag model are in Appendix 3-4. These tests are similar to the tests applied to a univariate context. The no cross terms in the White Test refer to the additional regressors being included which only appear at levels and squares, but not the cross products of each other. For more details, refer to pages 360-363 and pages 505-508 of \textit{EViews4 User's Guide}. 

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This says that if the variables are non-stationary but cointegrated, it is still feasible to estimate VARs in levels because the estimates are still consistent asymptotically, while first differencing will lead to model misspecification. Moreover, given the objective here is not to study the long-run dynamics of variables or for forecasting, it would make less sense to embark on the VECM route. This debate between the different estimation approaches in the context of the study of monetary policy transmission mechanism are succinctly summarised by Ramaswamy and Sloek (1997, page 13)

"If cointegration exists, and the true cointegrating relationship is both known and can be given an economic interpretation, the VAR should be estimated using the [VECM] with the reduced rank estimation suggested by Johansen (1995). However, if the true cointegrating relationships are unknown, and furthermore, when the relationships are the main focus of the analysis, then imposing cointegration may not be the appropriate estimation strategy. Imposing inappropriate cointegration relationships can lead to biased estimates and hence bias the impulse-responses derived from the reduced form VARs. In the cases, where there is no a priori economic theory which can suggest either the number of long-run relationships or how they should be interpreted ..., it is reasonable not to impose the restriction on the VAR model".

To test for unit root, the Augmented Dickey-Fuller (ADF) test is performed with two different specifications, one with just the intercept term and the other which includes the intercept term and a time trend. In addition, to account for the impact of the Asian crisis and as an extra robustness check, the tests are carried out in two periods: full-sample and pre-crisis sample (1981:1 to 1997:1). On the whole, the results show most series are 1(1) across the two sample periods at the conventional 5% level of significance (Table 3.4). The only exceptions are the US interest rates which are stationary at the 1% level depending on the type of specification, and RON and R3M (in the pre-crisis sample only) but at the 5% level.

19 Interested readers on this debate should also refer to Sims, Stock and Watson (1990), Chapter 11 of Lütkepohl (1993) and pages 650-651 of Hamilton (1994).
Table 3.4 Unit Root Tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Full Sample</th>
<th>Pre-Crisis Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>Intercept &amp; Trend</td>
</tr>
<tr>
<td>CP</td>
<td>-2.63</td>
<td>-2.85</td>
</tr>
<tr>
<td>OP</td>
<td>-2.83</td>
<td>-1.53</td>
</tr>
<tr>
<td>PUS</td>
<td>-1.51</td>
<td>-1.67</td>
</tr>
<tr>
<td>YUS</td>
<td>-0.50</td>
<td>-3.35</td>
</tr>
<tr>
<td>RUS</td>
<td>-1.32</td>
<td>-4.37*</td>
</tr>
<tr>
<td>PMY</td>
<td>-0.93</td>
<td>-3.27</td>
</tr>
<tr>
<td>YMY2</td>
<td>-0.66</td>
<td>-1.49</td>
</tr>
<tr>
<td>M0</td>
<td>-1.11</td>
<td>-1.62</td>
</tr>
<tr>
<td>M1</td>
<td>-0.01</td>
<td>-2.72</td>
</tr>
<tr>
<td>M2</td>
<td>-0.32</td>
<td>-3.42</td>
</tr>
<tr>
<td>M3</td>
<td>-1.05</td>
<td>-2.09</td>
</tr>
<tr>
<td>SRR</td>
<td>-1.67</td>
<td>-1.56</td>
</tr>
<tr>
<td>RON</td>
<td>-2.36</td>
<td>-2.86</td>
</tr>
<tr>
<td>R3M</td>
<td>-2.72</td>
<td>-3.42</td>
</tr>
<tr>
<td>BLR</td>
<td>-2.03</td>
<td>-2.67</td>
</tr>
<tr>
<td>L</td>
<td>-1.77</td>
<td>-2.86</td>
</tr>
<tr>
<td>ER</td>
<td>-1.26</td>
<td>-2.58</td>
</tr>
<tr>
<td>NEER</td>
<td>-1.28</td>
<td>-3.01</td>
</tr>
<tr>
<td>KLCI</td>
<td>-1.64</td>
<td>-2.56</td>
</tr>
</tbody>
</table>

Notes:
1. * and ** refer to the 1% and 5% level of significance respectively. Lag differences included in the tests are chosen automatically based on the AIC.
3. Refers to the seasonally adjusted real GDP series.
4. The test statistic when a structural break in 1987:1 is incorporated is -3.12 and statistically significant at the 5% level.

To test for cointegration, the Johansen (1995) trace tests are carried out. For robustness, checks are performed involving different specifications of the model, different assumptions on the deterministic term and different sample periods. A lag of two is chosen in order to be consistent with subsequent analyses. (Nonetheless, the cointegration tests are also conducted with the optimal lag chosen by the standard information criteria). Table 3.5 clearly shows there are more than one cointegrating relations in the model. These findings are robust across the different types of specifications, different assumptions on the deterministic term, different sample periods and the choice of lags. Several general observations can be gleaned. Both the assumptions of intercept, and

---

20 The Johansen cointegration/trace tests are performed in JMulti. In JMulti, the assumption of constant in the deterministic term means intercept in the cointegrating relations but not in VAR; for constant and trend, it means an intercept term and a linear trend term in the cointegrating relations but no linear trend in VAR; and for orthogonal trend, it means an intercept term in the cointegration relations and a linear trend term in VAR. For more details see its help menu or the book accompanied the software by Lutkepohl and Kratzig (2004).
intercept and linear trend give essentially a similar number of cointegration relations, while the orthogonal trend assumption gives a slightly lower number. However, when the optimal lag is chosen, the number of cointegrating relations increases. In VAR1, when consumer prices are measured as an index, the number of cointegrating relations is higher than in VAR2, when prices are measured as inflation rate. Note that even if one had decided to estimate via VECM, and if conservatively five cointegrating relations were thought to exist, it would be a tough challenge to come out with five different economic theories which support these relationships especially when they also involve the US variables.
<table>
<thead>
<tr>
<th>Model</th>
<th>r=0</th>
<th>r=1</th>
<th>r=2</th>
<th>r=3</th>
<th>r=4</th>
<th>r=5</th>
<th>r=6</th>
<th>r=7</th>
<th>r=8</th>
<th>r=9</th>
<th>r=10</th>
<th>r=11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Full</strong></td>
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<tr>
<td>VAR1</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>626*</td>
<td>497*</td>
<td>388*</td>
<td>305*</td>
<td>233*</td>
<td>169*</td>
<td>124*</td>
<td>87*</td>
<td>56**</td>
<td>30</td>
<td>11</td>
<td>0.8</td>
</tr>
<tr>
<td>Intercept &amp; Trend</td>
<td>643*</td>
<td>528*</td>
<td>421*</td>
<td>332*</td>
<td>253*</td>
<td>190*</td>
<td>141*</td>
<td>98*</td>
<td>67**</td>
<td>39</td>
<td>15</td>
<td>0.3</td>
</tr>
<tr>
<td>Orthogonal Trend</td>
<td>566*</td>
<td>452*</td>
<td>346*</td>
<td>264*</td>
<td>201*</td>
<td>149*</td>
<td>104*</td>
<td>72**</td>
<td>44</td>
<td>20</td>
<td>2.2</td>
<td>n.a.</td>
</tr>
<tr>
<td>Optimal Lag=6</td>
<td>1904*</td>
<td>1272*</td>
<td>987*</td>
<td>759*</td>
<td>561*</td>
<td>410*</td>
<td>284*</td>
<td>196*</td>
<td>117*</td>
<td>57*</td>
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<td>383*</td>
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<td>388*</td>
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<td>253*</td>
<td>199*</td>
<td>150*</td>
<td>104**</td>
<td>61</td>
<td>37</td>
<td>19</td>
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<tr>
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<td>319*</td>
<td>245*</td>
<td>174*</td>
<td>113*</td>
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Notes:
1. The trace statistics are shown.
2. * and ** refer to the 1% and 5% level of significance respectively. An asterisk at $H_0: r=0$ means the rejection of the null hypothesis that there is no cointegrating relations in the system; alternatively, the acceptance of one or more cointegrating relations in the system.
3. VAR1 refers to VAR of the following variables: CP, PUS, YUS, RUS, PMY, YMY, M1, R3M, ER, KLCI, BLR, L and an Asian financial crisis dummy. Again YMY here refers to seasonally adjusted real GDP.
4. VAR2 is essentially the same as VAR1 with consumer price indexes in both the US and Malaysia replaced by their inflation rates. This is chosen as this specification will remain the core of subsequent analyses.
5. This assumes that there is a linear trend in the series but not in the cointegration relations.
6. Optimal lag is chosen based on the AIC, HQC and SC. The results presented are for orthogonal trend.

n.a. Not applicable.
3.5 Conclusions

In this chapter, the foundation for an open-economy version of the monetary policy transmission mechanism VAR model for Malaysia is established. The preliminary specification chosen incorporates variables which are thought to address such empirical anomalies like the price and exchange rate puzzles. In other words, the choice of variables and their orderings are motivated by the "best practices" in this line of research. The preliminary ordering scheme is: the commodity price index (CP), the US CPI (PUS), the US real GDP (YUS), the US Federal Funds Rate (RUS), Malaysian CPI (PMY), real GDP (YMY), M3, 3-month interbank interest rate (R3M), the ringgit/US dollar exchange rate (ER), Kuala Lumpur Composite Index (KLCI), base lending rate (BLR) and bank loans (L). In the same spirit, by appealing to the consistency property of parameter estimates, the model will be estimated in levels despite having non-stationary and cointegrated variables. The period covered in the study spans mostly from 1981:1 to 2004:1, coinciding with the beginning of the series on the 3-month interbank interest rate. Chapter 4 will present empirical results of various specifications based on this preliminary ordering scheme with the view of finding a suitable VAR model for Malaysia.
Appendix 3-1 Dornbusch Model of Exchange Rate Overshooting (Dornbusch 1976, Hoy et al. 2001)

The model shows how price and exchange rate change as the money supply changes. They are two markets in the model. First, the asset market, where there are two equations: a money demand function that is equal to the real money supply; and the uncovered interest rate parity (UIP) condition, where the domestic interest rate is equal to the foreign interest rate, plus the expected depreciation of the domestic currency. (Exchange rate is defined as domestic currency per foreign currency. Economic agents are assumed to have perfect foresight so that expected and actual depreciation is the same).

The second is the goods market, which provides the dynamics of prices. Prices are assumed to be sticky. The inflation rate is determined by the difference between the aggregate demand and aggregate supply. Aggregate demand is determined by a constant and the relative price of goods. Aggregate supply is fixed.

An unexpected increase in money supply shifts the exchange rate isocline upwards as domestic currency depreciates. The price isocline does not adjust and besides, since prices are sticky, the real economy takes time to move to a new equilibrium. With exchange rate adjusting instantaneously and given the economy has to be on the saddle path in order for it to reach the new long-run equilibrium, the instantaneous adjustment in the exchange rate has to overshoot – it has to depreciate more than the long-run equilibrium level of exchange rate. However, over time as prices adjust (increase), the exchange rate will appreciate and move towards the long-run equilibrium level of exchange rate. In the immediate short-run, all adjustments occur in the asset market, as financial prices are fully flexible, while in the longer-run, adjustments will take place in the real economy.

Why overshooting? In summary, two important assumptions must be noted. First, asset prices can adjust instantaneously. Second, aggregate output is fixed in the short-run and prices are sticky. Intuitively, an expansionary money supply implies a lower value of that currency in the long-run (the currency will
depreciate based on the purchasing power parity (PPP) since prices will rise in the long-run). This is a long-run equilibrium outcome. In the near future however, UIP applies. This means the country with a lower interest rate should see its currency appreciate in the not too distant future. Amidst these theoretical underpinnings, it must be noted that in the immediate instance after an expansionary money policy, and hence a decline in interest rates, the currency of that country is expected to depreciate as capital flows out to search for higher returns elsewhere. The most important aspect of the overshooting phenomenon: since PPP should hold in the long-run steady state and UIP in the short-run, the initial and immediate response of the exchange rate has to be an overshooting beyond the long-run equilibrium level so that an appreciation could subsequently occur (as advocated by UIP) to move the exchange rate level back to the long-run equilibrium level.

Also prices will rise over time as the sharp drop in the currency spurs exports while dampening imports and with aggregate supply being fixed, these create excess demand in the economy leading to higher prices.
## Appendix 3-2 Data Description and Sources

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>Codes</th>
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<tbody>
<tr>
<td>Commodity Price Indexes and US data (Datastream)</td>
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<tr>
<td>CP¹</td>
<td>Commodity Price Index: World Export Price Index – All Exports, excluding Fuels, not adjusted – discontinued.</td>
<td>WDI76AXDF</td>
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<tr>
<td></td>
<td>World Export Price – Non Fuel Primary Commodities Index, not adjusted</td>
<td>WDI76NFDF</td>
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<tr>
<td>OP</td>
<td>Oil Price Index: World Market Price Index - Crude Petroleum, not adjusted</td>
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<tr>
<td>PUS</td>
<td>US Consumer Price Index: US CPI seasonally adjusted</td>
<td>USOCP009E</td>
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<tr>
<td>YUS</td>
<td>US Real Gross Domestic Product: US GDP, constant prices, seasonally adjusted (US$ billion)</td>
<td>USGDP...D</td>
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<td>RUS</td>
<td>US Federal Funds Rate (%)</td>
<td>USFEDFUN</td>
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<td>Malaysian data (BNM, Monthly Statistical Bulletin)</td>
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<td>PMY</td>
<td>Consumer Price Index (2000=100)</td>
<td>Table VI.12</td>
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<tr>
<td>YMY²</td>
<td>Real Gross Domestic Product (RM million)</td>
<td>Table VI.2</td>
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<tr>
<td>M0</td>
<td>Reserve Money (RM million)</td>
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<td>M1</td>
<td>Monetary Aggregate, M1 (RM million)</td>
<td>Table II.3</td>
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<tr>
<td>M2</td>
<td>Monetary Aggregate, M2 (RM million)</td>
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<td>M3</td>
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<tr>
<td>SRR</td>
<td>Statutory Reserve Requirement Ratio</td>
<td>Table III.26</td>
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<tr>
<td>RON</td>
<td>Average Overnight interbank interest rate (%)</td>
<td>Table V.3</td>
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<tr>
<td>R3M</td>
<td>Average 3-month interbank interest rate (%)</td>
<td>Table V.3</td>
</tr>
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<td>BLR</td>
<td>Average Base Lending Rate of Commercial Banks (%)</td>
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<td>L</td>
<td>Total Loans Outstanding in the Banking System, including Cagamas, excluding Danaharta (RM million)</td>
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<td>ER</td>
<td>Average Exchange Rate: RM/USD eg., RM3.80=1USD</td>
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<td>NEER</td>
<td>Nominal Effective Exchange Rate Index, seasonally adjusted (IMF International Financial Statistics)</td>
<td>MYI..NECE</td>
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<td>KLCI</td>
<td>The Kuala Lumpur Stock Exchange Composite Index</td>
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Notes:
1. The first series was discontinued at end-2002. In order to have a consistent series, data since then are obtained from the second series, whereby its growth rate (based on the preceding period percentage change) is used to extend the first series.
2. Officially, quarterly real GDP series starts from 1987. Data prior to that are based on the work by Abeyesinghe and Rajaguru (2004), who apply the Chow-Lin related series technique on the annual real GDP to obtain quarterly real GDP series. They are obtainable from http://courses.nus.edu.sg/course/ecstabey/gdpdata.xls. However, since the data use 1978 as a base instead of the current real GDP series which uses prices in 1987 i.e., the two sets of data are not the same, the quarter-on-quarter percentage changes from their data are used to derive the real GDP series prior to 1987 based on the existing official real GDP numbers.
Appendix 3-3 IRF of Variables to R3M Shock with Lag Order of Four

Notice in particular that there is a distinct price puzzle and a negligible impact on real GDP initially. And more noticeably, a shock to R3M leads to higher real GDP after six quarters. Money supply also increases with a shock to R3M.
Appendix 3-4 Test Results of Autocorrelation and Heteroscedasticity for the Two-Period Lag VAR

VAR Residual Serial Correlation LM Tests
Ho: no serial correlation at lag order h

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<tr>
<td>4</td>
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Probs from chi-square with 144 df.

VAR Residual Heteroscedasticity Tests: No Cross Terms (only levels and squares)

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Chapter 4
A VAR Model for Malaysia:
Empirical Results

Building on the materials from the previous chapter, this chapter aims to identify a suitable VAR specification for Malaysia. First, however, it is important to establish the appropriate variable to account for inflationary expectations to handle the potential price puzzle. Also, since BNM makes no formal announcement, it is worthwhile to examine the suitability of alternative variables as an indicator of the monetary policy stance besides the unofficial 3-month interbank interest rate. Only after having addressed these issues, attention is directed towards identifying an appropriate model. Thus, results in this chapter are presented based on a bottom-up approach.

Section 4.1 shows the preliminary results based on the initial ordering scheme as identified in Chapter 3 (this will be shown in detail below). From here, puzzling results are identified and efforts will be made to address them. These include replacing the commodity price index with the oil price index, investigating other potential candidates for the monetary policy stance and testing the sensitivity of results with respect to a different measure of the exchange rate. An attempt will also be made to explain the exchange rate puzzle which is only found when the 3-month interbank rate is chosen as the monetary policy instrument. Having settled on a reasonable specification, Section 4.2 undertakes various robustness checks via different alternative ordering schemes as well as different variable specifications, such as a closed-economy system, a model that accounts for the pegging of the ringgit to the US dollar and another model that invokes complete block exogeneity. Section 4.3 presents another layer of check whereby the focus is on the impact of the intermediate transmission variable shocks on the two target variables of output and inflation. From the results in Sections 4.2 and 4.3, a suitable VAR specification is identified. Before concluding in Section 4.5, Section 4.4 revisits the issue of the price puzzle.

1 See Section 3.3.1.2 of Chapter 3 for more details.
which a new study (Giodarni 2004) has argued could simply be due to the exclusion of an output gap variable in VAR models.

Briefly, the model that accounts for the pegging of the ringgit to the US dollar (as shall be denoted by AO?) is preferred. The price puzzle is particularly problematic when consumer prices are expressed in levels. Expressing them as inflation rates overcome the problem, in which case the commodity price index is found to be key in controlling for inflation expectations when M1 is the monetary policy indicator. Replacing output with an output gap variable does not help to address the price puzzle.

4.1 Preliminary Results

This section shows the results of the preliminary ordering scheme as identified in Chapter 3 as: CP, PUS, YUS, RUS, PMY, YMY, M3, R3M, ER, KLCI, BLR, L.² As mentioned in Chapter 3, the system will be estimated in levels, with a lag order of two plus a constant and Asian crisis dummy terms. Identification will be achieved by way of the Cholesky decomposition. In essence, this involves estimating the following reduced form VAR:

\[ Y_t = C_t + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \epsilon_t, \]  

(4.1)

where \( Y_t \) is a \( n \times 1 \) matrix of variables, \( C_t \) is a \( n \times 2 \) matrix of the intercept term and the Asian-crisis dummy, and \( \Phi_1 \) and \( \Phi_2 \) are \( n \times n \) matrices of parameter estimates of \( Y_t \) at lag one and two, respectively.

The impulse response function is used as the main analytical tool in line with previous studies.³ Several remarks on the plots of impulse responses are

² The abbreviations refer to the commodity price index, the US CPI, the US real GDP, the US Federal Funds Rate, Malaysian CPI, real GDP, M3, 3-month interbank interest rate, RM/USD exchange rate, Kuala Lumpur Composite Index, base lending rate and bank loans, respectively.

³ Other tools like generalised impulse response functions (Koop, Pesaran and Potter 1996), forecast error variance decompositions and historical decompositions will not be used.
appropriate. The impulse response plots presented are all in relation to a one standard deviation shock to the variable of interest or more precisely, on the structural error term of the variable of interest. Since the interest is on the impact of a monetary policy shock, most of the impulse response plots presented will be a response to this shock. The plots of interest are also those related to the domestic block. Two standard deviation error bands are also included along with the impulse responses and these are obtained based on the asymptotic distribution. Generally, the error bands are fairly large, which means most of the impulse responses are statistically insignificant. This, nonetheless, should not discourage the focus on the qualitative aspects of the impulse responses. Wide error bands are a common problem in the VAR literature, but as a standard practice they are presented along with the impulse responses; the same applies here. The unit of measurement on the y-axis depends on the unit of the response variable. All variables transformed to natural logarithm can be interpreted as percentage change by multiplying the y-axis by 100%. For variables which are already in percentage point, such as interest rates, no such conversion is required; the y-axis can be read as percentage point change.

Figure 4.1 shows the impulse responses of domestic variables to a R3M shock based on the preliminary ordering scheme. Notice the impulse responses of most variables are in accordance with the economic predictions discussed in Section 3.1 of Chapter 3. That is, following a contractionary monetary policy shock (modelled as a rise in R3M), lending rates (BLR) rise, stock prices (KLCI) and real GDP fall, and after a year, loans also decline. Bernanke and Blinder (1992) explain the slower fall in credit as being due to the fact that loans are quasi-contractual agreements whose volume cannot be changed quickly. According to the authors, a contractionary monetary policy leads to a decline in deposits (as reserves are reduced), which must be met initially by the fall in banks' securities holdings. Nonetheless, after this initial adjustment, loans will also fall and this precedes the rise in the unemployment rate (the real variable used in their study). This means the fall in loans (supply) drives the rise in the unemployment rate which is as predicted by the theory of the credit channel.

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4 As can be seen in all ensuing plots, real GDP of Malaysia is written as YMY_X11; this refers to the deseasonalised series of the data. For more details, see Section 3.3.2, Chapter 3.
However, what is evident in Figure 4.1 is the opposite – real GDP falls first before loans fall. So, it seems there is some evidence to suggest bank loans may be capturing the demand effects of slower economic activity.

Figure 4.1 IRFs to R3M Shock with Preliminary Ordering

Figure 4.1 also reveals two notable and famous empirical findings in the literature: the price puzzle and the exchange rate puzzle. The price puzzle is the phenomenon where a contractionary monetary policy leads to a rise in prices instead of an expected decline. Sims (1992) attributes this to the failure to include a rich enough specification to account for anticipated inflationary pressures in the model. What happens is central banks may increase interest rates in the present if they believe prices are likely to be higher in the near future. So what is evident is just a reaction of policymakers to the expectations of inflationary pressures. Prices evidently rose because policymakers correctly predicted they would, hence interest rates were raised in response. Walsh (2003) points out the price puzzle can also be attributed to policymakers' tardiness in responding to higher prices – after prices rise, then only interest rates are raised. The solution to alleviating the price puzzle as suggested by Sims (1992) is to include a variable that proxies anticipated inflationary pressures such as a commodity price index. But this recommendation does not
seem to work in the VAR model estimated here as the commodity price index has already been included in the model specification.

The exchange rate puzzle is a result that contradicts conventional economic wisdom based on the uncovered interest rate parity (UIP).\(^6\) According to the parity, which assumes free capital mobility, returns to ringgit deposits must be the same as the returns to dollar deposits at equilibrium. When there is a rise in the ringgit interest rate, and hence a rise in returns to ringgit deposits, capital will flow in from abroad, leading to an initial appreciation of the ringgit. However, in order for both returns to equalise, the ringgit will later have to depreciate. The puzzle arises because the result shows an immediate depreciation in the ringgit after an interest rate shock instead of an appreciation. Notice that the exchange rate (ER) rises after a shock to R3M and remains above the x-axis for two quarters before declining afterwards.\(^7\) (Recall, the exchange rate is defined as RM/USD. So, a rise in the exchange rate is a depreciation in the ringgit relative to the US dollar and, a fall is an appreciation). The exchange rate puzzle will be further investigated later.

One other unexpected result is that M3 seems to rise with a R3M shock. It would be convenient to label this as the liquidity puzzle, but it must be recognised that, strictly speaking, the liquidity puzzle only applies to an institutional setting where central banks follow a monetary targeting framework of changing base money to affect money supply and, in turn, interest rates. In a modern setting, the label of a perverse result may even be too strong. (For a theoretical discussion of the liquidity effects, see Ohanian and Stockman (1995), and issues to resolve the puzzle, see Pagan and Robertson (1995)).

\[4.1.1 \textbf{Commodity Price Index (CP) vs. Oil Price Index (OP)}\]

This part examines whether the price puzzle can be solved if CP is replaced by OP. The price puzzle can still exist if CP is not a good proxy for anticipated

\(^6\) For more details, see Section 3.1.3, Chapter 3.

\(^7\) A more detailed discussion of this phenomenon via the overshooting exchange rate model of Dornbusch is in Appendix 3-1, Chapter 3.
inflationary pressures. The results from Figure 4.2 show that even after substituting CP with OP, the price puzzle does not seem to disappear. (The exchange rate puzzle is also evident). Otherwise, both sets of results are largely similar. It appears whether CP or OP is used is immaterial to the analysis.

Figure 4.2 IRFs to R3M Shock with OP replacing CP

To further investigate this phenomenon, in particular whether monetary policy actions are reacting to anticipated inflationary pressures, the impulse responses of R3M to CP and OP shocks are examined (compare the last panel in the second row of Figure 4.3 and Figure 4.4). Instead of the expected rise in R3M to either a CP shock or an OP shock if the conjecture is correct, what is actually evident is a fall in R3M in the first quarter (for CP) and in the first two quarters (for OP), before R3M rises in the ensuing quarters. It is questionable whether these results are sufficient to support Sims' recommendation of using a commodity sensitive price index. Perhaps, they are due to other factors, such as Malaysia's traditional role as a primary commodity exporter including oil. This is investigated next.
Examining the impulse responses in Figure 4.3 after a positive CP shock, prices (PMY) rise from the second quarter onwards, while the rise in output (YMY) is immediate. This seems to lend support to Malaysia’s position as a primary exporter, since higher commodity prices induce the production of more goods (say, more palm oil is produced), leading to higher exports and higher output, which in turn exerts upward pressure on domestic prices, after some lags. However, the same patterns are not evident from Figure 4.4 in response to a positive OP shock. In that case, prices fall immediately and output increases marginally before declining from the second quarter onwards. These differences may be due to two factors. First, there is a difference in the definition of CP and OP, in which the former explicitly excludes fuels and the latter explicitly captures
oil prices. Since output falls after a positive OP shock, this could potentially be caused by the increase in domestic oil production being offset by the larger contraction in world demand due to higher world oil prices, which reduces overall exports and lowers domestic real GDP. This was evident during the oil price shock of 1979. (See pages 233-241 of BNM (1991), which discusses the impact of the oil crises on the Malaysian economy).

Second, since the price of petrol is controlled in Malaysia (unleaded petrol currently costs RM1.52 per litre), this suggests that after a positive OP shock, prices should increase more moderately or remain relatively flat. That is, since OP captures oil prices which are controlled, higher oil prices would be less easily translated into higher domestic prices than the case of using CP, which
captures commodity prices which are not controlled. However, this does not seem to be case as prices fall after an OP shock (Figure 4.4), unless this is associated with contraction in world demand, which exerts downward pressure on general price levels. If the experiences of the two oil crises are of any guide, world demand did contract but prices also rose substantially. Thus, the second possible reason that petrol prices are controlled seems improbable as an explanation of why prices decline following an OP shock.

Putting the perverse result of prices to an OP shock aside, and focusing on the impulse response of output to a positive OP shock, it would seem reasonable to expect R3M to fall immediately after a positive OP shock – since real GDP has fallen, interest rates would have to be lowered to support growth. This brief reduction in interest rates is also supported by a brief rise in stock prices and a sluggish response of the BLR. For the US variables, a positive OP shock very clearly leads to higher domestic prices, lower real GDP and lower interest rates. These results seem to imply a strategy that focuses more on countering slower economic growth than on containing higher prices after an oil price shock. Thus, it appears OP may not be a good proxy for capturing anticipated inflationary pressures in the context as advocated by Sims (1992), because in the US, interest rates are lowered despite imminent inflationary pressures, and in Malaysia, the expected relationship between prices and oil prices is less apparent.

On the other hand, since the rise in other commodity prices are not as harmful as oil prices in derailing the growth of the world economy, interest rates only fall very marginally and only temporarily (as seen from the last panel of the second row in Figure 4.3), before they are raised to combat the higher commodity prices affecting domestic price levels. By and large, the same results are evident in the case of the US, where CPI and real GDP rise, as do interest rates after a very marginal decline in the first period. Thus, it appears the impact of higher commodity prices, excluding oil, leads to a contractionary monetary policy to counter higher domestic prices. This means it is a reasonable proxy for capturing anticipated inflationary pressures, while the impact of higher oil prices leads to an expansionary monetary policy suggesting that it is not a reasonable proxy because the benefits of boosting the economy seem more important.
Overall, it appears that CP provides a more reasonable representation of the economy than OP in the scenario as elucidated by Sims and therefore it would be useful to include CP in the system. Still, there is no explanation as to why the interest rate falls before it increases, though it must be stressed the fall is marginal. One plausible reason is that while CP may be a reasonable proxy for inflationary expectations, BNM does not rely solely on this information to hike interest rates – the central bank has a tendency to wait until it is more certain that prices will continue to rise before acting. This inertia is understandable considering the loathsomeness associated with higher interest rates in general, and the prevalence of a national pro-growth psychic in particular (as discussed in Chapter 2). This is a plausible reason why in spite of the inclusion of CP in the model, the price puzzle remains unresolved.

4.1.2 Consumer Price Index (PMY) vs. Inflation Rate (PFMY)

The attempt to resolve the price puzzle by replacing CP with OP also did not make much difference to the results. The other scenario worth examining is to use the inflation rate rather than the consumer price index. This would seem a trivial attempt, but realistically, the choice of an inflation rate would be appropriate because what really matters to policymakers is not the level of CPI (PMY) but the inflation rate (PFMY).8 Countries adopting an inflation targeting framework have a clear mandate on their target inflation rates, and not on the level of the CPI. Even non-inflationary targeting countries have an implicit inflation target which is expressed in the growth rate of the CPI and not the level of CPI. Making this switch improves the overall results. Most striking is the absence of the price puzzle, and inflation actually falls following a R3M shock (see first panel on the first row, Figure 4.5). In addition, there is now a fall in M3. Otherwise, the results are essentially very similar to those in Figure 4.1, where the level of CPI was used. However, the exchange rate puzzle is still present. Since the price puzzle is already absent, an attempt to exclude CP is carried out. Interestingly, the results shown in Figure 4.6 cannot be differentiated from Figure 4.5 – it seems CP can be excluded from the model. However, as will be

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8 Similarly, the US inflation rate is used instead of the US CPI.
shown later, when money is the policy instrument, CP is essential in controlling for the price puzzle. Hence, the VAR model estimated hereafter will be based on the inflation rate and not the CPI index, but CP will continue to be included.

Figure 4.5 IRFs to R3M Shock, replacing PMY by PFMY

Figure 4.6 IRFs to R3M shock, with PFMY and excluding CP
As an aside, growth rates in real GDP were also used instead of real GDP in value terms, but the results were largely the same (for more details, see Appendix 4-1). Hence, real GDP at levels will continue to be used.

4.1.3 Proxy for Monetary Policy Stance

This section examines whether the statutory reserve requirement ratio (SRR), the overnight interbank interest rate (RON) or one of the various monetary aggregates (M0, M1, M2 and M3) is a potential indicator of monetary policy stance, besides the 3-month interbank rate (R3M).

4.1.3.1 Statutory reserve requirement ratio (SRR)

SRR has been a widely used tool of monetary policy over the years. For example, prior to the Asian crisis, or more specifically in 1994, SRR was progressively increased to address the massive capital inflows coming into the country as well as concerns about an overheating economy. In that year, SRR was increased by one percent on three occasions from 8.5% to 11.5%. It was at that level until 1996, just before the crisis struck, when it was increased twice during the year by the same margin to 13.5%. Finally, 1998 saw the aggressive reductions in SRR to just 4% as part of the measures implemented to support economic recovery during the Asian crisis.

In Figure 4.7, where SRR replaces R3M, a SRR shock seems to have a desired impact on inflation, though the impact is short-lived (and there is no price puzzle here). The exchange rate puzzle has also vanished. The other results, however, are less promising. Its impact on real GDP shows a marginal increase before declining. The decline lasts not more than seven quarters. It has a negligible impact on M3, if anything M3 seems to be on the rise. Its impact on stock prices and loans is also contrary to expectations. Moreover, the system is unstable when estimated with a two-period lag and there is also heteroscedasticity but no autocorrelation at the conventional test level of 5%. As a comparison, the VAR model is also estimated with the pre-crisis sample (up to 1997:1); while the price puzzle and exchange rate puzzle continue to be absent, as does the stock price
puzzle. However, the result for real GDP remains quite unexpected as it rises for several quarters before declining (see Figure 4.8).

Figure 4.7 IRFs to SRR Shock

Figure 4.8 IRFs to SRR Shock, pre-crisis sample
In sum, SRR does not appear to be a reasonable candidate for the monetary policy stance, particularly over the entire sample size vis-à-vis the 3-month interbank rate. Interestingly, however, it overcomes both the price and exchange rate puzzles.

4.1.3.2 Overnight interbank rate (RON)

The overnight interbank rate is also a potential candidate for the monetary policy stance as it is known to be a rate closely watched by the central bank. In fact, in the bank’s day-to-day operations, the overnight interbank rate has greater relevance because the bulk of the bank’s monetary operations are concentrated in the shorter-end maturity. Likewise, trading in overnight deposits among market players comprises the biggest share of total trading volume in interbank deposits. In 2003, the share of overnight deposits over the total volume of interbank deposits traded was 67.5%, whereas the 3-month deposits’ share was a meagre 8.6%. The overnight interbank rate has also gained greater standing in the aftermath of the crisis when the 3-month Intervention Rate began to deviate from underlying market conditions. All these developments have unequivocally propelled the overnight interbank rate to become the Operating Policy Rate (OPR) in the New Interest Rate Framework introduced by the central bank in April 2004.

Figure 4.9 based on the full-sample period shows an absence of both the price puzzle and exchange rate puzzle. However, real GDP seems to rise marginally before declining and the response of loans is completely negligible to a RON shock. Apart from that, other results are largely similar to the VAR with R3M. The system is stable but autocorrelated and heteroscedastic when the VAR is estimated with a lag order of two.10 With lag orders of three and four, there is still autocorrelation but no heteroscedasticity, and the systems are stable. Comparing these findings to the VAR estimated with the pre-crisis sample, similar patterns are evident, although they tend be an amplification of those

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9 As an aside, these results are very similar even without CP – there are still no price and exchange rate puzzles.
10 The tests for autocorrelation and heteroscedasticity are the same as those used in Section 3.4.4, Chapter 3.
observed in the full-sample (see Figure 4.10). There is a clearer case of an absence of the price puzzle, and a closer match to the UIP theory, although the subsequent depreciation seems to be substantially larger than the initial appreciation. The response of bank loans is less perverse, but the rise in real GDP before it declines is more obvious.\footnote{In models estimated with both the full and pre-crisis samples, the exclusion of CP does not lead to a price puzzle, i.e., the price puzzle is still absent.}

**Figure 4.9 IRFs to RON Shock**

Overall, despite the improvements over the specification using R3M, diagnostic checks reveal there is persistent autocorrelation in the system with lag orders of two, three and four. Unless, one is prepared to ignore these checks, it would appear RON is a more suitable candidate than R3M as a policy instrument. Accepting RON would also mean accepting a negligible role played by bank loans. This would be difficult to justify in reality. If the analysis was only based on the pre-crisis sample, RON would be a better choice because R3M exhibits both the price and exchange puzzles.
Money gained kudos in the business cycle literature ever since Friedman and Schwartz's (1963) seminal study found a relationship between higher money growth leading to higher output growth. *Post hoc ergo propter hoc* aside (Tobin 1970), this highlights the usefulness of monetary aggregates as a potential monetary policy instrument. Undoubtedly, this would be the natural choice for countries adopting a monetary targeting framework. In Malaysia, although the current operating procedure of BNM is no longer based on a monetary targeting framework, the latter was however claimed to be the adopted regime for most of the 1970s, 1980s and early 1990s. Hence, examining money represents an important comparison to the 3-month interbank rate.

Figure 4.11 shows the impulse responses of domestic variables to money shocks: M0, M1, M2 and M3. The most startling finding, common across all

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12 For a detailed discussion refuting this claim, see Chapter 2, Section 2.6.2.
13 Each column of Figure 4.11 presents the case where each individual monetary aggregate is included in the model specification; it does not mean that the four
measures of money and unable to be dealt with in the VAR specifications thus far, is the absence of the exchange rate puzzle. More precisely, a positive monetary shock (or expansionary monetary policy or equivalently in the previous specification a decline in interest rates) leads to a depreciation in the ringgit (ER increases). In addition, the price puzzle is absent in all monetary aggregates except M3. (Actually there is a very minute amount of the price puzzle in M1 and M2 but they are barely legible from the plots). The response of real GDP also conforms to a priori, except for M0 which exhibits a small initial decline. Similarly, stock prices rise with positive money shocks, while BLR falls except for M0 which increases initially. Bank loans' responses are roughly similar across all measures of money with an initial decline before a further rise, but the decline is smaller and the rise larger for M0 and M1, than M2 and M3. These findings look promising except for the presence of the liquidity puzzle in M0 and M3. Note the liquidity puzzle arises when an increase in money supply, supposedly leading to lower interest rates, instead leads to higher interest rates. Otherwise, all models exhibit no autocorrelation and no heteroscedasticity, and are stable, with the exception of M0.

These VAR specifications are also being examined by dropping CP. Recall the inclusion of CP is to account for inflationary expectations and to address the price puzzle. Yet, when CP is dropped, the price puzzle is again evident in all measures of money except M0 (see Figure 4.12). In addition, with the exception of M0, the responses of bank loans are also perverse – an expansionary monetary policy contributes to lower loans. The other results are largely similar to those of Figure 4.11.

Why M1 is better than M0 or M3 remains an open question. In terms of controllability, BNM should have better control over M0 than M1, which intuitively implies M0 would be a more reasonable candidate. Since M3 was adopted as the intermediate target during the span of the sample size used here, it would also be expected to quite closely resemble the monetary policy actions of the central bank. However, this is not supported by the results. One important reason why M3 is not suitable is because it is also influenced by many factors measures of money are included together in the same specification. R3M continues to be included in each case.
beyond those under the ambit of the central bank namely, demand and external
shocks. A case in point is the episode of large capital flows in the mid-1990s
when M3 fluctuated between 30% to 8% in response to huge inflows and
subsequent reversals.

In sum, both M1 and M2, particularly M1, seem to be the ideal choice as a policy
instrument. It accords with the economic a priori and intuition about the
Malaysian economy and, most notably, addresses the exchange rate puzzle,
which the 3-month interbank rate fails to solve. M3, on the other hand, though a
measure of money most widely followed by BNM, exhibits both the price and
liquidity puzzles, while M0 also has the liquidity puzzle and is unstable.

Since M1 performs very well, as an additional check, it is used to replace M3 in
the original VAR specification. Meanwhile R3M continues to be taken as the
policy instrument. The results are largely similar to the original case using M3
(Figure 4.5), with the only exception that money as represented by M1 now
actually falls following a positive shock to R3M. So, it appears M1's dynamics
have a closer resemblance to monetary policy actions, while M3's behaviour is
clearly influenced by both monetary and non-monetary activities.
Figure 4.11 IRFs to Money Shocks

M0 Shock
Response of PFM to M0
Response of YMY to M0
Response of M1 to M0
Response of R3M to M0
Response of ER to M0
Response of KLC1 to M0
Response of BLR to M0
Response of L to M0

M1 Shock
Response of PFM to M1
Response of YMY to M1
Response of M1 to M1
Response of R3M to M1
Response of ER to M1
Response of KLC1 to M1
Response of BLR to M1
Response of L to M1

M2 Shock
Response of PFM to M2
Response of YMY to M2
Response of M2 to M2
Response of R3M to M2
Response of ER to M2
Response of KLC1 to M2
Response of BLR to M2
Response of L to M2

M3 Shock
Response of PFM to M3
Response of YMY to M3
Response of M3 to M3
Response of R3M to M3
Response of ER to M3
Response of KLC1 to M3
Response of BLR to M3
Response of L to M3
Figure 4.12 IRFs to Money Shocks without CP

- MO Shock Response of PFM Y to MO
- M1 Shock Response of PFM Y to M1
- M2 Shock Response of PFM Y to M2
- M3 Shock Response of PFM Y to M3

- Response of M2 to MO
- Response of M3 to MO
- Response of ER to MO
- Response of KLCI to MO
- Response of BLR to MO
- Response of L to MO

- Response of R3M to M2
- Response of ER to M1
- Response of KLCI to M1
- Response of BLR to M1
- Response of L to M1

- Response of R3M to M3
- Response of ER to M2
- Response of KLCI to M2
- Response of BLR to M2
- Response of L to M2

- Response of R3M to M3
- Response of ER to M3
- Response of KLCI to M3
- Response of BLR to M3
- Response of L to M3
In this section, NEER will replace ER in two specifications, one with R3M$^{14}$ as the policy instrument and the other with M1 to see, among others, whether the exchange rate puzzle is sensitive to the measurement of the exchange rate. In addition, the pre-crisis sample will be used to check how the results may have differed.$^{15}$ These results will be compared with those in Figure 4.5 (that which use the inflation rate instead of the CPI index).

Examining Figure 4.13 first, the shapes of the impulse responses of domestic variables in the full-sample and the pre-crisis sample (columns three and four, respectively) to a positive R3M shock (a contraction in monetary policy) are fairly similar. Parallel to the original VAR specification with ER (as presented in Figure 4.5), they also exhibit the exchange rate puzzle. (Note: higher NEER implies an appreciation in ringgit and vice versa). But unlike the original specification, there is a price puzzle using NEER. Otherwise, both sets of results are largely the same. On the other hand, Figure 4.14 which corresponds to a positive shock in M1 (an expansionary monetary policy), exhibit no price and exchange rate puzzles in either sample period. In addition, the other results are also consistent with a priori. Compared to the results of the M1 shock in Figure 4.11, which are reproduced in Figure 4.14, both results are very much alike.

Several points are worth highlighting. First, the use of NEER instead of ER does not change the overall results in either sample period. This holds regardless of whether R3M or M1 is used as the policy instrument. Second, when R3M is the policy instrument, the exchange rate puzzle is present in both sample periods with ER or NEER. This is not evident with M1 as the policy instrument. Third, overall M1, as shown in Figure 4.11, seems to be a more robust choice of monetary policy instrument.

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$^{14}$ In this specification M3 will still be retained as the monetary aggregate in the model.

$^{15}$ In all these estimations, two-lag is used. For estimations with the pre-crisis sample, the impulse responses tend to be unstable.
Figure 4.13 IRFs to R3M Shock with NEER

Note: As a comparison, the first column reproduces the results from Figure 4.5 using ER with full-sample, while the second column uses pre-crisis sample.
Figure 4.14 IRFs to M1 Shock with NEER

Note: As a comparison, the first column reproduces the results from Figure 4.11 using ER with full-sample, while the second column uses pre-crisis sample.
4.1.4 An Explanation of the Exchange Rate Puzzle

Recall that the exchange rate puzzle occurs in the model where \( R3M \) is used as the policy instrument. Grilli and Roubini (1995) offer two complementary explanations to this puzzle. The first is based on the leader-follower hypothesis. When a leading country, such as the US, increases interest rates, other countries will follow because they are concerned their weaker currencies will lead to higher inflationary pressures from abroad. That is why when the ringgit depreciates (or the US dollar appreciates), \( R3M \) increases because it follows the movement of the US interest rates. The second explanation is that interest rate shocks are an endogenous response to underlying inflationary pressures in the economy, which relates back to the first explanation. That is, in order to minimise the impact of imported inflation caused by an increase in US interest rates, followers will raise their interest rates to minimise depreciation of their currencies.

One way to ascertain the leader-follower hypothesis is to examine the impulse response of \( R3M \) to a RUS shock, and RUS to a \( R3M \) shock. If the leader-follower hypothesis is true, \( R3M \) should rise when RUS rises (supported by the first plot in Figure 4.15); and RUS should not rise when \( R3M \) increases (this is also supported by the second plot, at least RUS does not rise). Grilli and Roubini also find the response of US interest rates to some G-7 countries’ interest rate shocks to be declining. This asymmetry provides some evidence supporting the leader-follower hypothesis.

Figure 4.15 IRF of \( R3M \) to RUS Shock, and RUS to \( R3M \) Shock

![Graphs showing impulse response functions](image)
4.2 Alternative Variable Orderings and Model Specifications

Recall the preliminary ordering scheme presented in Section 4.1 is ordered as follows: CP, PUS, YUS, RUS, PMY, YMY, M1, R3M, ER, KLCI, BLR, L. However, the preceding experiments suggest the following scheme:

AO0: CP, PFUS, YUS, RUS, PFMY, YMY, M1, R3M, ER, KLCI, BLR, L.

Hereafter, this ordering scheme shall be called the original specification and labelled as AO0. It is different from the preliminary ordering scheme in two ways. First, prices are included in terms of inflation rates (PFUS and PFMY) instead of in levels (PUS and PMY). Second, M1 replaces M3. M1 from now on will also be used a proxy for the monetary policy stance together with R3M since it performs comparably with R3M but also addresses the exchange rate puzzle.

4.2.1 Different Orderings

A common criticism of the recursive identification is that its results are sensitive to different orderings. The first alternative ordering attempted is based on Levy and Halikias (1997) where the policy instrument is positioned first, followed by the existing intermediate variables and then the real target variables. No changes are made to the foreign block. Thus, the first alternative ordering (AO1) as shown by the rearrangement of the variables underlined at the end is:

AO1: CP, PFUS, YUS, RUS, M1, R3M, ER, KLCI, BLR, L, PFMY, YMY.

In the above, M1 is the policy instrument and, for comparison, the results using R3M as the policy instrument are also presented. The results are shown in Figure 4.16. In stark contrast to the original ordering, the price puzzle has re-emerged regardless of the policy instrument choice. Otherwise, the results are
essentially the same as the original ordering. Notice as well that the exchange rate puzzle is still present in A01 with R3M as the policy instrument. In addition, even when PFMY and YMY are placed just after M1, the results remain the same (the results are not shown here).

The second alternative ordering (A02) examines changes among the intermediate variables, specifically what happens if BLR and L are placed ahead of ER and KLCI. This ordering dismisses the basis that faster-moving variables of the more liquid markets should be placed before slower-moving variables. The second alternative ordering as shown by the variables underlined is:

A02: CP, PFUS, YUS, RUS, PFMY, YMY, M1, R3M, BLR, L, ER, KLCI.

The results for both M1 and R3M as the policy instrument are shown in Figure 4.17, and they are based on the exact ordering as per A02 i.e., when R3M is used as the policy instrument, it is not placed ahead of M1. (In any case, the results do not differ when R3M is placed ahead of M1). Clearly, the findings here are no different from the original specification, A00.

To sum up, there are two findings which stand out. First, placing the target variables after the policy instrument matters because doing so leads to the price puzzle. Second, reordering among the intermediate variables does not alter the overall results.

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16 There is just a minor difference, i.e., for M1 shock, there seems to be a jump in real GDP compared to a more gradual increase in A00. This arises because real GDP is now contemporaneously influenced by M1.
Note: Columns one and two reproduce the results from AO0 when M1 and R3M are the policy instruments respectively, and columns three and four refer to M1 shock and R3M shock respectively in AO1.
Figure 4.17 Alternative Ordering 2: IRFs to M1 and R3M Shocks

Note: Columns one and two reproduce the results from A00 when M1 and R3M are the policy instruments respectively; and columns three and four refer to M1 shock and R3M shock respectively in AO2.
4.2.2 Scaled-down Open Economy Specifications

In the following alternative specifications, experiments are undertaken to determine whether a closed economy model and the removal of certain foreign variables matter. These experiments also serve as further robustness checks on the hypothesis that an open-economy model with the full-set of variables as per AO0 is reasonable.

Recall, the removal of CP matters especially for M1. As such, it is left in the specification. To see what happens if a closed economy VAR is estimated, the three US variables are excluded from the original specification. Hence, the third alternative ordering with the US variables crossed-out is:

**A03:** CP, PFUS, ¥US, RUS, PFMY, YMY, M1, R3M, ER, KLCI, BLR, L.

Interestingly, results (Figure 4.18) from the closed economy specification (A03) are quite similar to that of the open economy specification (AO0). One minor difference is small evidence of the price puzzle in A03. Another is the response of BLR to both M1 and R3M shocks takes longer to return to x-axis than otherwise. These results suggest a closed economy model would suffice. However, this is only one part of the picture. In the next section, when the analyses are focused on the responses of the target variables to the intermediate variable shocks, it will be clearer whether a closed economy model is indeed preferred.

Having a liberal capital account has always meant Malaysia is subjected to bouts of massive capital flows, as evident from the experience of the mid-1990s. Naturally, policymakers have always been watchful of factors that might lead to capital swings; one such factor being world interest rates, specifically US interest rates. So, including US interest rates in the model would be most apt. Thus, the fourth alternative ordering is as follows:

**A04:** CP, PFUS, ¥US, RUS, PFMY, YMY, M1, R3M, ER, KLCI, BLR, L.
There is still some evidence of the price puzzle in both scenarios of M1 and R3M being the policy instrument. Otherwise the results are almost identical to Figure 4.18, hence, they are not presented here. What might be more appropriate is to include the real US interest rate (RRUS) since this is what really matters to investors. Doing so, leads to another specification:

**AO5:** CP, PFUS, YUS, RUS, RRUS, PFMY, YMY, M1, R3M, ER, KLCI, BLR, L.

RRUS is simply the difference between the level of the US Fed Funds Rate (RUS) and the US inflation rate (PFUS). The results presented in Figure 4.19 show that for M1 shock, the impulse responses now closely resemble the original specification; while for R3M shock, there is still some evidence of the price puzzle. Nonetheless, the model is unstable and has heteroscedasticity. (AO4 only has heteroscedasticity, but both AO4 and AO5 have autocorrelation at lag one).

The final specification (AO6) is the case where the US GDP is included in AO5, that is:

**AO6:** CP, PFUS, YUS, RUS, RRUS, PFMY, YMY, M1, R3M, ER, KLCI, BLR, L.

Now, the price puzzle in both scenarios of R3M and M1 shocks has disappeared. Otherwise, the results are like the original specification, but the system is unstable.

In sum, estimating a closed economy model or some scaled down version of an open economy model seems appropriate. But this disregards the impact of the intermediate variables on the target variables, failures of some diagnostic tests of the model, and the price puzzle (though this is very minor).
Figure 4.18 Alternative Ordering 3: IRFs to M1 and R3M Shocks

Note: Columns one and two reproduce the results from A00 when M1 and R3M are the policy instruments respectively; and columns three and four refer to M1 shock and R3M shock respectively in A03.
Figure 4.19 Alternative Ordering 5: IRFs to M1 and R3M Shocks

Note: Columns one and two reproduce the results from A00 when M1 and R3M are the policy instruments respectively; and columns three and four refer to M1 shock and R3M shock respectively in A05.
4.2.3 Modified Models

Two modifications are made to the original specification (AOO) to make it more representative of the underlying economic characteristics of Malaysia. First, it is useful to account for the pegging of the ringgit to the US dollar since September 1998. Perhaps, this may address the exchange rate puzzle found with R3M shock. Second, it is worthwhile to see whether the invocation of complete block exogeneity of the US block together with the account of the pegged exchange rate would change the overall results; since strictly speaking this is more in accordance with the concept of a small-open economy which assumes a smaller open economy is influenced by a larger economy but not the reverse. Hitherto, all the specifications have followed a straight recursive identifying restriction. By virtue of the ordering of the US block before the Malaysian block, no Malaysian variables affect the US variables contemporaneously. However, the Malaysian variables do affect the US variables with a lag. In a sense, this is not true block exogeneity as it is known in the literature, rather it is a partial or incomplete block exogeneity. With the suggested modification, the Malaysian variables neither affect the US variables contemporaneously nor in lags.

To account for the pegged exchange rate entails re-estimating Equation (4.1) above with a change to the $C_t$ matrix. The $C_t$ matrix now has two additional interaction dummy terms: one with the exchange rate variable at lag one, and the other with the exchange rate variable at lag two. The dummy variable takes the value of zero from 1981:1 to 1998:2 and one from 1998:3 to 2004:1. In the second modification to invoke complete block exogeneity, another change is made to Equation (4.1). In this case, in the US block of equations, all the Malaysian explanatory variables at both lag one and two are excluded. This approach is the same as Suzuki's (2003), where both the foreign and domestic blocks are estimated as a single system. Nonetheless, in this case, the model is unstable as not all its roots lie outside the unit circle. Perhaps, this is due to the recursive identifying restriction used. In order to be able to make consistent

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17 It is not estimated as a VARX model, in which case the system only comprises domestic equations, while the foreign variables are not estimated but only included as exogenous explanatory variables to the domestic equations.

18 In JMulti, this is shown by the modulus of one of the eigenvalues of the reverse characteristic polynomial being less than one.
comparisons with other model specifications which are all based on the recursive identifying restriction, no other zero-type restrictions are attempted. As such, the instability issue is not investigated further. Results of this model are therefore presented solely for qualitative comparisons only. For convenience, the two modified models shall be labelled as AO? and AO8, respectively.

Figure 4.20 shows the impulse responses of the Malaysian variables to both the M1 and R3M shocks under the first modification that accounts for the pegged exchange rate (AO7). The first two columns reproduce the corresponding impulse responses of the original specification to the respective shocks. Comparing the corresponding impulse responses to the monetary policy shocks shows a striking similarity between them – there are virtually no marked differences between the two specifications. Notice, however, that the exchange rate puzzle continues to be evident in the case of R3M shock only.

Figure 4.21 shows the same impulse responses but with respect to the second modification that invokes complete block exogeneity and accounts for the pegged exchange rate (AO8). In this case, the two standard error bands have not been included since the interest is on the dynamics or shapes of the impulse responses. By and large, in comparison with the same shock of the original specification, the shapes of the impulse responses are still fairly similar, albeit they are not as close resemblance as those in Figure 4.20. Most of the less similar impulse responses are found with respect to R3M shock namely that of inflation, exchange rate and bank loans.

If a decision has to be made at this stage with regard to the most appropriate choice of model, the decision would tend to favour the model that controls for the pegged exchange rate (AO7) because it is more reflective of the underlying features of the economy than the original specification (AO0). Unfortunately, the model with complete block exogeneity and the pegged exchange rate (AO8) is unstable otherwise it would be a more attractive choice. Having said that, the close resemblance of the model’s impulse responses with that of AO0 (and by extension AO7) particularly with respect to M1 shock should provide some assurance that the choice of AO7 is not utterly unreasonable.
Figure 4.20 AO7: IRFs to M1 and R3M Shocks

Note: Columns one and two reproduce the results from AO0 when M1 and R3M are the policy instruments respectively; and columns three and four refer to M1 shock and R3M shock respectively in AO7.
Note: Columns one and two reproduce the results from AO0 where M1 and R3M are the policy instruments respectively, and columns three and four refer to M1 shock and R3M shock respectively in AO8.
4.3 Shocks to Intermediate Variables

In this section, the impulse responses of the target variables (PFMY and YMY) to the intermediate variable shocks (ER, KLCI, BLR and L) in different specifications are presented. If the impulse responses of a particular specification conform to *a priori* then this provides further evidence in support of that specification.

The first set of results comes from the original specification, AA0, to be followed by the other alternative orderings. From the first column of Figure 4.22, in the case where the target variable is inflation (the first set of four plots), a positive ER shock (a depreciation in ringgit) leads to an increase in inflation as higher foreign prices are gradually passed-on to domestic goods and services. Similarly, a positive shock to stock prices also leads to higher inflation as the wealth effects kick-in. A positive shock to BLR, on the other hand, increases the cost of bank borrowings which reduces aggregate demand and induces falling prices. A positive shock to loans has the opposite effect on aggregate demand and thus on prices.

In the case where the target variable is real output (the second set of four plots in Figure 4.22), a depreciating ringgit should lead to greater demand for domestic goods from overseas because they are now relatively cheaper. However, this is not immediately evident. In fact, what is evident is something that looks like a J-curve effect. The J-curve phenomenon is sometimes explained by the volume and value effects. Initially, when the ringgit depreciates, the value of imports immediately rises, while the value of exports remains the same if exports are priced in ringgit. Hence, the trade balance worsens. However, over a period of time, say several quarters, when old contracts are settled and new ones are being drawn-up, the volume effect sets in as Malaysian goods become cheaper to foreigners, thereby increasing their demand. At the same time, the volume of imports declines as imported goods become dearer, and the Malaysian public and companies turn to domestic substitutes. This reverses the previous position and contributes to a trade
surplus.\textsuperscript{19} Intuitively, however, as mentioned above, since the bulk of Malaysia’s trade including exports is priced in US dollars, the J-curve effect would appear to be less prominent in Malaysia, as the initial depreciation in the ringgit should also improve the value of exports.

The result of a fall in real GDP after a positive ER shock seems to be rather puzzling. Indeed, this is the case if the analysis focuses solely on trade linkages and the expenditure-switching argument. On the other hand, if asset holdings and capital flows are considered, this result may not seem to be that puzzling. A positive ER shock (ringgit depreciation) can also be interpreted as a rise in the ringgit risk premium. When this happens, investors will demand higher returns for holding ringgit assets. A typical outcome is that investors will sell-off their ringgit assets, causing bond prices to fall (interest rates to rise), equity prices to fall, and when the funds leave, the ringgit to depreciate. If a central bank chooses to defend its currency, interest rates will also rise. The twin impact of falling asset prices and higher interest rates will reduce consumers’ wealth and hence their spending, as well as firms’ investments.\textsuperscript{20} Hence, output falls accordingly. McKibbin and Vines (2000) illustrate this phenomenon using the G-Cubed model in the context of the Asian crisis. Malaysia’s experience appears to conform to this, as the impulse response of R3M to ER shock does show an increase following ringgit depreciations. Actual evidence also shows that BNM did in fact raise interest rates initially during the Asian crisis to defend the ringgit. As a comparison, the pre-Asian crisis sample is also examined. Figure 4.22, (column two, the fifth plot from top) shows that, in contrast, prior to the Asian crisis, the conventional trade/demand side explanation seems to dominate.

\textsuperscript{19} This of course assumes the Marshall-Lerner condition holds i.e., for the case of initial zero current account, the sum of relative price elasticities of exports and imports demand is greater than one.

\textsuperscript{20} See Chapter 6, Section 6.2.1.3 for more details.
Figure 4.22 IRFs of Target Variables to Intermediate Variable Shocks: Original Specification (AO0)

ER (Full Sample)  
- Response of PFMY to ER

ER (Pre-crisis Sample)  
- Response of PFMY to ER

Response of PFMY to KLCI

Response of PFMY to BLR

Response of PFMY to L

Response of YMY_11 to ER

Response of YMY_11 to KLCI

Response of YMY_11 to BLR

Response of YMY_11 to L

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For other intermediate transmission variables, a positive stock price shock has the correct positive impact on real GDP and similarly that of a positive bank loans shock. As expected, higher borrowing costs dampen real GDP. On the whole, these results show ER, KLCI, BLR and L all appear to be important in affecting inflation and real GDP, implying the exchange rate, wealth, interest rate and credit channels all have a role to play in transmitting monetary policy shocks.

For the closed economy model (AO3, the first column of Figure 4.23), the "output/exchange rate puzzle" appears to be more prevalent and declining for the entire duration of the plot (fifth plot). In addition, a positive shock on bank loans has a negligible impact on real GDP (last plot) and similarly on inflation, for the initial rise in inflation is quickly offset by deflation (fourth plot). On the whole, these results seem to be less supportive of a closed economy VAR model.

Adding the US interest rate (AO4, second column) appears to have redressed the above perverse findings. The responses of the target variables to the intermediate variable shocks now closely resemble that of the original specification. Subsequent modification by including real US interest rates (as per AO5, third column) instead of nominal rates in AO4 seems to have exacerbated the "output and exchange rate puzzle"; there is now a prolonged decline in output following a positive ER shock (fifth column). A further modification by including US real GDP into AO5 somewhat lessens the above effect, but it still does not lead to any improvement in Malaysia's real GDP (AO6, fourth column, fifth plot).

Taking into account the results in the previous section on the different alternative orderings under different monetary policy shocks, AO4 which just includes US interest rates seems to be a reasonable alternative to the original specification of AO0. The other specifications which re-expressed interest rates in terms of real rates, and including US real GDP, do not seem to improve on AO4. But recall all these scaled-down open economy specifications tend to fail some diagnostic tests and are unstable.
When the focus is turned to the modifications done on the original specification, a quick comparison between the impulse responses of output and inflation of the modified models (AO7 and AO8) and that of the original specification (AO0) reveal a great similarity between both sets of impulse responses (see Figure 4.24). In short, this implies, just like the original specification, the intermediate transmission variables in both AO7 and AO8 also play an important role in transmitting monetary policy shocks to output and inflation. More importantly, coupled with the findings in the above Section 4.2.3, the modified model that incorporates the pegged exchange rate (AO7) appears to be an appropriate model.
Figure 4.23 IRFs of Target Variables to Intermediate Variable Shocks: Scaled-down Open Economy Specifications

A03

Response of PFMY to ER

Response of PFMY to KLCI

Response of PFMY to BLR

Response of PFMY to L

Response of YMY_X11 to ER

Response of YMY_X11 to KLCI

Response of YMY_X11 to BLR

Response of YMY_X11 to L
Figure 4.24 IRFs of Target Variables to Intermediate Variable Shocks:
Pegged Exchange Rate (AO7), and Complete Block Exogeneity and
Pegged Exchange Rate (AO8)

Note: Column one reproduces the first column of Figure 4.22 (AO0).
4.4 Price Puzzle Revisited

In a recent paper, Giordani (2004) shows that the cause of the price puzzle could be due to the omission of the output gap variable in a VAR model. To investigate this, the original specification (AO0) and the modified model that accounts for the pegged exchange rate (AO7) are estimated. In both models, the commodity price index is removed and the output gap variable\textsuperscript{21} replaces real GDP, while the rest of the specification remains unchanged. In the first model, there continues to be price puzzles in both R3M and M1 shocks. In the second model, there is no price puzzle, but the impulse response of real GDP to the monetary shocks has become more perverse. Output rises more in the first quarter before declining following a R3M shock. For a M1 shock, output rises for six quarters before declining. The latter result is particularly striking since no such pattern is evident when the commodity price index is used. As a further check, the commodity price index is included in the second model; although there is no price puzzle and no perverse response of output, the system becomes unstable. Therefore, it does not appear the output gap variable works better than just real GDP at levels, based on the models and data used. Actually, as part of the robustness checks, Giordani also finds the overall results are sensitive, among other things, to the different measures of output gap - the price puzzle may not eliminated when different output gap measures are employed.

It is interesting to see what another new study has to say about the use of commodity prices in VAR models. Hanson (2004) examines a range of indicators which are considered good predictors of inflation, including standard commodity prices and oil prices, as well as financial, monetary and real indicators. Surprisingly, he finds little evidence that these indicators are able to forecast inflation and resolve the price puzzle. The pre-Volcker period from 1959 to 1979 exhibits a particularly strong price puzzle which cannot be resolved by the inclusion of commodity prices. Even if commodity prices are able to solve

\textsuperscript{21} Giordani uses the capacity utilisation series in the manufacturing sector of the Federal Reserve Board, while in the models used here, the HP filtered log output is taken as the proxy for potential output due to data unavailability. In Malaysia, the series on capacity utilisation in the manufacturing sector and the output gap only start from 1991:Q1.
the price puzzle (post-Volcker), the author claims this may be attributed to an “information channel – commodity prices respond more quickly than aggregate good prices to future inflationary pressures rather than serving as a proxy for marginal costs or otherwise measuring costs of production” (page 1413).

4.5 Conclusions

In this chapter, an open-economy version of the monetary policy transmission mechanism VAR model is built for Malaysia. The specification that is preferred (A07) comprises, in addition to the Asian crisis dummy variable, two interaction dummy terms that accounts for the pegging of the ringgit to the US dollar since September 1998. This by and large is similar to the original specification without the pegged exchange rate (A00) and another modified model which invokes complete block exogeneity and accounts for the pegged exchange rate (A08). Nonetheless the latter is unstable while the original specification is less reflective of the underlying economic conditions than the preferred model.

In terms of the choice of variable to proxy for inflationary expectations, the commodity price index (CP) rather than the oil price index (OP) seems to better reflect the behaviour expected of such a proxy. In particular, a positive shock to CP leads to higher prices and, after a while, higher interest rates. In contrast, a positive OP shock does not lead to increasing prices and hence obviously interest rates are never raised. Instead, what happens is interest rates are lowered to boost falling output. Nonetheless, even with CP included in the model, the price puzzle is still present. Presumably this implies CP is not able to completely capture inflationary expectations and/or the policymaker always reacts late to rising prices. Nonetheless, when prices are expressed in terms of inflation rate instead of in levels, the price puzzle disappears. In this instance, CP is imperative in controlling for inflationary expectations especially when M1 is the policy instrument – without CP, the price puzzle is again present.

Four possibilities of policy instrument are examined; the 3-month interbank rate (R3M), statutory reserve requirement ratio (SRR), overnight interbank rate (RON) and monetary aggregates (M0, M1, M2 or M3) because there was no
official announcement of monetary policy stance until very recently; although, R3M was the unofficial indicator for many years. Accepting SRR and RON as policy instruments, means accepting their negligible impact on output and bank loans, as well as the failure of some diagnostic checks. However, both specifications have no price and exchange rate puzzles. R3M has no such negligible impacts, but has the exchange rate puzzle with no price puzzle. For the monetary aggregates, M1 appears to be the most suitable candidate with results conforming to a priori and intuition, and satisfying the diagnostic checks. It also has no exchange rate puzzle. Including R3M and M1 in the same specification, instead of M3, seems to suggest a tighter relationship between interest rates and M1, unlike M3. This is in agreement with the actual experience that M3 being a broader measure of money is influenced more by demand factors (those beyond the direct control of the central bank).

As alluded to above, the exchange rate puzzle is found in all specifications with R3M as the policy instrument, but not M1. Using NEER instead of ER does not change the results. The inclusion of the US variables, specifically, the US interest rates, is meant to control for the leader-follower effect in setting interest rates. Unfortunately, such intended control is at best inadequate for there is related evidence to suggest Malaysia's interest rate behaviour tends to follow that of the US.

As a robustness check as well as to see whether other specifications perform better that the original specification, six other alternative ordering schemes have been investigated. Placing the target variables of output and inflation after all the intermediate transmission variables affect the overall results in contributing to the presence of the price puzzle. On the other hand, swapping the ordering of the intermediate transmission variables does not matter. In terms of the scaled-down open economy specifications, the specification that only includes the US interest rates performs reasonably well (AO4) but not so for the completely closed economy specification (AO3). Nonetheless, all the scaled-down open economy specifications tend to fail the diagnostic checks in one way or another.
Appendix 4-1 Real GDP (YMY)\textsuperscript{22} vs. Growth in Real GDP (YGMY)

If the inflation rate is used instead of the CPI, the growth rate in real GDP can also be used to replace the level of real GDP. Likewise, policymakers do not target a level of GDP but instead aim for a growth rate of GDP. Besides, in the public domain, economic performance is often assessed and quoted in terms of the growth rate. However, this does not imply the level of GDP has no role to play since it is used in other forms of economic analyses. For example, in the calculations of the various financial and economic ratios of a country: GDP per capita, import coverage ratio, total debt to GDP, current account deficit to GDP, size of the stock market, bond market, etc.

Figure 4.25 IRFs to R3M Shock, replacing YMY with YGMY

As shown in Figure 4.25, the impulse responses based on the use of the growth rate in real output (YGMY)\textsuperscript{23} are fairly close to the original specification of using

\textsuperscript{22} The real GDP referred to here is the deseasonalised natural log of real GDP which in the plots are labelled as YMY\textsubscript{X11}, but for brevity, the X11 extension is dropped. The levels of real GDP used in the estimations are taken to mean the deseasonalised series, though in the text it will simply be YMY. However, the growth rates are based on the actual data (original data with seasonality). At any rate, calculated based on the deseasonalised data, the two growth rates are indistinguishable.
the deseasonalised natural log of real GDP (EMY). A few minor differences can be found. With YEMY, there is a clearer picture of persistence in deflation and a smaller exchange rate puzzle. The rise in R3M which declines gradually has also become more persistent and it takes longer to return to zero. This seems to have also translated into the persistency in BLR and L. In the case of loans, a R3M shock seems to have a lesser impact on reducing total credit and the time lag taken for loans to actually fall has increased. This is not comforting because it signals the futility of bank loans in driving economic growth, which is counterintuitive given the prominence of the banking system in financing the economy. Otherwise, this VAR system remains stable and has no autocorrelation and heteroscedasticity problems. Since there are only minor differences between the two and taking the view that banking loans should be more influential, the current specification using YMY will continue to be used.

23 The same adjustment is made to the US real GDP.
Chapter 5
Transmission Channels: A Contest

The previous chapter developed an open economy VAR model for Malaysia, and this chapter uses that model in a contest among the different monetary policy transmission channels. The results from the previous chapter show monetary policy actions and intermediate variable shocks are capable of influencing output and inflation, but they do not show which mechanism is more important. The aim of this chapter is therefore to uncover the relative strength of the different transmission channels in influencing output and inflation.

The chapter is divided into four sections. Section 5.1 looks at the methodology of isolating the impacts of the various monetary policy transmission channels which forms the basis of examining the relative strength of each channel. Section 5.2 presents the results of the basic model based on the original specification (AO0) as developed in Chapter 4. As in that chapter, results pertaining to both M1 and R3M shocks as indicators of the monetary policy stance will be shown. In addition, an alternative scaled-down open economy specification (AO4)\(^1\) that has been found to produce similar impulse responses to the original specification will also be included as comparison to see whether its results on the relative strength of the transmission channels are still comparable. Section 5.3 shows the results of the same contest based on some modifications to the original specification. These involve the pre-Asian crisis scenario, the pegging of the ringgit to the US dollar since September 1998 (AO7), and the invocation of complete block exogeneity and the incorporation of the pegging of the ringgit to the US dollar (AO8).\(^2\) The intention of presenting several sets of results is for robustness purposes and to examine how the overall conclusions would have differed if one or the other models was used

\(^1\) This is the specification that excludes all US variables bar the US interest rates.
\(^2\) AO7 and AO8 are the same modified models discussed in Section 4.2.3, Chapter 4. Although the latter is unstable, it is still worthwhile to inspect the qualitative results of the model, particularly over the typically plotted horizon of interest where the impulse responses still tend to be well-behaved.
instead of the preferred model, AO7. Likewise, it is also beneficial to inspect the
case before the Asian crisis to discover how the crisis may have altered the
relative strength of the transmission channels. It is encouraging to observe the
overall conclusion particularly with reference to the transmission channel that is
most important is rather robust to the different specifications. Section 5.4
concludes.

5.1 Shutdown Methodology

The key idea behind the examination of the relative strength of the monetary
policy transmission channels is to compare the impulse response functions of
the target variables of output and inflation, under two scenarios: a baseline
model versus a constrained model (Levy and Halikias 1997, Ludvigson, Steindel
and Lettau 2002, Ramey 1993). Any of the specifications discussed in the
previous chapter can represent a baseline model. As an illustration, let the
original specification (AO0) be the baseline model. Recall, AO0 comprises the
following 12 variables: 1. the commodity price index (CP), 2. the US inflation rate
(PFUS), 3. the US real output (YUS), 4. the US Fed Funds Rate (RUS), 5.
Malaysian inflation rate (PFMY), 6. real output (YMY), 7. money supply (M1), 8.
3-month interbank interest rate (R3M), 9. ringgit/US dollar exchange rate (ER),
10. stock price index (KLCI), 11. base lending rate (BLR), and 12. bank loans
(L).

The constrained model is equivalent to the baseline model but with a certain
channel shutdown. Therefore, the deviation of the constrained impulse response
function from the baseline impulse response function represents the strength of
that channel – the larger the deviation, the stronger or more important the
channel.

The reduced form representation of the basic model in the previous chapter can
be written as follows:

\[ Y_t = \hat{C}_t + \hat{\Phi}_1 Y_{t-1} + \hat{\Phi}_2 Y_{t-2} + \varepsilon_t, \]  

(5.1)

\(^3\) Helliwell and Higgins (1976) was an earlier work using this technique.
where $Y_t$ represents a $n \times 1$ matrix of variables, $\hat{C}$ represents a $n \times 2$ matrix of the estimated intercept terms and the Asian-crisis dummy, and $\hat{\Phi}_1$ and $\hat{\Phi}_2$ are $n \times n$ matrices of parameter estimates at lag one and two, respectively. In the original specification (AOO), $n=12$. The constrained model is that which sets certain coefficients (elements) in $\hat{\Phi}_1$ and $\hat{\Phi}_2$ to zero. Recall, there are four transmission channels of interest: exchange rate, asset price/wealth, interest rate and credit; which are represented by the respective variables: ER, KLCI, BLR and L. As an example, to shutdown the interest rate channel on inflation, the estimated coefficients of BLR in the inflation equation, $\hat{\phi}_{6,11}^1$ and $\hat{\phi}_{6,11}^2$, are set to zero; where the subscript “5” corresponds to the row of the Malaysian inflation (PFMY) equation, and the second subscript, “11”, corresponds to the ordering of the BLR in the model, while the superscripts “1” and “2” refer to lag one and two, respectively. The impulse response functions of inflation can then be calculated in the usual way and shall be labelled as “Without Interest Rate Channel”. Similarly, to shutdown the interest rate channel on output, the estimated coefficients of BLR in the Malaysian output equation, $\hat{\phi}_{6,11}^1$ and $\hat{\phi}_{6,11}^2$, are set to zero. In this case, the first subscript “6” refers to ordering of the Malaysian output variable (YMY) in the model. By following the same approach for each variable representing each transmission channel, the rest of the constrained impulse response functions can be obtained: the “Without Exchange Rate Channel”, “Without Asset Price/Wealth Channel”, and “Without Credit Channel”. In each case, the constrained impulse response refers to the case where that particular transmission is being shutdown or muted, as opposed to the baseline impulse response, where all the transmission channels are operating.

5.2 Results: Basic Model

5.2.1 Original Open-Economy Specification (AOO)

Figure 5.1 shows the results from the original specification (AOO) with the different transmission channels being muted. For comparison purposes, the results for both the R3M and M1 monetary policy shocks are shown. The
impulse response of the baseline model, that is without any of the transmission channels muted is also shown by a solid line. Examining the impulse response function of output to a R3M shock first (Panel A1), suggests that within the first eight quarters after a positive interest rate shock or a tightening of monetary policy, the interest rate channel seems to be the most prominent channel in transmitting the monetary policy shocks to real output. This is followed by the asset price/wealth channel and, marginally behind, the exchange rate channel. Beyond that, however, the credit channel appears to be most prominent as well as the exchange rate channel. It is interesting to note that the impulse response with the exchange rate channel shutdown actually lies below the baseline impulse response. This seems counterintuitive because a positive interest rate shock should lead to ringgit appreciation which stimulates imports over exports leading to a fall in output. That is, if the exchange rate is shutdown, output should contract less, meaning the “Without Exchange Rate Channel” impulse response should lie above, not below, the baseline impulse response. This outcome is likely to be affected by the inability of the specification to account for the pegging of the ringgit to the US dollar. Soon after the pegging of the ringgit, Malaysia experienced an export boom, which helped to cushion the otherwise more adverse impact of the crisis on output. By muting the exchange rate channel, the impact of the export boom would have been curtailed and hence output would have contracted more.

In the case of the impulse response of output to a positive M1 shock or an easing of monetary policy (Panel A2), the results again show that within the first eight quarters following the shock, the interest rate channel is dominant, followed by the exchange rate channel and, marginally behind, the asset price channel. Subsequent to that, the credit channel seems to be the most dominant, along with the exchange rate channel. As in the case of R3M shock, the impulse response function muting the exchange rate channel seems counterintuitive. But this cannot be attributed to the exchange rate puzzle, a problem only found when R3M is the policy instrument, since it also appears in the results here with a M1 policy shock. (Recall from Chapter 4, in the case of M1 shock, the exchange rate puzzle is never present).
Another point worth noting is that the credit channel also seems to have a similar counterintuitive effect on real output in the first eight quarters, whereby switching off the credit channel following a positive interest rate shock counterintuitively worsens the contraction in real output as compared with the baseline scenario when the credit channel is operational (Panel A1). Or put differently, as in Panel A2, when the credit channel is switched off following an easing of monetary policy, real GDP increases more than when the credit channel is switched on. Nonetheless, a plausible reason for this can be seen from the results in Figure 4.16 (columns one and two, last plots) where bank credit increases initially after a tightening of monetary policy before falling.

Unlike Panel A, Panel B, where the target variable is now the inflation rate, shows a less clear distinction between the relative dominance of each channel across the different policy instruments. In Panel B1, where R3M is the policy instrument, the interest rate channel followed by the wealth channel seems most dominant in the first six and four quarters respectively. Beyond that the exchange rate channel seems most important, and the credit channel also has a notable role. However, in Panel B2, where M1 is the policy instrument, the interest rate channel followed by the exchange rate channel appears to be the most dominant conduits in the first eight quarters. Beyond that the credit channel becomes increasingly important, while the interest rate and exchange rate channels become less so. On the whole, the asset price channel also makes notable contributions especially at the longer-horizon.

To summarise, based on the original specification (AOO) when the target variable is real GDP, the interest rate channel is clearly most dominant in the first eight quarters across both types of shock. This is followed by the asset price channel, albeit only very marginally ahead of the exchange rate channel in the case of R3M shock (the opposite is true with M1 shock, again by not much). Beyond the eight quarters, the credit channel is far superior, regardless of the choice of policy instrument. On the other hand, when inflation is the target variable, the interest rate channel is again the most important conduit in the first six to eight quarters. Otherwise the exchange rate channel and the credit channel also make important contributions, depending on the choice of policy instruments and the horizon being examined. The asset price channel may not
stand out among the rest but it does nonetheless consistently make important contributions.

Figure 5.1 IRFs of YMY (Panel A) and PFMY (Panel B) to R3M and M1 Shocks based on the AO0 Specification: Comparison of Different Channels

Panel A1: IRF of YMY to R3M Shock

Panel A2: IRF of YMY to M1 Shock
5.2.2 A Scaled-down Open Economy Specification (AO4)

Next, the results based on the AO4 specification, which consists of the Malaysian block plus the commodity price index and the US interest rate, are examined (Figure 5.2). Again, results for R3M and M1 shocks are shown. Examining the target variable, real GDP first, Panel A1 shows the overall dominance of the interest rate channel and, much less, the asset price channel at the shorter horizon of less than 10 quarters. Again, there is very little difference between the asset price channel and the exchange rate channel in the beginning. Beyond that, the credit channel and the exchange rate channel are crucial. In Panel A2, similar observations are evident as in Panel A2, Figure 5.1, whereby the interest rate channel is again the most dominant conduit, followed by the exchange rate channel and the asset price channel. Beyond about 10 quarters, the credit channel takes over, while the exchange rate channel continues to be important.

In the case of the target variable being the inflation rate and the shock being R3M, Panel B1 shows the dominance of the interest rate channel and the asset price channel in the first four quarters. Subsequent to that, the exchange rate channel seems most important, while the interest rate channel also continues to be relevant. In Panel B2 where the shock is M1, the interest rate and exchange rate channels appear to be equivalently dominant, followed by the wealth channel. In both panels, the credit channel is the least important.

In comparison to AO0, in the case of the impulse response of real GDP, the results obtained from AO4 are largely the same, independent of the choice of the monetary policy instrument – the interest rate and asset price/exchange rate channels are most relevant in the short-horizon, and the credit channel after that. For the impulse response of inflation, there is less agreement between the two specifications apart from the overwhelming support for the interest rate channel, especially at the shorter horizon. For instance, at the shorter-horizon, in AO4 under both monetary policy instruments, the asset price channel is much more prominent than in AO0. At the longer horizon with M1 shock, the credit channel is least important in AO4, while being most prominent in AO0.
Figure 5.2 IRFs of YMY (Panel A) and PFMY (Panel B) to R3M and M1 Shocks based on AO4 Specification: Comparison of Different Channels

Panel A1: IRF of YMY to R3M Shock

Panel A2: IRF of YMY to M1 Shock
Cont'd

Panel B1: IRF of PFMY to R3M Shock

Panel B2: IRF of PFMY to M1 Shock
To summarise, the different specifications do not seem to matter when real GDP is the target variable, in which case the results overwhelmingly support the interest rate channel followed by the asset price and exchange rate channels as the most important conduits over the shorter horizon of less than 10 quarters, and the credit channel beyond that. However, the same cannot be said for inflation. While the interest rate channel is still important at the shorter-horizon; at the longer-horizon the results with M1 shock show the credit channel is dominant in AO0, while with R3M shock, the exchange rate channel is dominant in both AO0 and AO4.

Table 5.1 The Relative Importance of Each Channel (most important first): AO0 and AO4

<table>
<thead>
<tr>
<th>Specification</th>
<th>Short-Horizon</th>
<th>Longer-Horizon</th>
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<tr>
<td></td>
<td>R3M Shock</td>
<td>M1 Shock</td>
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<td>AO0 (Original Open Economy)</td>
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<tr>
<td>YMY</td>
<td>Interest Rate,</td>
<td>Interest Rate,</td>
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<tr>
<td></td>
<td>Asset Price,</td>
<td>Exchange Rate,</td>
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<td>Asset Price</td>
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<tr>
<td></td>
<td>(8 qtrs)</td>
<td>(8 qtrs)</td>
</tr>
<tr>
<td>PFMY</td>
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<td>Interest Rate,</td>
</tr>
<tr>
<td></td>
<td>(6 qtrs),</td>
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<tr>
<td></td>
<td>Asset Price</td>
<td>Credit,</td>
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<tr>
<td></td>
<td>(4 qtrs),</td>
<td>(8 qtrs),</td>
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<tr>
<td></td>
<td>Exchange Rate</td>
<td>Asset Price</td>
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<td>(6 qtrs)</td>
<td>(4 qtrs),</td>
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AO4 (Scaled-down Open Economy)

<table>
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<th>Longer-Horizon</th>
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<td>M1 Shock</td>
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<tr>
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<td>(10 qtrs)</td>
<td>(10 qtrs)</td>
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<tr>
<td>PFMY</td>
<td>Interest Rate</td>
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<td>(4 qtrs)</td>
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<tr>
<td></td>
<td></td>
<td>Asset Price</td>
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5.3 Further Results: Modified Models

This section presents the results of the same contest from three modified models. The first model is essentially the same as the basic model (the original specification) but it is estimated with the pre-Asian crisis data only. The second model (AO7) is the one that accounts for the pegging of the ringgit to the dollar since September 1998. The third model (AO8) incorporates complete block
exogeneity of the US block to the Malaysian block and the pegging of the ringgit to the US dollar. The latter two models are the same as those discussed in Section 4.2.3, Chapter 4.

Overall, in terms of the most important channel in transmitting monetary policy actions to output and inflation, both R3M and M1 shocks in all cases support the interest rate channel in the short-horizon, and the credit channel at the longer-horizon. However, there are some minor differences among the secondary channels, and depending on the choice of monetary policy indicator being R3M or M1.

5.3.1 Pre-Asian Crisis Model

Under this scenario, the estimation is done on the sample prior to the Asian crisis; that is, prior to 1997:1, giving a total of 65 observations. The results are presented in Figure 5.3. Table 5.2 summarises these results and also the results of other modifications. For ease of comparison, the results of the original specification with full-sample period (AO0) are reproduced in the top part of Table 5.2.

In the case of the response of output (Panel A, Figure 5.3), both sets of results are qualitatively the same regardless of whether the shock is due to R3M or M1: the interest rate and asset price channels are most important at the short-horizon, beyond that the credit channel dominates (cf. Panel A, Figure 5.1). The only notable exception is that under this scenario, the exchange rate channel appears to be least important. This is suggestive of the enhanced role of the exchange rate channel caused by the Asian crisis related events in the original specification with full-sample period. The other only slight exception is that the interest rate and asset price channels also seem to be relevant at the longer horizon. In terms of the impulse response of inflation (Panel B, Figure 5.3), the result reinforces the importance of the interest rate channel at the short-horizon, and the credit channel at the longer-horizon. The only notable exception is in the case of R3M shock, where the full-sample result shows an overwhelming importance of the exchange rate channel at longer horizon, but in the case of the pre-crisis sample, the credit channel is most important.
Figure 5.3 IRFs of YMY (Panel A) and PFMY (Panel B) to R3M and M1 Shocks based on AOO Specification: Pre-Crisis Sample
Cont’d

Panel B1: IRF of PFMY to R3M Shock

Panel B2: IRF of PFMY to M1 Shock
5.3.2 Pegged Exchange Rate Model (AO7)

In the second modification, the original specification (AO0) is altered to account for the pegging of the ringgit to the US dollar. This entails estimating the same equation as Equation (5.1) but now the $C$ matrix has two additional interaction dummy terms: one with the exchange rate variable at lag one, and the other with the exchange rate variable at lag two. The dummy variable takes the value of "0" from 1981:1 to 1998:2, "1" from 1998:3 to 2004:1.

Comparing the results of this modification (Figure 5.4) with that of the original specification (Figure 5.1), for the impulse responses of output and inflation to R3M and M1 shocks, the results again largely show the dominance of the interest rate channel at the short-horizon, and the credit channel subsequent to that. For the impulse response of output in particular, there is also greater consistency of results between the choice of monetary policy instruments – the asset price channel looks more dominant than the exchange rate channel at the short-horizon, and over the longer-horizon (in the original specification (AO0), the asset price channel is irrelevant at the longer-horizon). On the other hand, there are some differences, particularly with respect to the impulse response of inflation. For one, the asset price channel is now more muted in both the cases of R3M and M1 shocks, and as a result, the role of the exchange rate channel becomes relatively more prominent, especially with R3M shock. For the latter shock, however, at the longer-horizon, the credit channel becomes more dominant; in contrast, in the original specification, the exchange rate channel is most important at the longer-horizon. Conceivably, by including the interaction dummy variables, the otherwise more zealous effects of the exchange rate channel during the Asian crisis, appear to have been better controlled. In turn, this seems to have made the overall results more akin to the pre-crisis scenario, especially at the longer-horizon, where the credit channel is much more dominating.
Figure 5.4 IRFs of YMY (Panel A) and PFMY (Panel B) to R3M and M1 Shocks based on the Pegged Exchange Rate Model (A07)

Panel A1: IRF of YMY to R3M Shock

Panel A2: IRF of YMY to M1 Shock
Panel B1: IRF of PFMY to R3M Shock

Panel B2: IRF of PFMY to M1 Shock
5.3.3 Complete Block Exogeneity and Pegged Exchange Rate Model (AO8)

This modification estimates the original model with complete block exogeneity together with the inclusion of the pegged exchange rate interaction dummy variables. In this case, unlike the previous estimation, the interaction dummy variables only appear in the Malaysian block. Both the US block and the Malaysian blocks are estimated as a single VAR system. As can be seen from Figure 5.5, and in comparison with Figure 5.4 (from the previous case), both sets of results are largely the same. In terms of output impulse response (Panel A), regardless of the type of shock, the interest rate channel followed by the asset price and the exchange rate channels continue to remain most important over the short-horizon. The only exception is the rather muted impact of the credit channel to the R3M shock at the longer horizon. For that matter, all the transmission channels are rather subdued at the longer-end. As for M1 shock, the credit channel is again dominant at the longer-end. For the inflation impulse response, the results are essentially the same as Panel B, Figure 5.4: the dominance of the interest rate and the exchange rate channels at the shorter-end, and the credit channel at the longer-end, especially with M1 shock.
Figure 5.5 IRFs of YMY (Panel A) and PFMY (Panel B) to R3M and M1 Shocks based on the Complete Block Exogeneity and Pegged Exchange Rate Model (AO8)

Panel A1: IRF of YMY to R3M Shock

Panel A2: IRF of YMY to M1 Shock
Panel B1: IRF of PFMY to R3M Shock

Panel B2: IRF of PFMY to M1 Shock
To summarise, in comparison to the original model without modification (AOO), the estimation based on the pre-crisis sample does not change the overall result, in that the interest rate channel is still most important at the short-horizon, and the credit channel beyond that. If anything, the inclusion of the crisis period appears to have enhanced the role of the exchange rate channel, especially at the shorter-horizon. In fact, in the original specification full-sample case (AOO), at the longer-horizon when R3M is the policy instrument, the exchange rate channel appears to be most important. Nonetheless, it would be unfortunate to restrict any analysis to the pre-crisis sample, not least because it throws away seven years worth of observations. Given the degrees of freedom limitations of VAR models, the need for more data should take on a higher priority.

To fully utilise all information, interaction dummy variables are included in the model to account for the pegging of the ringgit. This produces some interesting findings, though it must be stressed the overall results are not markedly different from the original specification without the interaction dummy variables. In this case, the interest rate channel’s dominance continues to be unchallenged, but there seems to be a clearer role for the asset price channel in influencing output vis-à-vis the exchange rate channel. In contrast, in the case of inflation rate, there is an absence of the asset price channel, while the interest rate and the exchange rate channels remain important. Hence, it seems including the interaction dummy variables have weakened somewhat the role of the exchange rate channel in affecting output, as well as the asset price channel on inflation.

When block exogeneity with interaction dummy variables are applied to the full-sample, there is again an absence of the asset price channel in influencing the inflation rate. Compared with the case without complete block exogeneity, the only difference is the rather weak effect of the credit channel on output at the longer-horizon, with R3M shock. Otherwise, the results are comparable to the case without complete block exogeneity. On the whole, there is certainly an obvious advantage to include the entire sample in the estimation, and to do this appropriately means to also include the interaction dummy variables to control for the pegging of the ringgit to the US dollar. Yet, it is not obvious that applying the more representative feature of complete block exogeneity changes the overall results in any meaningful way. Moreover, the model is unstable.
Table 5.2 The Relative Importance of Each Channel (most important first): Various Models

<table>
<thead>
<tr>
<th>Specification</th>
<th>Short-Horizon</th>
<th>Longer-Horizon</th>
<th>Short-Horizon</th>
<th>Longer-Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R3M Shock</td>
<td>M1 Shock</td>
<td>R3M Shock</td>
<td>M1 Shock</td>
</tr>
</tbody>
</table>

**Original Full-Sample (AO0)**

<table>
<thead>
<tr>
<th>YMY</th>
<th>Interest Rate, Asset Price, Exchange Rate (8 qtrs)</th>
<th>Interest Rate, Exchange Rate, Asset Price (8 qtrs)</th>
<th>Credit</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFMY</td>
<td>Interest Rate (6 qtrs), Asset Price (4 qtrs), Exchange Rate</td>
<td>Interest Rate, Exchange Rate (8 qtrs), Asset Price</td>
<td>Exchange Rate, Credit, Interest Rate</td>
<td>Credit, Asset Price, Exchange Rate</td>
</tr>
</tbody>
</table>

**Pre-crisis Sample (AO0 pre-crisis)**

<table>
<thead>
<tr>
<th>YMY</th>
<th>Interest Rate, Asset Price (12 qtrs)</th>
<th>Interest Rate, Asset Price (9 qtrs)</th>
<th>Credit, Interest Rate, Asset Price</th>
<th>Credit, Asset Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFMY</td>
<td>Interest Rate (8 qtrs), Exchange Rate, Asset Price (5 qtrs)</td>
<td>Interest Rate (8 qtrs), Asset Price, Credit, Exchange Rate</td>
<td>Credit, Asset Price, Exchange Rate</td>
<td>Credit, Asset Price, Exchange Rate</td>
</tr>
</tbody>
</table>

**Pegged Exchange Rate Model (AO7)**

<table>
<thead>
<tr>
<th>YMY</th>
<th>Interest Rate, Asset Price (8 to 10 qtrs), Exchange Rate</th>
<th>Interest Rate, Asset Price (9 qtrs), Exchange Rate</th>
<th>Credit, Asset Price, Exchange Rate</th>
<th>Credit, Asset Price, Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFMY</td>
<td>Interest Rate (7 qtrs), Exchange Rate, Credit (4 qtrs)</td>
<td>Interest Rate (8 qtrs), Exchange Rate (4 qtrs)</td>
<td>Credit, Interest Rate</td>
<td>Credit, Interest Rate</td>
</tr>
</tbody>
</table>

**Block Exogeneity and Pegged Exchange Rate Model (AO8)**

<table>
<thead>
<tr>
<th>YMY</th>
<th>Interest Rate (16 qtrs), Asset Price (8 qtrs), Exchange Rate (4 qtrs)</th>
<th>Interest Rate, Asset Price (8 qtrs), Exchange Rate (4 qtrs)</th>
<th>Credit (from 17th qtr), Exchange Rate (10th to 16th qtr)</th>
<th>Credit, Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFMY</td>
<td>Interest Rate (6 qtrs), Exchange Rate (4 qtrs)</td>
<td>Interest Rate (8 qtrs), Exchange Rate (5 qtrs)</td>
<td>Credit (marginally)</td>
<td>Credit</td>
</tr>
</tbody>
</table>
5.4 Conclusions

In this chapter, the relative importance of the four main monetary policy transmission channels (interest rate, asset price/wealth, exchange rate and credit) is evaluated. The methodology that does this compares the impulse response of the target variables (output and inflation) of the baseline model versus that of the constrained model. Effectively, there are four impulse responses derived from the constrained model. Each corresponds to the case where a particular channel is shutdown. To gauge the robustness of the overall results, besides the original specification, several alternative models are explored. The first is a scaled-down open economy model of the original specification. The second is essentially the original specification but restricts the sample size to pre-Asian crisis. The third accounts for the pegging of the ringgit to the US dollar, and the fourth invokes complete block exogeneity and incorporates the pegged exchange rate. Since both the 3-month interbank interest rate (R3M) and M1 have shown to be a reasonable monetary instrument, all impulse response functions presented are in response to these shocks. Fittingly, this also serves as an additional robustness check.

On the whole, the results show the interest rate channel is the most important channel within a horizon of about two years, and the credit channel beyond that. This finding is largely consistent across both target variables, the choice of R3M or M1 as monetary policy instrument and the different modifications. Nonetheless, there are some minor variations with respect to the transmission channels of secondary importance. Taking the model with the pegged ringgit interaction dummy variables as the most reasonable specification, the asset price channel followed by the exchange rate channel also appear to be important in the short-horizon, particularly in influencing output. On the other hand, for inflation, the exchange rate channel is also dominant, while the asset price channel is almost irrelevant. The results from the model with complete block exogeneity and the pegged ringgit interaction dummy variables are also largely comparable.

Not accounting for the pegged ringgit appears to have boosted the role of the exchange rate channel, to the extent that in the case of the impulse response of
inflation to M1 shock, the exchange rate channel stands out as the most important conduit at the longer-horizon. This finding is most obvious in the scaled-down open economy model; even as the credit channel becomes irrelevant. In fact, in the pre-crisis sample, if this may be likened to normal times, the exchange rate channel is also found to play a minimal role in transmitting monetary policy actions to output, and marginally more important, to inflation. Qualitatively, the results from the pre-crisis sample are similar to the model with the pegged ringgit interaction dummy variables. Presumably, the inclusion of the interaction dummy variables has the desired effect of controlling for the more volatile circumstance.

The exchange rate puzzle found with R3M shock does not seem to cause any major problem to the overall analysis; its results are qualitatively similar to the case with M1 shock. This further suggests that on the whole, either R3M or M1 would be a reasonable proxy for monetary policy stance.
Appendix 5-1 Inflation Rate is Calculated as Preceding Change

This appendix attempts to show whether the overall findings would differ if inflation was measured as preceding change instead of quarter-on-quarter change. The results are summarised in Table 5.3. As a comparison, the results from Table 5.1 using quarter-on-quarter inflation rate based on the same specification, AOO, are also included. Note that the results are qualitatively the same (Figure 5.6). But now there is evidence of the price puzzle.

Table 5.3 The Relative Importance of Each Channel (most important first): Different Inflation Rate Calculations

<table>
<thead>
<tr>
<th>Specification</th>
<th>Short-Horizon</th>
<th></th>
<th>Longer-Horizon</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R3M</td>
<td>M1</td>
<td>R3M</td>
<td>M1</td>
</tr>
<tr>
<td>AOO (Qtr-o-Qtr Change)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YMY</td>
<td>Interest Rate, Interest Rate, Credit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asset Price, Exchange Rate, Asset Price</td>
<td>Asset Price, Exchange Rate, Asset Price</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6 qtrs)</td>
<td>(6 qtrs)</td>
<td>(8 qtrs)</td>
<td>(8 qtrs)</td>
</tr>
<tr>
<td>PFMY</td>
<td>Interest Rate, Interest Rate, Exchange Rate, Credit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asset Price, Exchange Rate, Asset Price</td>
<td>Exchange Rate, Interest Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6 qtrs), Asset Price, Exchange Rate</td>
<td>(8 qtrs), Asset Price</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4 qtrs), Asset Price</td>
<td>(4 qtrs), Asset Price</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AOO (Preceding Change)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YMY</td>
<td>Interest Rate, Interest Rate, Credit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asset Price, Asset Price</td>
<td>Asset Price, Asset Price</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8 qtrs)</td>
<td>(10-12 qtrs)</td>
<td>(10-12 qtrs)</td>
<td>(10-12 qtrs)</td>
</tr>
<tr>
<td>PFMY</td>
<td>Interest Rate, Exchange Rate, Credit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asset Price, Interest Rate, Asset Price</td>
<td>Exchange Rate, Exchange Rate, Asset Price</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4 qtrs)</td>
<td>(4 qtrs)</td>
<td>(4 qtrs)</td>
<td>(4 qtrs)</td>
</tr>
</tbody>
</table>
Figure 5.6 IRFs of YMY (Panel A) and PFMY (Panel B) to R3M and M1 Shocks based on the A00 Specification: When Inflation is calculated as Preceding Change

Panel A1: IRF of YMY to R3M Shock

Panel A2: IRF of YMY to M1 Shock
Panel B1: IRF of INFMY to R3M Shock

Panel B2: IRF of INFMY to M1 Shock
Chapter 6
Malaysia in G-Cubed

This chapter is divided into two separate parts. The first part discusses the theoretical underpinnings of G-Cubed. The second presents simulation results on Malaysia with the aim of highlighting the characteristics of the G-Cubed model. It will be apparent that the richness of G-Cubed enables in depth and extensive analyses on the myriad interconnectedness in an economy far beyond the purview of VAR models, besides its notable strength in performing counterfactual experiments.

6.1 Theoretical Framework of G-Cubed

G-Cubed is a multi-country, multi-sector, dynamic intertemporal general equilibrium model. The model's building blocks are derived from international trade theory, macroeconomics and microeconomics. Different degrees of adoption of these strands of studies distinguish the three major types of large structural models namely, computable general equilibrium (CGE) models, real business cycle models, and Keynesian macroeconometrics. In essence, G-Cubed's theoretical underpinnings are built on the foundation of these three models.

As in international trade theory, G-Cubed divides countries into regions linked together via bilateral trade flows. Goods produced in different regions are assumed to be imperfect substitutes i.e., there is a bias on home-made goods (the Armington assumption). Unlike trade models, financial and physical capital flows are differentiated. Financial capital flows are perfectly mobile across sectors, and regions and driven by forward-looking investors seeking arbitrage opportunities. Physical capital flows are immobile after they are installed across sectors and regions. Intertemporal budget constraints are imposed on regions, meaning trade deficits must be fully met by future trade surpluses.
As in the CGE model, each country comprises a multi-sector CGE component. Each sector's production function is estimated econometrically from the cost function. Unlike traditional CGE models, macroeconomics is applied to determine savings and investment based on forward-looking intertemporal optimisation of households and firms. Households maximise their utility subject to a lifetime budget constraint, while firms maximise their stock market values.

From macroeconomics, international capital flows are determined by intertemporal optimisation as alluded to above. This has the advantage in tracking short and longer-term dynamics. Households are assumed to be liquidity constrained and nominal wages are slow to adjust. This is meant to capture the empirical regularity in the real world. Finally, in the model, money is used for transactions and central banks set interest rates based on a monetary policy reaction function. Table 6.1 summarises the key features of G-Cubed.

Table 6.1 Five Key Features of G-Cubed

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explicit intertemporal optimisations by households and firms in the economy, subject to explicit intertemporal budget constraints, which allow analysis on time and dynamics unlike most standard CGE models.</td>
</tr>
<tr>
<td>2.</td>
<td>Incorporates myopic and liquidity constraint households which allow for short-run deviations from optimal behaviour in order to better track empirical reality. However, the long-run still follows a single intertemporal optimising equilibrium à la the Solow/Swan/Ramsey neoclassical growth model.</td>
</tr>
<tr>
<td>3.</td>
<td>Explicit introduction of money as a means to purchase goods and services, and as a component in the holding of financial assets.</td>
</tr>
<tr>
<td>4.</td>
<td>Presence of short-run wage rigidity which allows for periods of unemployment in an economy. This and the inclusion of money mimic the features of macroeconometric models but not the standard market clearing assumption of CGE models.</td>
</tr>
<tr>
<td>5.</td>
<td>Physical capital is sticky while financial capital is mobile flowing to avenues with the best expected returns. This distinguishes the quantity of physical capital available at any point, and the valuation of that capital which is influenced by the allocation of financial capital.</td>
</tr>
</tbody>
</table>

G-Cubed was initially built in response to the debate on environmental and international trade in the context of global warming policies, but has since expanded and made useful contributions in other areas of macroeconomic and microeconomic policy issues. For example, McKibbin and Wilcoxen (2002) look at environmental regulations on climate change and propose an alternative, economically and politically more realistic approach to the Kyoto Protocol; Lee,
McKibbin and Park (2004) examine the current debate on causes and remedies of the trade imbalances between the US and the East Asian economies; McKibbin and Martin (1998) explain the causes and policy responses of the Asian crisis; McKibbin (1999) discusses the impacts of financial liberalisations and the changing risk perceptions on the APEC economies and policy dilemma dealing with these issues; McKibbin (1998a) studies the unilateral, regional and multilateral impacts of trade liberalisations with particular emphasis on the Asia-Pacific economies, distinguishing their short-term and sometimes painful adjustment effects, from the much vaunted and largely positive long-term gains; and McKibbin and Le (2004) assess the suitability of different exchange rate regimes in Asia in the aftermath of the 1997 Asian Crisis. Many of these issues are summarised by McKibbin and Vines (2000), together with other studies which used the MSG2 model looking at the effects of Reaganomics on Europe in the early 1980s, German reunification, the impact of the North Atlantic Free Trade Area, and the impacts of the Maastricht targets and the Stability and Growth Pact.

G-Cubed is actually an amalgamation of the MSG2 model, a multi-country single sector dynamic intertemporal general equilibrium model (McKibbin and Sachs 1991), and the disaggregated, econometrically estimated, general equilibrium model of the US economy developed by Jorgenson and Wilcoxen (1990). Hence, the main difference between MSG2 and G-Cubed is the larger number of sectoral breakdowns and the greater use of econometrically estimated parameters in the latter. Currently, G-Cubed is made up of 13 countries (groupings) with 12 sectoral breakdowns in each country. In addition, the standard G-Cubed has given birth to other variants. Asia-Pacific (AP) G-Cubed focuses more on the Asian countries (19 in total) but with only 6 sectors, while G-Cubed (Agriculture), developed for the US Agriculture Department, has greater agricultural sectoral breakdowns (see Table 6.2). There is also a capital producing sector in all the models.
Table 6.2 Countries and Sectoral Coverage of MSG2, G-Cubed, AP G-Cubed and G-Cubed (Agriculture)

<table>
<thead>
<tr>
<th>MSG2</th>
<th>G-Cubed</th>
<th>AP G-Cubed</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>United States</td>
<td>Australia</td>
<td>1.</td>
</tr>
<tr>
<td>5.</td>
<td>Canada</td>
<td>5. Japan</td>
<td>5.</td>
</tr>
<tr>
<td>11.</td>
<td>China</td>
<td>11. Other non-oil developing countries</td>
<td>11. Taiwan</td>
</tr>
<tr>
<td>12.</td>
<td>Taiwan</td>
<td>12. Rest of Latin America</td>
<td>12. Thailand</td>
</tr>
<tr>
<td>15.</td>
<td>Thailand</td>
<td>15. Oil Exporting Developing Countries</td>
<td>15. United States</td>
</tr>
<tr>
<td>16.</td>
<td>India</td>
<td>16. Other Developing Countries</td>
<td>16. United States</td>
</tr>
<tr>
<td>17.</td>
<td>Philippines</td>
<td>17. Developing Countries</td>
<td>17. United States</td>
</tr>
<tr>
<td>18.</td>
<td>Hong Kong</td>
<td>18. Non-Oil Developing Countries</td>
<td>18. United States</td>
</tr>
</tbody>
</table>

**Sectors:**

1. Single

1. Electric Utilities

2. Gas Utilities

3. Petroleum Refining

4. Coal Mining

5. Crude Oil and Gas Extraction

6. Other Mining

7. Agriculture, Fishing and Hunting

8. Forestry and Wood Products

9. Durable Manufacturing

10. Non-durable

1. Energy

2. Mining

3. Agriculture

4. Durable Manufacturing

5. Non-Durable Manufacturing

6. Services

7. Food Grains (rice and wheat)

8. Feed Grains

9. Non-Grain Crops

10. Livestock and its Products

11. Processed Food

12. Forest and Fishery Mining

13. Energy

14. Textile and Clothing

15. Other Non-
6.1.1 Model Structure

This section provides a broad overview of the theoretical structure of G-Cubed, particularly in the context of the intertemporal optimisation problems faced by agents in the economy. There are four types of agents in a country or region: households, firms, government, and the financial sector. Since there is one firm in each sector, this means there are 12 firms in G-Cubed and six in AP G-Cubed. They are six types of markets: goods and services, factors of production, money, bond, equity and foreign exchange. Both the supply and demand side of an economy are explicitly modelled.

6.1.1.1 Firms

Each sector has a firm, which chooses input factors and investment level to maximise stock market value subject to a multiple-input production function and exogenously given prices. The production technology follows a constant elasticity of substitution (CES) function. Output is produced by a firm that chooses a combination of capital, labour, energy and materials:

\[ Q_j = A_j \left( \sum_{i=K,L,E,M} (\delta^i)^{(\sigma^i - 1)} X_j^{(\sigma^i - 1) / \sigma^i} \right)^{1 / (\sigma^i - 1)} \]  

(6.1)

This section is largely based on McKibbin and Wilcoxen (1995, 1999) and McKibbin and Vines (2000).
where $Q_i$ is the output of sector $i$, $X_{ij}$ is the sector $i$'s use of input $j$, $A_i^o$ is the parameter of technological progress, $\sigma_i^o$ is the elasticity of substitution, and $\delta_i^o$ represents the different input weights in production ($\sum \delta_i^o = 1$); subscript $o$ represents the parameters that apply to the top tier.

In addition, inputs from the 12 sectors are used to produce energy and materials. To produce energy, $X_{iE}$, a firm chooses goods from sectors 1 to 5, while to produce materials, $X_{iM}$, a firm chooses goods from sectors 6 to 12. Similar to the production of $Q_i$, the production technology of energy and materials also follow a CES function, with the corresponding parameter: $A_{iE}^o, \delta_{iE}^o$ and $\sigma_{iE}^o$; and $A_{iM}^o, \delta_{iM}^o$ and $\sigma_{iM}^o$ as similarly defined above.

Equation (6.1) may give the impression that only domestic inputs are used in production, but that is only partially true. To account for the use of foreign inputs, $Y_i$ is defined as the composite output produced in sector $i$ which is made up of domestic inputs ($Q_i$) and foreign inputs ($M_i$). Both these inputs are assumed to be imperfect substitutes and $Y_i$ follows a CES production function as follows:

$$Y_i = A_i^o \left( \left( \delta_i^{oE} \right)^{1/\sigma_i^o} Q_i^{\sigma_i^o - 1/\sigma_i^o} + \left( \delta_i^{oM} \right)^{1/\sigma_i^o} M_i^{\sigma_i^o - 1/\sigma_i^o} \right)^{1/\sigma_i^o},$$

(6.2)

where $\sigma_i^{o}$ is the elasticity of substitution between domestic and foreign inputs.

The imported input $M_i$ is itself a composite of imports from other countries $M_{ic}$, where the subscript $c$ indicates the country of origin:

$$M_i = A_i^o \left( \sum_{c=1}^{12} \left( \delta_i^{oc} \right)^{1/\sigma_i^{oc}} M_{ic}^{\sigma_i^{oc} - 1/\sigma_i^{oc}} \right)^{1/\sigma_i^{oc}},$$

(6.3)

where $\sigma_i^{oc}$ is the elasticity of substitution between imports from different countries. The model also assumes agents have identical preferences over domestic and foreign inputs of each commodity. This implies that, for example, both the transportation and services sectors have the same preference over
foreign oil input and domestic oil input. Figure 6.1 illustrates diagrammatically the production nesting of G-Cubed.

**Figure 6.1 Production Nesting of G-Cubed**

\[
Y_t = A^n \left( \left( \delta^n_y \right)^{\nu_y} Q^{(\alpha^n_y) \cdot \nu_y} + (\delta^n_y)^{\nu_y} M^{(\alpha^n_y) \cdot \nu_y} \right)^{\nu_y \cdot (\alpha^n_y - 1)}
\]

\[
M_i = A^n \left( \sum_{0=1}^{12} \left( \delta^n_y \right)^{\nu_y} M_i^{(\alpha^n_y) \cdot \nu_y} \right)^{\nu_y \cdot (\alpha^n_y - 1)}
\]

\[
Q_y = A^n \left( \sum_{i=1}^{12} \delta^n_y^{\nu_y} X_i^{\nu_y \cdot (\alpha^n_y - 1)} \right)^{\nu_y \cdot (\alpha^n_y - 1)}
\]

1. Electricity  
2. Natural Gas  
3. Petroleum  
4. Coal  
5. Crude Oil  
6. Mining  
7. Agriculture  
8. Forestry/Wood Products  
9. Durable Manufacturing  
10. Non-Durable Manufacturing  
11. Transportation  
12. Services

In each sector, capital stock evolves according to the standard dynamics:

\[
\dot{K}_i = J_i - \delta_i K_i,
\]

where \(J_i\) is the rate of fixed capital formation and \(\delta_i\) is the rate of geometric depreciation.

Assuming investment \((I)\) follows the adjustment cost models and subject to rising marginal cost of installation, gross investment can be expressed as follows:

\[ J \text{ can be likened to net investment, and } I \text{ to gross investment, both in units.} \]
\[ I_j = \left(1 + \frac{\phi_i J_i}{2 K_i}\right) J_i, \tag{6.5} \]

where \( J/K \) is the rate of investment and \( \phi \) is a non-negative parameter.

Equation (6.5) says that to install capital \( J \), a firm must buy a larger quantity of \( I \) since it is costly to install new capital, which is influenced by \( J/K \).

The objective of each firm is to maximise intertemporal after-tax profits \( \pi_j \) by choosing its investment and inputs of labour, materials and energy:

\[
\int_t^s [\pi_j - (1-\tau_4)P_t I_t] e^{-(R(s)-n)(s-t)} ds, \tag{6.6}
\]

where \( \pi_j = (1-\tau_2)(P^*Q_i - W_i L_i - P^E X_{iW} - P^M X_{im}) \)

\[
R(s) = \frac{1}{s-t} \int_t^s r(v) dv.
\]

Note \( \tau_4 \) is an investment tax credit and \( \tau_2 \) is the corporate tax rate, \( P^* \) is price of output, \( R(s) \) is the interest rate between period \( s \) and \( t \). Solving the Hamiltonian for Equation (6.6) subject to Equations (6.1) and (6.4), yields the following equations depicting a firm’s behaviour:

\[
X_j = \delta_j (A_i^{\phi_j})^{\phi_j-1} Q \left( \frac{P_i}{P^*} \right)^{\phi_j} \text{ where } j \in \{L,E,M\}, \tag{6.7}
\]

\[
\lambda_i = (1 + \phi_i J_i) (1 - \tau_4) P_i, \tag{6.8}
\]

\[
\frac{d\lambda_i}{ds} = (r + \delta_i) \lambda_i - (1 - \tau_2) P^* \frac{dQ_i}{dK_i} - (1 - \tau_4) P_i \phi_i \left( \frac{J_i}{2 K_i} \right)^2. \tag{6.9}
\]

Equation (6.7) is a firm’s factor demand for labour, energy and materials. Note \( \lambda_i \) is the shadow price of additional unit of investment in industry \( i \). Equation (6.9)

\[\text{Profits are discounted by an adjustment for the rate of population and productivity growth, } n.\]
is the optimal evolution of the capital stock. Integrating Equation (6.9) at the optimum path of investment and capital accumulation \( \hat{J}(t), \hat{K}(t) \) yields the following expression for \( \lambda_j \):

\[
\lambda_j(t) = \int_{\tau_1}^{\tau_2} \left[ (1-\tau_2)P_l \frac{dQ_l}{dK_l} + (1-\tau_2)P_l \phi J^j \right] e^{-(R(s)+\delta)(s-t)} ds. \tag{6.10}
\]

Hence, the shadow price of an additional unit of investment is determined by two components: the after-tax marginal product of capital (the first term on the right hand side), and savings in adjustment costs (the second term). This in fact relates to the after-tax marginal Tobin's \( q \):

\[
q_i = \frac{\lambda_i}{(1-\tau_2)P^i}. \tag{6.11}
\]

Given this relationship, Equation (6.8) can be re-expressed as:

\[
\frac{J}{K_i} = \frac{1}{\phi_i} (q_i - 1). \tag{6.12}
\]

Substituting this into Equation (6.5) gives another expression for gross investment:

\[
I_i = \frac{1}{2\phi_i} (q_i^2 - 1)K_i. \tag{6.13}
\]

The above equation represents the optimal investment, and to account for the empirical regularity that investment may also be sourced from a firm's retained earnings, the equation is modified to include a second component comprising a firm's profits adjusted for investment tax credit (Equation (6.14)). In addition, a weight of \( 1 - \alpha_2 \) is assigned to this component, while the first component takes
on a weight of $\alpha_2^4$. Equation (6.14) represents the investment demand for each sector:

$$I_i = \alpha_2 \frac{1}{2\phi} (q_i^2 - 1)K_i + (1 - \alpha_2) \frac{\pi_i}{(1 - r_s)}P^r. \quad (6.14)$$

Apart from the 12 industries mentioned above, the model also includes an additional sector that produces capital goods. This sector produces investment goods demanded by other sectors. The representative firm here faces the same optimisation problem as the firms in other sectors – it has a CES production function chooses capital, labour, energy and materials as inputs. It incurs the same adjustment cost when buying new capital stock. It earns no profits.

### 6.1.1.2 Households

Households in the model buy goods and services (and demand capital services), supply labour services and save. Using a representative agent to model households in each economy, the following intertemporal utility function of the representative agent is assumed:

$$U_t = \int_0^\infty \left[ \ln C(s) + \ln G(s) \right] e^{-\theta(s-t)} ds, \quad (6.15)$$

where $C(s)$ is the household’s aggregate consumption of goods and services at time $s$, and $G(s)$ is government consumption as a measure of public goods and services provided at time $s$, and $\theta$ is the rate of time preference.

The goal of the household is to maximise Equation (6.15) with the condition that the present value of human wealth, $H$, and financial wealth, $F$, must be equal to the present value of lifetime consumption as follows:

$$\int_0^\infty P^C(s)C(s) e^{-\theta(R(s)-\phi)s} ds = H_t + F_t. \quad (6.16)$$

$^4$ The value of $\alpha_2$ is empirically estimated as 0.3 based on McKibbin and Sachs (1991).
Human wealth is defined as the expected present value of the future stream of after-tax labour income and transfers:

$$H_i = \int (1 - \tau_i) \left[ W(L^G + L^C + L' + \sum_{i} L_i') + TR \right] e^{-[R(s)-\rho][s-t]} ds , \quad (6.17)$$

where $\tau_i$ is the income tax rate; $W(L^G + L^C + L'^{L'})$ is income in government employment, from producing final consumption, producing investment goods, and employment in sector $i$, respectively; and $TR$ is government transfers.

In turn, financial wealth is defined as the sum of real money balances, $MON/P$, public holdings of real government bonds, $B$, net holding of claims against foreign residents, $A$, and the value of capital stock in each sector ($K'$) including the investment goods supply sector ($K'$) and the provision of household capital services sector ($K''$), and holdings of emission permits, $Q'_i$:

$$F_i = \frac{MON}{P} + B + A + q'K' + q''K'' + \sum_{1}^{12} q'K' + \sum_{1}^{12} P_i Q'_i . \quad (6.18)$$

Setting up the Hamiltonian and solving for the optimisation problem yields the following standard result, among others, that aggregate consumption expenditure is a constant proportion of human wealth and financial wealth:

$$P^C C = \theta(F_i + H_i) . \quad (6.19)$$

This equation captures the intertemporal optimising behaviour of the household and the insights advocated by the real-business-cycle models – the forward looking component. It also implies the presence of Ricardo equivalence. However, to enhance the model’s empirical realism, Equation (6.19) is modified to include a backward-looking component which is determined by a part of current after-tax income ($\gamma INC$) to reflect, for example, liquidity constrained households:

---

5 For more details, see pages 47-48 of McKibbin and Sachs (1991) for an application based on the MSG2 model.
\[ P^C = \alpha_s \theta (F_t + H_t) + (1 - \alpha_s) \gamma \textrm{INC}. \] 

(6.20)

This rule of thumb is chosen to ensure the same steady-state behaviour as the optimising agent's so that in the long-run there is only one intertemporal equilibrium. Hence, total consumption spending is a weighted average of intertemporal smoothed consumption \( \alpha_s \) and liquidity constraint consumption \((1 - \alpha_s)\). The latter group of consumers is generally assumed to be larger and given a weight of 70 per cent. Note the inclusion of this additional component implies the absence of full Ricardo equivalence.

With the overall consumption expenditure determined, spending is divided into various goods and services according a two-tier CES utility function. At the top level, spending on capital, labour, energy and materials can be obtained as:

\[ P_i X_{Ci} = \delta_{Ci} P^C \left( \frac{P^C}{P_i} \right)^{\sigma_{C_i} - 1} \quad \text{where} \quad i \in \{K, L, E, M\}. \]

(6.21)

\( X_{Ci} \) is the household demand for good \( i \), \( \delta_{Ci} \) is the input-specific parameter of the utility function and \( \sigma_{C_i} \) is the elasticity of substitution of the top tier utility function. \( P^C \), the price index of consumption is equal to:

\[ P^C = \left( \sum_{j=K,L,E,M} \delta_{Cj} P^{C_j \sigma_{C_j} - 1} \right)^{-\frac{1}{\sum_{j=K,L,E,M} \delta_{Cj} \sigma_{C_j}}} . \]

(6.22)

At the second tier at the energy and materials level, the same demand equations and price indices can be derived.

As alluded to above, the household also demands capital services which are derived from the use of consumer durables and residential housing. These services are supplied by households themselves, who also invest in household

\[ \text{Footnote: Households can also be myopic in the sense of viewing future income largely based on current income.} \]
capital, \( K^c \), to provide a flow of capital services, \( C^k \), based on the following relationship:

\[
C^k = \alpha K^c ,
\]

(6.23)

where \( \alpha \) is a constant. Changes in household capital adopt the following dynamics:

\[
\dot{K}^c = J^c - \delta^c K^c.
\]

(6.24)

Similar to the representative firm's problem, gross household investment, \( f^c \), is assumed to face a rising marginal cost of installation and determined by net household investment, \( J^c \), as follows:

\[
f^c = \left( 1 + \phi^c \frac{J^c}{2 K^c} \right) J^c.
\]

(6.25)

Hence, the household's goal is to choose investment to maximise:

\[
\int (P^c K^c - P^c f^c) e^{-(R(s)-\eta)(s-t)} ds,
\]

(6.26)

where \( P^c \) is the imputed rental price of household capital. Unlike the representative firm's problem, the production of household capital services involve no variable inputs and investment tax credit. Otherwise the results obtained are very similar to the representative firm's case. As such, the marginal value of an additional unit of household capital, \( \lambda_c \), can be derived as:

\[
\lambda_c(t) = \int \left[ P^c K^c + P^c \phi^c \frac{J^c}{2 K^c} \right] e^{-(R(s)-\delta)(s-t)} ds.
\]

(6.27)

By taking the integration along the optimal path of investment and capital accumulation \((\dot{J}_c(t), \dot{K}_c(t))\), and defining marginal \( q \) as:

\[
q = \frac{\lambda_c}{P^c}.
\]

(6.28)
Household investment is thus given by:

\[
\frac{J_c}{K_c} = \phi_c (q_c - 1) .
\]  

(6.29)

6.1.1.3 Labour Market

Labour is assumed to be perfectly mobile within each country or region and perfectly immobile across regions. This means wages across the different sectors within each region are the same, while this may not be true across regions. The long-run supply of labour is determined exogenously by the population growth rate. And long-run wages adjust to ensure each region attains full employment. However, in the short-run, wages are assumed to be sticky; the next period wages determined by current wages, the expected, current and lagged values of the consumer price index, and current employment over full employment, as follows:

\[
\begin{align*}
W_{t+1} &= W_t \left( \frac{P_{t+1}^c}{P_t^c} \right)^{\alpha_5} \left( \frac{P_t^c}{P_{t-1}^c} \right)^{1-\alpha_5} \left( \frac{L_t}{L} \right)^{\alpha_6} ,
\end{align*}
\]

(6.30)

where \( \alpha_5 \) is the weight given to the expected price change and \( \alpha_6 \) is the weight given to current departure of employment from its full level. This set-up allows for shocks that cause short-run unemployment when the real wage is too high to clear the labour market, and short-run employment exceeding its full level when the real wage falls below the long-run equilibrium.

6.1.1.4 Government

Government spending in each region is assumed to be exogenous and allocated among inputs in fixed proportions based on 1996 prices. Its outlays are made up of purchases of goods and services, interest payments on government debt, investment tax credit and transfers to households. Its revenue is sourced from income and corporate taxes, sales taxes and the sale of government bonds.
The government budget constraint can be expressed in terms of the accumulation of public debt as follows:

\[ \dot{B}_t = D_t - r_t B_t + G_t + TR_t - T_t, \quad (6.31) \]

where \( B \) is the stock of debt; \( D \), the budget deficit; \( rB \), the interest payment on debt; \( TR \), the transfers to households; and \( T \), the total tax revenue minus investment tax credit. The following no Ponzi game condition is imposed so that the government cannot forever issue debt and all debt must be paid off at some stage:

\[ \lim_{s \to \infty} B(s) e^{-(R(s) - \eta)s} ds = 0. \quad (6.32) \]

Given this condition, integrating Equation (6.31) gives:

\[ B_t = \int (T - G - TR) e^{-(R(s) - \eta)(s-t)} ds. \quad (6.33) \]

This states that the current level of debt must be equal to the present value of future budget surpluses. In other words, current budget deficits must be met by future budget surpluses. In order for Equation (6.33) to hold in all periods, it is assumed the government levies a lump sum tax equivalent to the amount of interest payments on its outstanding debt. Hence, increases in government debt are financed via consols, while future taxes are raised to cover interest costs. Other fiscal rules such as the debt targeting rule and strict fiscal conservatism are possible, but they are not adopted here. McKibbin (1998b) examines the other fiscal rules and finds some interesting results.

### 6.1.1.5 Financial Markets and the Balance of Payments

Regions in G-Cubed are connected by flows of goods and assets. The flows of goods are driven by the import demands mentioned above (consumption, investment and government spending). The flow of each good is captured by a bilateral trade matrix between importing and exporting countries. In total, the number of such matrices is equal to the number of sectors in the model.
Flows of assets between regions finance trade imbalances. Hence, each region with a current account deficit (surplus) must be matched by an equivalent capital account surplus (deficit). More generally, flows of real and financial assets such as private physical investment accumulates to stocks of capital (or equity), public physical investment to infrastructure capital, fiscal deficits to government debt, and current account imbalances to net external debt. Hence, the level and composition of a region’s wealth changes in the long-run. Such adjustments will have short-run impacts on prices in forward-looking stock markets, bond markets and foreign exchange markets as future economic conditions change.

The model assumes financial assets are perfect substitutes within a region and internationally. Asset prices adjust to equilibrate rates of returns in all assets given exogenous risk premia; this links asset prices within a region and across regions. There are four kinds of financial assets: money (see below), stocks, short-term bonds and long-term bonds. Long-term bonds are priced within an economy based on the arbitrage relationship linking the expected change of bond price and the difference between the returns of long-term bonds and that of short-term bonds. A similar treatment applies to stocks.

With the assumption that asset markets are perfectly integrated, meaning with free capital mobility, the expected returns of assets between two countries follow the relationship below:

\[ i_k + \mu_k = i_j + \mu_j + \frac{E_j^i}{E_k^i} \]  

(6.34)

where \( i_k \) and \( i_j \) are the interest rates in country \( k \) and \( j \), \( \mu_k \) and \( \mu_j \) are exogenous risk premiums demanded by investors, and \( E_j^i \) is the exchange rate between the two countries. Essentially, the relationship determines the exchange rate based on the standard uncovered interest rate parity but with additional features accounting for the risk premium.

Capital flows, in the model, can be portfolio flows and/or direct investments, and they are assumed to be perfectly substitutable \textit{ex ante}, adjusting to the expected
rates of returns between regions, and sectors. Within each economy, the expected returns of assets across sectors are determined by arbitrage activity, after accounting for the cost of installing physical capital stock and the exogenous risk premium. Similarly, it is also costly to dismantle physical capital once it has been set-up. The presence of installation and dismantling costs means shocks to the system can lead to gains and losses to owners of physical capital stocks, and *ex post* would contribute to the divergence of returns between sectors and regions.

6.1.1.6 Monetary Policy

Money in the model is used for transaction purposes, and pays no interest. However, the demand for money is not derived from an optimising behaviour. It follows a standard money demand function of:

\[ \text{MON} = P Y^\epsilon, \]  

(6.35)

where \( \text{MON} \) is the nominal money balance; \( P \), the price index; \( Y \), the aggregate output; \( i \), the interest rate; and \( \epsilon \), the interest elasticity of money demand. The latter is estimated to be -0.6 following McKibbin and Sachs (1991).

The monetary policy reaction function of central banks follows a modified Henderson-McKibbin-Taylor rule:

\[ i_p, t = i_{p, t-1} + 0.5(\eta, t - \hat{\eta}, t) + 0.5((Y, t - \hat{Y}, t) - (Y, t-1 - \hat{Y}, t-1)) - 0.5(E, t - \hat{E}, t). \]  

(6.36)

That is the current policy rate \( (i_p) \) follows the previous policy rate, the deviation of current inflation \( (\eta, t) \) from target inflation \( (\hat{\eta}, t) \), the change in aggregate output from its potential output in the current period \( (Y, t - \hat{Y}, t) \) and previous period \( (Y, t-1 - \hat{Y}, t-1) \), and the deviation of the current exchange rate \( (E) \) from the target exchange rate \( (\hat{E}) \), where the exchange rate is defined as foreign currency per one unit of domestic currency e.g., USD per RM1, i.e., a rise in the exchange
rate means an appreciation of ringgit and vice versa. Note Equation (6.36) applies to central banks which follow a strategy of leaning against the wind. For pure floaters, the last term on the right hand side is excluded. Given that central banks follow an interest rate rule, money supply in the model is determined endogenously i.e., monetary policy operates by directly adjusting the level of interest rates rather than by changing the money supply as commonly discussed in textbooks.

6.1.2 Model Closure and Parameterisation

The model is closed by assuming market clearing conditions except in labour markets. In the goods market, prices adjust so that supply equals demand in each period. Prices therefore explicitly account for the effects of exchange rate changes on the costs of imports and in turn on domestically produced goods. In contrast, wages are sticky and set in advance as per Equation (6.30). Although the model in the long-run is driven towards achieving a neoclassical steady-state growth-equilibrium, unemployment can still occur owing to wage stickiness, which may differ between countries due to differences in labour market institutions. In effect, the term, general equilibrium, is taken to capture the many interactions of the model rather than to mean an economy at full market-clearing equilibrium in each period.

Parameters in the model are estimated mainly from the input-output tables. The main source of data comes from the input-output tables of the US economy since they represent the most comprehensive and extensive series available. Details on construction of the database used for G-Cubed are elaborated in McKibbin and Wilcoxen (1995). The inadequacy of data in other regions and the fact that geographic entities in the model comprise several individual countries means that for these said regions, some parameters estimated from the US data have to be adopted. In particular, the elasticity of substitution in each sector of each region follows that of the US, but the elasticities of substitution of the different sectors within a country are different. As for the share parameters, the US estimates are based on the input-output table prepared by the Bureau of Labor Statistics. For Japan, Australia, China and the former Soviet Union, they are obtained from tables of each region. For other regions, their share
parameters are calculated by adjusting US share parameters to account for their actual final demand. These arrangements imply that all regions share a similar but not an identical production technology as the US. In summary, key substitution elasticities in production and consumption are estimated econometrically from a time-series of US input-output tables. All countries are assumed to share the same isoquant and indifference curve, but with different starting technological levels in each sector and with different starting input endowments, which give different relative prices and different relative factor prices.

To estimate the parameters of the model involves deriving estimable equations from the optimisation problem faced by each agent in the economy. On the production side, this involves deriving estimable equations from each of the 12 sectors in G-Cubed (6 sectors in AP G-Cubed) which is represented by the tiered-CES production function. Recall, output is a function of capital, labour, energy and materials. At the next level, energy is a CES function of inputs from sectors 1 to 5, and materials from sectors 6 to 12.

The energy and materials tiers are estimated first because they are assumed to follow a constant return of scale and all inputs are variable. Expressing the production function in a more convenient dual cost function gives the following unit cost function of sector $i$:

$$
C_i^E = \frac{1}{A_i^E} \left( \sum_{k=1}^{5} \delta_{ik}^E P_k^{1-\sigma_i^E} \right)^{1/(1-\sigma_i^E)}.
$$

Equation (6.37) is the unit cost function of energy in sector $i$. The same function can be derived for materials. $A_i^E$ is the technology level of sector $i$, $\delta_{ik}^E$ is the share parameter or weight of input in production from industry $k$, $P_k$ is the price of input from industry $k$, and $\sigma_i^E$ is the elasticity of substitution in sector $i$. If energy and materials productions are assumed to make zero profits, $C$ will be equal to the price of output. With Shephard lemma, individual commodity’s
demand equation can be derived and converted to cost shares with the following expression:

\[ s^n_k = \delta^n_k \left( \frac{P_k}{A^n_k P_j} \right), \quad \text{where } k = 1, \ldots, 5. \]  

(6.38)

\( s^n_k \) is the cost share or the share of sector \( i \)'s spending on energy which is used to buy input \( k \). By combining Equations (6.37) and (6.38) as a system of equations, \( A^n_i, \delta^n_k \) and \( \sigma^n_i \) can be estimated given the data on cost shares and prices. A similar approach can be applied to estimate the parameters for the materials tier.

At the output tier, with the assumption that capital is fixed in the short-run, the derivation of the estimable equation is slightly different. It involves maximising the following profit function:

\[ \pi_i = P_i A^n_i \left( \delta^n_i \sigma^n_i - \sum_{j \in LEM} \delta^n_j \sigma^n_j \right)^{\sigma^n_i - 1} \sigma^n_i - \sum_{j \in LEM} P_j X^j_i, \quad (6.39) \]

where \( K_i \) is the quantity of capital owned by the firm, \( \delta^n_k \) is the distributional parameter associated with capital, to obtain the following factor demand equation for industry \( i \):

\[ X^j_i = \delta^n_j P^n_j \left( \delta^n_i \sigma^n_i - \sum_k \delta^n_k P^n_k \right)^{\sigma^n_i - 1} \sigma^n_i, \quad j \in \{L, E, M\}. \]  

(6.40)

With this group of equations, the output tier's parameters can then be estimated. McKibbin and Wilcoxen (1999) provide a listing of all the estimates. In that paper, for each of the 12 sectors, parameters at the energy (\( \sigma^n, A^n, \delta, \ldots, \delta \)), materials (\( \sigma^m, A^m, \delta, \ldots, \delta \)), and output (\( \sigma^o, A^o, \delta, \delta_L, \delta_E, \delta_M \)) tiers are presented. One notable observation is that the elasticities of substitution at the various tiers are usually markedly different from one. In particular at the output tier, statistical tests strongly reject the presence of a unitary elasticity of substitution. The
authors also examine the case where capital is treated as a variable input instead of a fixed input. They find the substitution elasticities in most cases are biased towards one, which they argue is intuitively unappealing given the nature of the industries.

For the final demand parameters, those associated with the household's optimisation problem are estimated in a similar way. Notably, the US input-output tables provide the elasticities, and individual regional tables, the share parameters. Trade shares are sourced from the United Nations' Standard Industry Trade Classification (SITC) taken from the four-digit level. Due to the lack of adequate data, trade elasticities for other regions are imposed to be one.

6.1.3 Baseline Assumptions

In a VAR model, the most common analysis tool is to plot the impulse response functions. Similarly, G-Cubed also uses the plots of impulse response functions, but in this case, movements of the plots are interpreted as deviations from baseline scenarios. A baseline scenario of an endogenous variable portrays a business as usual economic condition given certain assumptions about the future outlook of an economy. As parts of G-Cubed are forward-looking in nature, in order to determine endogenous variables such as GDP and inflation, it is necessary to predict first the future course of exogenous variables. The key exogenous variables are: population growth by region; productivity growth by sector by region; tax rates by region; fiscal spending patterns on each sector's output by region; real oil price; and other exogenous shifts in spending patterns (Bagnoli, McKibbin and Wilcoxen 1996).

Forecasts of population growth rates in different regions are based on 2000 World Bank projections. The long-run real interest rate is taken to be 5% across all regions. Tax rates and shares of government spending are assumed unchanged at the 2002 levels. An important forecast is the productivity growth by sector and by region. Due to the historical availability of the US data, the sectoral paths of technical change in the US are also adopted by the corresponding sectors in the regions. Nonetheless, adjustments are also made
to these forecasts to account for each region’s aggregate productivity growth in the last five years.

To generate a baseline projection, the model is solved for an equilibrium over time in which all equations must hold given the values of all exogenous variables, and current and expected values of future variables. The basis of this projection is a convergence model for exogenous population projections and sectoral productivity growth. The model is adjusted to ensure it directly replicates the base year data set of 2002. This is done on the constant term in behavioural equations. For example, in an arbitrage equation such as the interest rate parity condition, it is equivalent to estimating the risk premia. With a baseline projection from 2002 determined, the model is moved forward to 2003, the first year of simulation, taking into account the information set for 2003 to generate a baseline from 2003 to 2100.

6.1.4 Model Solution

Incorporation of rational expectations in the model implies the presence of various forward-looking variables which are dependent on the future path of all variables in the system. The solution therefore involves identifying the values of these forward-looking variables. Essentially, the problem is a two-point, boundary value problem, where the values of the state variables are known and the expected paths of the exogenous variables are assumed to take certain values as mentioned above, but for forward-looking variables only their terminal conditions are assumed. This is by no means an easy feat as it involves solving over 2,500 variables in each of the 98 periods, which includes *inter alia*: the equilibrium prices and quantities of each good in each region, intermediate demands for each commodity by each sector in each region, asset prices by region and sector, regional interest rates, bilateral exchange rates, incomes, investment rates and capital stock by sector and region, international flows of goods and assets, labour demanded in each sector in each region, wages rates, capital and current account balances, final demands by consumers in all regions and government deficits (page 9, Lee, McKibbin and Park 2004).
The numerical technique used in G-Cubed is illustrated in detail in McKibbin (1987) and Appendix C of McKibbin and Sachs (1991). It is based on a backward-recursive algorithm which in addition to solving for rational expectation equilibria, also solves for dynamic game equilibria. Briefly, the technique involves firstly linearising the model and expressing it in the minimal state-space representation. Following the work done by Blanchard and Kahn (1980), the forward-looking (jumping) variables can be expressed as a function of known state variables and the current and the future path of the exogenous variables. The objective is then to identify these rules via a numerical technique. Page 258 of McKibbin and Sachs (1991) summarises the technique as follows: ".... first solve a finite-period optimisation problem in which the terminal period is arbitrarily chosen to some period $T$. The problem is solved in period $T$, giving a solution for the jumping variables and the control variables in period $T$. The problem is then solved in period $T-1$, taking as given the policy rules being followed in the next period and the state variables inherited. The forward-looking variables are then conditioned on the known future rules. The rules that are found for the finite-period problem will be time dimensioned. The second step of the procedure is to find the limit of the finite-period problem as $T$ approaches infinity. The limit is found by repeating the backward recursion procedure until rules are found, for the control variables and the jumping variables, that do not change as the terminal period is arbitrarily extended. The case which the policymakers are not optimising is found by setting the rules that link the control variables to the state and exogenous variables to zero during backward recursion. The rule for the jumping variables is therefore the unique stable manifold of the system."

6.2 Results Characterising G-Cubed

This section presents the impulse responses of some Malaysian macroeconomic variables to selected shocks in G-Cubed with the aim of highlighting the key features of the model. The shocks are chosen to correspond to the VAR shocks analysed in earlier chapters. Specifically, the focus is on the interest rate, exchange rate risk premium, equity risk premium and augmented labour productivity shocks. These shocks are similar to the

\[\text{APG3V58N.}\]
interest rate, exchange rate, stock price and output shocks of the VAR. Since G-Cubed has no banking sector, no credit shock is considered. Unlike VARs, G-Cubed has the flexibility for users to specify whether a shock is permanent or temporary, as well as the magnitude of each shock, and in each period. A permanent shock is one that occurs every year over the entire simulation period. A temporary shock is one that takes place in the first year only. For simplicity, the magnitude of the various shocks is given an identical unit of one percent/percentage point per year.

Table 6.3 Legend Description

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTNMMNC</td>
<td>Nominal interest rates</td>
</tr>
<tr>
<td>INTRMMNC</td>
<td>Real interest rates</td>
</tr>
<tr>
<td>INFLMMNC</td>
<td>Consumer price inflation</td>
</tr>
<tr>
<td>TOB5MMNC</td>
<td>Tobin’s q, non-durable manufacturing sector (proxy for equity price)</td>
</tr>
<tr>
<td>EXCHMUNC</td>
<td>Nominal exchange rate (USD/RM)</td>
</tr>
<tr>
<td>REXCMUNC</td>
<td>Real exchange rate (USD/RM)</td>
</tr>
<tr>
<td>GDPRMMNC</td>
<td>Real GDP</td>
</tr>
<tr>
<td>CONPMMNC</td>
<td>Private consumption</td>
</tr>
<tr>
<td>INVTMNC</td>
<td>Total investment</td>
</tr>
<tr>
<td>IMPTMMNC</td>
<td>Imports</td>
</tr>
<tr>
<td>EXPTMMNC</td>
<td>Exports</td>
</tr>
<tr>
<td>TBALMMNC</td>
<td>Trade balance</td>
</tr>
<tr>
<td>CURREMMNC</td>
<td>Current account balance</td>
</tr>
</tbody>
</table>

All results presented in this section are deviations from the baseline of the model, meaning the unit in the y-axis is either percentage, per cent of GDP, or percentage point. Real GDP, consumption, investment, imports, exports, trade balance, and current account balance, are in per cent of GDP; interest rates and inflation rates are in percentage point; and the rest in percentage. Two sets of results are presented. The first relates to the flexible ringgit and mobile capital

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9 In fact, a shock can also be classified as an anticipated or unanticipated shock, but this is not the interest of the ensuing simulations.
flows scenario, and the second to the fixed ringgit and closed capital account scenario. In each of the following figures, column one refers to permanent shock and column two to temporary shock.\textsuperscript{10} Table 6.3 provides a description of the legends used in the plots.

6.2.1 Flexible Ringgit and Open Capital Account

6.2.1.1 Permanent Interest Rate Shock

The most interesting result of a permanent positive interest rate shock\textsuperscript{11} is that nominal interest rates stay below the baseline for quite a while (see Figure 6.2). In essence, this happens due to the dampening effects of the permanent interest rate shock on long-run prices projecting long-run interest rate levels onto lower levels of short-run interest rates. Put simply, this shock is equivalent to a permanent reduction in domestic consumer prices or a negative inflation target shock, in which case, nominal interest rates respond by declining to lower levels. Besides, since the central bank targets consumer price inflation, nominal interest rates are allowed to fall. Later, nominal interest rates return to base in line with the path of inflation returning to base.

Prices decline very quickly in the first several years reaching a floor of about two percent below base in the long-run (its path is likened to a smoothed L-shape). Prices fall sharply as a result of the adjustment taking place in the economy whereby the interest rate shock depresses aggregate demand far more than the fall in production. Consumption and investment are cut back sharply mainly because of the forward-looking nature of consumers and firms. Production, on the other hand, adjusts more slowly because wage stickiness prevents the labour market from clearing immediately. Given that the goods market must

\textsuperscript{10} Discussions on the results to follow will largely correspond to the ordering of each plot, namely, first on inflation (prices), interest rates, Tobin’s \( q \); followed by exchange rates, the real economy; and finally, the balance of payments. It would be easier to follow if the texts and the plots are read together.

\textsuperscript{11} This is applied via an increase in the exogenous nominal interest rate term (INTNMMXC) in the monetary policy reaction function of the central bank. Alternatively, a negative shock can be applied to the inflation target in the same equation.
clear in each period, prices have to adjust or fall. The substantial fall in inflation causes real interest rates to rise marginally.

An interest rate shock by depressing real output reduces the profitability of firms as well as increases the discounting rate of future investment. This reduces \( q \) and hence investment. However, \( q \) rebounds above base subsequently as the fall in investment lowers capital stock accumulation, which improves the marginal product of capital, and contributes to higher \( q \). Soon too, \( q \) gradually returns to base, as the higher marginal product of capital encourages new investment leading to gradual accumulation of capital in line with the rising marginal cost of installation.

A rise in real interest rates attracts capital inflows, which increases the demand for ringgit – both nominal and real ringgit rates appreciate as a consequence. Lower Malaysian prices also lure domestic consumers and firms to local products putting downward pressure on the US dollar. In the long-run, the nominal ringgit's appreciation reaches a plateau of about two percentage points above base consistent with the long-run decline in prices. Accordingly, the real rate of ringgit returns to base.

Given the small rise in real interest rates, it is hardly surprising that the fall in output is also very small. Also note the paths taken by consumption and output to return to baseline are more disjointed. What is most striking is that investment actually rises above base after some time. This is due to the higher \( q \), but only after \( q \) has been rising for some years; a result that comes about as investment is dependent upon a forward looking and backward looking component (see Equation (6.14)).

The impact of an interest rate shock has two opposing forces on the trade balance: a real ringgit appreciation makes exports dearer and imports cheaper leading to a deterioration in the trade balance (the expenditure switching effect); on the other hand, a rise in interest rates slows down economic growth and contributes to lower demand for both domestic and foreign products leading to lower imports and, all else being equal, an improvement in the trade balance (the income absorption effect). In the current simulation, the rise in trade and
current account balances is largely due to the income absorption effect as the
contraction in output leads to significantly lower imports, despite, albeit a smaller
decline in exports. Interestingly, exports seem to hover below the baseline in the
long-run. This is expected as larger trade surpluses mean accumulation of more
foreign assets (or less debt); hence, exports required to service debt are also
lower.
Figure 6.2 Flexible Ringgit and Mobile Capital Flows: Permanent and Temporary Interest Rate Shocks
6.2.1.2 Temporary Interest Rate Shock

A one-off one percent positive interest rate shock leads to a 20 bps rise in nominal interest rates. However, it falls gradually to base reflecting the inertia in the monetary policy rule. The one-off shock reduces aggregate demand, particularly with regard to backward-looking consumers and firms, which reduce current consumption and investment by far more than forward-looking agents. As explained in the permanent shock case, because of wages stickiness, prices fall as a result of a larger fall in aggregate demand than production. In subsequent periods and in the absence of further interest rate shocks, aggregate demand recovers. Production, which was reduced in the previous period, fails to match the recovery in aggregate demand leading to upward pressure on prices. Nonetheless, production eventually recovers relieving the upward price pressure and, in due time, prices also return to base.

The behaviour of other variables is similar to the permanent case. Higher real interest rates contract domestic demand, reduce firms' profitability and increase the discounting rate of future income. Hence, consumption, investment, output, wealth, stock prices and $q$, all fall. Real interest rates rise following the shock, which sees the immediate fall in $q$ in the first year. But $q$ rebounds subsequently because of the fall in capital leading to higher marginal product of capital. Accordingly, after an initial decline, investment begins to improve.

At the same time, higher interest rates attract capital from abroad leading to an appreciating ringgit, but the appreciation gradually returns to base as prices gradually rise. The real appreciation of the ringgit in the first period contributes to lower exports as well as imports. The latter, however, appears to be mainly driven by the contraction in domestic demand – the income absorption effect. Overall, a larger reduction in imports than exports contributes to improvement in the trade balance. The subsequent path of exports continues to mirror the path of the real exchange rate, while the path of imports follows the overall state of output.

On the other hand, improvement in the current account is due to higher investment income. Being a net debtor (i.e., the country's total external assets
are less than external liabilities), Malaysia’s investment income increases if the ringgit appreciates (it pays less interest on its foreign debt, and the value of its foreign debt is reduced, in ringgit terms) and/or the ringgit interest rates decrease (if some of its debts are in ringgit). The results support both possibilities. Over the long-run, the real ringgit rate actually appreciates and the real interest rate falls, although their magnitudes are too small to be clearly seen from the plots. In the model, the current account balance is defined as equal to the trade account balance plus real asset payments. The latter is what has increased. It seems to be a misnomer to refer to an increase in real asset payments as an improvement in the current account over the trade account. After all, payments imply an outflow – a reduction from the trade balance position. Actually, the term, real asset payments, is defined from the US perspective i.e., an increase in real asset payments from the US perspective implies a rise in real asset receipts to Malaysia. This is simply a convention used in the model whereby all national current balances are converted into US units in line with the model closure that the world’s current account deficit is matched by its current account surplus.

6.2.1.3 Permanent Exchange Rate Risk Premium Shock

A rise in ringgit exchange rate risk premium\(^\text{12}\) means investors are demanding a higher return on ringgit assets (currency, bonds, stocks, etc). A typical outcome is the dumping of ringgit assets by investors – equity prices fall (\(q\) falls), bond prices fall (interest rates rise), and the ringgit depreciates as capital flows out. As a defence against the ringgit’s depreciation, the central bank raises interest rates. The fall in the value of capital coupled with a marked revaluation of US dollar denominated foreign debt leads to a sharp fall in wealth and a collapse in consumption. At the same time, returns to capital fall and real interest rates rise leading to an investment collapse. All this has a protracted impact on real GDP. See Figure 6.3.

There are three features worth emphasising. First, domestic prices actually fall as a result of a permanent ringgit shock, instead of rising when the same

\(^{12}\) A positive shock to EXCRMXXC.
permanent shock is applied to the US case. In effect, what happens is the collapse of aggregate demand in an environment of sticky wages, hence sticky production, leads to downward pressure on prices, which more than offsets the effects of higher imported inflation from a depreciated ringgit. Besides, as mentioned above, the central bank raises interest rates to alleviate the depreciating ringgit, thereby further dampening the impact of imported inflation. (In comparison, in the US case, the exchange rate is not included in the monetary policy reaction function. Hence, the Federal Reserve Board is assumed not to react to a falling dollar). Second, notice after quite some time the ringgit actually appreciates, which would seem counterintuitive in the case of a positive exchange rate risk premium shock. This result follows from the intertemporal budget constraints of households, governments and countries, whereby current account surpluses (capital outflows/foreign asset accumulations) recorded in earlier years are gradually brought back to be consumed. Third, \( q \) continues to stay above the baseline even in the long-run, which theoretically should return to the baseline. This is a technical problem in the form of linearisation errors during simulations.

It is also interesting to note that the fall in consumption is less than in investment. The fall in equity prices reduces the financial wealth of households, while higher interest rates reduce their future income. The profitability of firms is affected by lower economic activity. A higher risk premium makes it more costly to raise funds, higher interest rates increase the discounting rate of future investment, and a lower \( q \) directly impinges on future investment. Besides, the marginal propensity of consumption from financial wealth in the model is rather small. Technically, in the model, a positive exchange rate risk premium shock (and a positive equity risk premium shock) directly raise the required return on capital, which reduces \( q \), and hence, investment. A higher risk premium is in fact captured by the discount rate in the present value calculation of a firm's Tobin's \( q \). (See McKibbin and Vines (2003), page 6). In contrast, this shock only appears in the financial wealth component of household total wealth, and is not directly accounted for in the calculation of the human wealth component. Therefore, the model has an in-built characteristic that shows a larger fall in investment than consumption when faced with an exchange rate risk premium shock. In fact, this result can be observed from a temporary exchange rate risk shock.
premium shock. The same applies to permanent and temporary equity risk premium shocks.

On the balance of payments front, a depreciated real ringgit depresses imports but contributes to the surge in exports, trade and current account balances. Note imports continue to stay below baseline reflecting continued weakness in income even when the real ringgit rate has appreciated.

An important result worth noting is the model's ability in explaining key economic or financial events, such as, the Asian crisis. This owes much to its features of fluidity of financial capital vis-à-vis fixity of physical capital. As the Asian crisis evolved, there was great fear that a protracted collapse of the affected Asian economies would drag down US economic growth and, in turn, world economic growth. This stemmed mainly from the predictions of models focused solely on trade linkages and on the demand side. Contrary to these models, G-Cubed showed there was no discernible negative impact from the Asian crisis on US economic growth. Instead, there was actually a positive impact, mainly as a result of the outflow of capital en masse from these countries into the US, pushing down US interest rates and stimulating the non-traded sectors of the economy. Indeed, this was what happened. Another key feature of the model follows from the assumption that physical investment is subject to rising costs of adjustment, which are quadratic in the rate of investment \((\dot{I}/K)\). This means a country with a larger capital base incurs lower installation costs in transforming financial capital into physical capital. This feature reinforces the above result as it implies capital would flow to the US rather than, say, Canada, thereby having an even greater downward impact on the US interest rates.

### 6.2.1.4 Temporary Exchange Rate Risk Premium Shock

A temporary ringgit risk premium shock also leads to an immediate disposal of ringgit and ringgit assets. Again, interest rates rise and the ringgit depreciates in both nominal and real terms. Unlike the permanent case, and at least in the first

\(^{13}\) A temporary exchange rate risk premium shock as will be shown below also has the same impact.
year, higher interest rates fail to contain the upward price pressure emanating from a depreciated currency. Subsequently though, the impact of lower aggregate demand and higher interest rates dominate the weakened ringgit as prices fall for several years. Parallel to falling prices, the nominal ringgit rate begins to appreciate. Likewise, $q$ falls sharply as equity prices fall with the disposal of shares and again it rebounds above base before declining gradually for the reason explained before.

With the familiar outcome of lower profitability for firms, lower income and lower current wealth for consumers, investment, consumption and real output all decline. Again, as in the permanent shock case, investment decreases more sharply than consumption. But investment also recovers much earlier, presumably because $q$ improves as early as the second year, and export-oriented firms benefiting from a depreciated currency begin to expand. More intuitively, since the shock is only temporary and the physical capital is still in place, when confidence returns, recovery is evidently much quicker. This is an important result found from G-Cubed on the Asian crisis which explains the actual path of recovery of the affected Asian countries. The key insight to this result again comes from the difference between the fixity of physical capital and the flexibility of financial capital in the short-run.

On the balance of payments front, the nominal depreciation in the ringgit translates into a real depreciation making local exports cheaper and imports dearer, and boosting exports while dampening imports leading to improvements in the trade balance. The impact on imports closely reflects the state of real output as imports begin to improve when real GDP moves above baseline.
Figure 6.3 Flexible Ringgit and Mobile Capital Flows: Permanent and Temporary Exchange Rate Risk Premium Shocks

INTNMNC -- INFLMNMC -- INTRMNMC -- TOBSMNMC

EXCHMNMC -- REXCMNMC

GDPRMNMC -- CONPMNMC -- INVTMNMC

IMPTMNMC -- EXPTMNMC -- TBALMNMC -- CURREMNMC
6.2.1.5 Permanent Equity Risk Premium Shock

Recall that in the case of a rise in the exchange rate risk premium, investors demand a higher return on all ringgit assets, whereas in the case of a rise in an equity risk premium, investors demand a higher return on shares only. A higher equity risk premium is typified by investors selling-off shares. From Figure 6.4, equity prices fall and, accordingly, $q$ falls by about 10% in the first year. Note the appearance of $q$ moving above the baseline in the long-run, as in the case of the exchange risk premium shock, is due to the linearisation of errors during simulations. In G-Cubed, changes to the exchange rate risk premium work through the intertemporal condition for Tobin's $q$. Essentially, the exchange rate premium shock is an additional term added to Equation (6.10), specifically as an additional discounting term alongside the real interest rate and the depreciation rate.

The disposal of shares forces the redistribution of portfolio investment into other ringgit assets such as bonds. Bond prices rise and yields decline. Some portfolio investment may also go abroad as bond yields become less attractive. This puts downward pressure on the ringgit and both nominal and real ringgit rates decline for several years. Normally, a fall in bond yields signals falling interest rates and a weakened ringgit, which contributes to rising domestic prices. But, in this case, because the central bank is leaning against the wind and since the fall in the exchange rate is substantial, interest rates are allowed to rise. This lasts for several periods. Interest rates are later reduced to accommodate the depressed state of the economy and lower consumer prices. Consumer prices are largely held down by the fall in real wages and the financial wealth of households, despite higher bond prices. These factors coupled with the initial rise in interest rates appear to have dampened the upward price pressure emanating from a weaker ringgit.

As in the case of the exchange rate risk premium shock, there is a sharp depreciation of the ringgit until the level at which an expected re-appreciation provides the required higher return on Malaysian assets relative to abroad. Likewise, after several years of depreciation, the real ringgit rate starts to

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14 A positive shock to RISEMMXC.
appreciate as initial capital outflows are being brought back for domestic consumption. With consumer price inflation and the nominal exchange rate already being targeted, the adjustment necessary for this to happen has to come from other elements in the economy; in this context, from the rise in domestic output prices. As a result, the real ringgit rate appreciates in subsequent years.

The current account and trade balances remain in surplus for a long period. The initial real depreciation in the ringgit boosts exports, and contracts imports. However, exports fall some time later as the real ringgit rate begins to appreciate, while imports continue to fall reflecting the continued weakness in real income. Overall, lower long-run real interest rates and a depreciated real ringgit cushion the adverse impact of the shock, which would otherwise certainly see a more significant fall in consumption, investment and real output.
Figure 6.4 Flexible Ringgit and Mobile Capital Flows: Permanent and Temporary Equity Risk Premium Shock
6.2.1.6 Temporary Equity Risk Premium Shock

As anticipated, a one-off shock to the equity risk premium leads to a one-off adjustment in $q$. Again $q$'s subsequent rebound is marginally higher than the baseline (see Figure 6.4).

Bond returns also fall following the redistribution of portfolio investment from equities into bonds. On this occasion, the same dynamics cause house prices to rise temporarily. (Note in the permanent equity risk premium shock case, this is not apparent. Presumably in that scenario, the upward price pressure created by the redistribution of portfolio investment into the housing market faces stronger opposing dynamics arising from the sharp fall in household wealth, which significantly depresses demand for household consumer durable services (residential services derived from investment in the housing market)).

Meanwhile, lower bond returns (lower interest rates) also redistribute funds abroad leading to downward pressure on the nominal and real ringgit rates. It is likely nominal interest rates are raised to stem the depreciation of ringgit, but amid the generally higher output prices, real interest rates actually fall as a consequence. In fact, the fall in real interest rates perks up consumption in the first year and more generally dampens the adverse impact of reduced financial wealth of households. Investment falls sharply following the fall in $q$. This drags down aggregate demand, and given that production cannot adjust immediately and the goods market has to clear, prices must therefore adjust by falling. This sharp contraction in demand depresses consumer prices for a substantial period. Later, consumer prices do recover, against the backdrop of rising house prices. Closer inspection of house prices shows a boom and bust phenomenon characterised by the short-run fixity of physical capital in the model specification.

Being a one-off shock, the recovery of investment is also noticeable amid the expansion undertaken by trade-oriented firms, which continue to benefit from improvements in the trade and current account balances. This dynamic in turn spurs the recovery in the real economy.
The long-run paths of nominal and real ringgit rates are similar to the permanent case – the initial real depreciation lasts only briefly followed by appreciation as accumulated resources are ploughed back to the economy.

The factors that motivate the balance of payments position are the same as the case of the permanent shock, with one qualification in that their effects are more short-lived.

6.2.1.7 Permanent Labour Productivity Shock

A permanent rise in labour productivity\(^1\) produces an economic boom characterised by rising expected return to capital, higher equity prices and lower domestic output prices (see Figure 6.5). Investment increases markedly as the rise in productivity increases the desired stock of capital. Higher investments, and by extension greater accumulation of capital, therefore ensures the sustainability of a higher long-run output. Through wealth effects, there is a consumption boom. In particular, forward-looking consumers bring forward some of their future gains to be consumed now. This effect is further magnified by backward-looking consumers who experience a current surge in wealth. Nonetheless, the increase in overall wealth also leads backward-looking consumers to save more. This translates into lower aggregate demand vis-à-vis the significant improvement in productivity (a sharp increase in output), leading to downward pressure on wages and prices. (Although, real wages actually rise in the long-run). Notably domestic output prices undershoot in the first period, recovering somewhat, though still below base, before declining further in the long-run. Consumer prices, on the other hand, experience a recovery in the second year for several periods, amidst a boom in the property market. It appears that the productivity shock in boosting consumers' wealth has led to greater investments in the household capital sector (loosely, the property sector). Interestingly, the bond market experiences no such spillover from households' new-found wealth. (By design, investments in the household capital sector are considered as part of household consumption, meaning unlike investments in

\(^1\) A positive shock to SHLiMMXC where \(i=1,2,\ldots,6\), the six sectors in G-Cubed.
bonds, they provide utility to households and hence, are preferred over investments in bonds).

Given a booming economy and consumer price inflationary tendencies, albeit temporarily, nominal interest rates respond with a sharp rise and stay above base for a lengthy period. At least initially, the increase does not appear to puncture the economic boom as real interest rates fall marginally following an even sharper decline in output prices.\(^\text{16}\) What the rise in nominal interest rates does is encourages greater capital inflows leading to nominal ringgit appreciation. The ringgit also appreciates owing to the fall in prices making domestic goods more attractive. In spite of this, the real ringgit rate depreciates sharply and continues to remain below base in line with the substantially lower domestic output prices. Intuitively, the real ringgit rate has to depreciate for without this, foreign consumers whose incomes have not changed would not be able to buy Malaysian products. The ringgit has to stay depreciated as a means of rebuilding the current account position in order to meet future withdrawals of capital inflows which have financed the current account deficit. (This is the opposite of the phenomenon to that explained in both the exchange rate and equity risk premium shocks). All this is driven by a continued long-run decline in domestic prices, which is also reflected in a higher long-run real interest rate and a lower long-run \(q\).

On the balance of payments front, the hike in imports is driven by a strong jump in real income, while the surge in exports is due to the depreciated real ringgit rate. Since the growth in the economy is much stronger, the rise in imports is more than offset by the rise in exports creating a deficit in the trade and current account balances.

\(^\text{16}\) In the model, the difference between nominal interest rates and domestic output prices determine real interest rates, while nominal interest rates (the monetary policy reaction function) are determined by, among others, consumer price inflation.
Figure 6.5 Flexible Ringgit and Mobile Capital Flows: Permanent and Temporary Labour Productivity Shocks
6.2.1.8 Temporary Labour Productivity Shock

In many ways, the results of a temporary rise in labour productivity are similar to that of a permanent shock. Most noticeably, consumption, investment and real GDP all rise, albeit only temporarily/one-off, before gradually returning to base. In terms of prices, consumer prices actually rise mainly as a result of a spike in the prices of the household capital sector (loosely house prices). A one-off productivity shock temporarily boosts households' wealth through higher equity prices, which spills over into the housing market. Output prices, on the other hand, decline as expected for the same reason as explained above, that the productivity surge increases output more than the increase in aggregate demand.

The response of nominal interest rates is more obvious - higher consumer prices and stronger output motivate the central bank to raise nominal interest rates. Nonetheless with substantially lower domestic output prices, real interest rates fall much more than the increase in nominal interest rates. The rise in nominal interest rates also attracts capital inflows which lead to a spike in nominal ringgit rate. Even with an appreciation in nominal ringgit rate, the real ringgit rate depreciates as domestic output prices fall more sharply. Again, this underlies the necessary adjustment which allows foreign consumers whose income remains unchanged to buy Malaysian products.

Likewise, on the balance of payments side, the surge in imports mirrors the surge in real income, while the performance of exports is tied closely to the real exchange rate. The much smaller magnitude of a real ringgit depreciation compared to the surge in real income implies a much smaller rise in exports than imports, resulting in a deficit in the trade and current account balances.
6.2.2 Fixed Exchange Rate and Closed Capital Account

The experiments in this section are meant to illustrate an extreme scenario compared to the one presented previously. As will be clear later, it is not meant to replicate exactly the exchange rate/capital controls regime of Malaysia post September 1998.

6.2.2.1 Permanent and Temporary Interest Rate Shocks

The way in which the fixed exchange rate is modelled in G-Cubed is that nominal interest rates respond almost entirely to the nominal exchange rate deviation from the target exchange rate. As such, an exogenous interest rate shock in this context is of little importance as any potential effects would be swamped by the nominal exchange rate effects which force the nominal interest rate to respond in accordance to the fixing of the exchange rate. This is revealed in the simulations involving both permanent and temporary interest rate shocks where the results are so small to be of any relevance. See Figure 6.6.

These results are unique to the current set-up of the model. Based on the Impossible Trinity, there should actually be monetary policy independence in an environment of fixed exchange rate and immobile capital (capital controls). The Impossible Trinity stipulates that no country can have control over more than two elements of the trinity, namely monetary independence, fixed exchange rate regime and mobile capital flows. In Malaysia's situation, the central bank made the decision to have monetary policy independence and a pegged exchange rate regime, in which case capital mobility cannot be had. Instead, in its position is immobile capital or capital controls. In the current set-up, the approach adopted in modelling capital controls has implications for the role of monetary policy. Capital controls are modelled such that the real ringgit rate is determined by the current account position, which is restricted to be the same as the baseline current account. Since the current account position plus the capital account position sum to zero (or the current and capital account balances must be equal to each other), the capital control identity requires the capital account balance must also be unchanged, i.e., there are no capital flows. Implicit in the identity is the inclusion of the change in reserves as a part of the capital account.
Such a modelling strategy is most apt in the context of a fully flexible exchange rate, but less adequate in the current context of a fixed exchange rate and capital controls. It would be better to explicitly account for the change in reserves. In reality, even in a fixed exchange rate and capital controls regime, the current account balance can still change, since trades can still take place even when there are capital controls and the capital account is unchanged. In other words, a change in the current account position will be captured by the change in reserves.

Having said that, the specification adopted here is at one extreme of the continuum and it is by no means the most fitting model for Malaysia. To be realistic, it would be improbable for G-Cubed to capture controls strictly on capital outflows, these being the form of controls implemented by Malaysia.
Figure 6.6 Fixed Ringgit and Capital Controls: Permanent and Temporary Interest Rate Shock
6.2.2.2 Permanent and Temporary Exchange Rate Risk Premium Shocks

Neither a permanent nor a temporary exchange rate risk premium shock has any impact on the economy. In the standard G-Cubed model (flexible exchange rate and open capital account), an exchange rate risk premium shock is an extra term added to the real interest rate parity which determines the real exchange rate. However in the current set-up, the real exchange rate is not determined by this parity condition. Hence, the exchange rate premium is absent from the model. Instead, the real exchange rate is determined such that the current account balance is equal to the baseline. Technically, this explains why the ringgit risk premium shock has no impact on the economy. Intuitively though, these results would have been expected because neither a permanent nor a temporary shock raises the risk premium on all Malaysian assets (their relative risk premiums remain unchanged), and given capital cannot flow out, no redistributions of portfolio investments within different assets and/or overseas can take place. Therefore, the economy cannot be susceptible to this shock (see Figure 6.7).
Figure 6.7 Fixed Ringgit and Capital Controls: Permanent and Temporary Exchange Rate Risk Premium Shocks
6.2.2.3 Permanent Equity Risk Premium Shock

The sell-off of equity as expected leads to a sharp fall in $q$. See Figure 6.8. (As in other permanent shocks, the subsequent rise in $q$ above base is due to linearisation errors). The shock also redistributes portfolio investment into other areas notably the housing and bond markets. Hence, prices in those markets rise. Being a component of consumer prices, the rise in house prices means consumer prices also rise. The rise in house prices is also connected to higher household wealth which increases the demand for household residential services (discussed below). Meanwhile, the rise in bond prices leads to consistently lower bond returns (lower interest rates). This is reflected in consistently lower levels of nominal and real interest rates, except initially. More simply, long-run interest rates remain below base in line with the lower return on equity (capital) arising from the permanently higher risk premium on equity. On the other hand, the initial rise in interest rates has as much to do with strong consumer inflationary pressures as high real income. Effectively, as the Purchasing Power Parity would have it, higher domestic prices imply a depreciated nominal ringgit rate as foreign goods become more attractive. Thus, as a response in defending the fixed nominal ringgit rate, interest rates have to be raised.

One of the most startling results is the rise in consumption for a considerable length of time, despite falling equity values and real wages. The pivotal influence here is that lower interest rates raise the present value of human wealth. This effect is more pronounced in the current scenario of capital controls, whereby without the leakage of portfolio investment abroad, all funds have to be channelled domestically e.g., into bonds. As such, interest rates fall more drastically, by 75 basis points in the long-run. In fact, real GDP even rises for a while.

To a large extent, the strength of household wealth also explains the different paths of output prices and consumer prices. Output prices rise and stay above base by just over two percentage points in the long-run, while consumer prices closely mimic the path of house prices which rise initially but gradually decline below base. The rise in output prices under the current regime cannot be
explained by the need to bring back resources accumulated abroad (capital outflows) since the current account remains unchanged throughout the period. Instead, what is happening is that while the positive equity risk premium shock directly and severely impinges on the productive capacity of firms, it nonetheless benefits households (through a lower interest rate environment) which cushions the adverse impact on aggregate demand. Thus, the sharp cut back in production amid the continued robustness of household wealth causes output prices to rise. In addition, output remains lower in the long-run because of lower capital stock from lower investment.

On the balance of payments side, with the nominal exchange rate fixed and output prices rising, by definition, the real exchange rate has to appreciate. The appreciating real ringgit rate hurts Malaysian exports. Yet, despite the more substantive fall in real income vis-à-vis the real ringgit rate appreciation, imports fall by less than exports. This apparent counterintuitive outcome lies in the way in which capital controls are modelled in the current set-up, which imposes the current account position to be equal to the baseline position. Recall in the flexible ringgit and mobile capital scenario (Figure 6.4), the current account is in surplus. So, what the capital controls condition does is reduce this surplus so that it becomes equal to the baseline position. To do this, given imports have already fallen in line with the fall in real income, exports must fall by a larger proportion. In effect, this is what is seen in the last plot (column one) of Figure 6.8.
Figure 6.8 Fixed Ringgit and Capital Controls: Permanent and Temporary Equity Risk Premium Shocks
6.2.2.4 Temporary Equity Risk Premium Shock

In sharp contrast to the permanent shock, deviations of variables from the baseline of a temporary shock are often short-lived (see Figure 6.8).

The temporary equity risk premium shock directly reduces \( q \). Again common to other temporary shocks in the model, \( q \) rebounds in the next period and then gradually falls to base. The equities sell-off forces investors into other markets, such as the bond market and housing market, thereby pushing up the prices of bonds and houses. As in the permanent shock, the rise in house prices contributes to the initial spike in consumer prices, and the subsequent slowdown of the housing market leads to lower consumer prices.

Although, the sell-off reduces the value of equity and the financial wealth of households, the fall in interest rates more than compensates for this decline. Human wealth in fact increases for several years lifting consumption and dampening the fall in aggregate demand vis-à-vis substantially lower production, thereby exerting upward pressure on output prices.

In terms of the exchange rate and the balance of payments, the real ringgit rate appreciates with the nominal ringgit rate fixed and domestic prices rising. Likewise, both imports and exports fall. But the fall in exports is larger in order to maintain the parity condition that the current account position must be equal to the baseline as explained previously.

6.2.2.5 Permanent Labour Productivity Shock

The most direct impact of a permanent labour productivity shock is the sharp rise in \( q \) which then gradually declines to base. The gradual decline to base is attributed to the gradual installation of physical capital which reduces the marginal product of capital gradually, while the subsequent reduction below base is due to higher long-run real interest rates. See Figure 6.9.

Another interesting feature is the behaviour of consumer prices which is largely determined by prices in the household capital sector (house prices). This comes
about from the rise in equity prices which boosts households' financial wealth, which leads them to demand more residential housing services. On the other hand, domestic output prices decline and stay consistently below base in the long-run as the surge in production creates excess supply in the market, thereby putting downward pressure on prices. From another perspective, backward-looking consumers increase savings arising from higher wealth, and hence, dampen the rise in aggregate demand.

In terms of exchange rates, as the nominal ringgit rate is fixed, falling output prices cause the real ringgit rate to depreciate. Intuitively, given that the permanent labour productivity shock boosts Malaysia's production of goods and services, and that foreign households' consumption bundle includes some portion of Malaysian products and their incomes are unchanged, the real ringgit rate must fall (depreciate) so that foreigners can buy more Malaysian products. Underlying this adjustment is persistently lower domestic output prices which is translated into the long-run depreciation in the real ringgit rate.

In terms of interest rates, given the objective is to maintain a fixed exchange rate, nominal interest rates are reduced initially to counter upward pressure on the nominal ringgit rate. The pressure comes about as lower domestic prices make Malaysian products more attractive to foreigners, as well as domestic consumers and firms, as they switch from more expensive foreign products. These forces increase the demand for the ringgit and reduce the demand for foreign currencies. On the other hand, in the long-run, interest rates stay high reflecting the higher marginal product of capital of the permanent labour productivity shock. Such is the case as capital from abroad is prevented to come-in to earn higher returns and in the process drive down the returns to base.

In the context of the balance of payments, there is also a counterintuitive but opposite result to that found from a permanent equity risk premium shock. Specifically, exports rise more than imports in spite of the small depreciation in the real ringgit rate, and when the economy is booming which rightly should boosts imports. The reason is the same but opposite to the case of an equity risk premium shock. In the flexible exchange rate and mobile capital flows scenario (see Figure 6.5), both the trade and current accounts are in deficit.
Because capital controls in the current set-up are modelled such that the current account balance remains unchanged from the baseline, it implies the current account deficit which is evident in the flexible ringgit and capital flows scenario will have to be improved further (deficit to be reduced). This happens by way of a sharper depreciation in the real ringgit rate so as to narrow the difference between exports and imports i.e., so that exports rise more than imports. As clearly evident from the last plot of the second column of Figure 6.9, the real ringgit depreciates more sharply and exports rise more than imports (cf. Figure 6.5).
Figure 6.9 Fixed Ringgit and Capital Controls: Permanent and Temporary Labour Productivity Shocks
6.2.2.6 Temporary Labour Productivity Shock

The results from a temporary labour productivity shock are very much a short-lived version of the permanent case. Consumer prices rise in one period and fall to below base in the next mirroring the boom and bust of house prices. (The fixity of physical capital vis-à-vis its valuation means house prices surge when households' wealth surges. In the next period, more properties are built but this coincides with a fall in real income and in the absence of new shocks, house prices fall as a result). So, is q. Similarly, output prices fall in the first period and returns to near base in the next. Thus, with the nominal ringgit fixed, real ringgit depreciates sharply in the first year and returns close to base in the next period. Again, the fall in the real ringgit rate is sharper and its return to base more gradual compared to the flexible ringgit and capital flows scenario. This ensures exports are larger than imports and that the unchanged position of the current account balance is satisfied. Note in the flexible ringgit and capital flows scenario, the current account balance is in deficit for quite a number of years (cf. Figure 6.5).

6.3 Conclusions

What is most apparent from the simulation results are the stories which can be told from the myriad linkages that exist in an economy. These epitomise the intertemporal optimisation features of the model together with short-term stickiness in the forms of sticky wages, adjustment costs in capital accumulation and the rule-of-thumb behaviour of households and producers. Although it may not be obvious given the focus is solely on Malaysia, one of the salient strengths of the model is its ability to capture the interactions between asset markets and real economic activity, notably the interweaving of highly mobile international capital flows and short-run fixity of physical capital. Notwithstanding its strengths, interpretations of the model are also far more challenging than most standard CGE models as the latter exclude the time dimension. The presence of time dynamics provides a much richer story but at the same time its short-run outcomes may sometime be counterintuitive or contradictory to theory. More precisely, this comes about as theories, most often, are interested in a new equilibrium outcome after a shock, and silent on the dynamics.
Chapter 7
Simulated Data

This chapter discusses how simulated data are generated. This is done to bridge the frequency mismatch between the actual quarterly VAR used thus far, and the annual G-Cubed model which will be used as a representation of the Malaysian economy. Simulated data are required, specifically annual simulated data because there is no sufficient actual annual data available to estimate an annual VAR. An annual VAR is needed as input to generate pseudo data based on the (annual) G-Cubed model. In turn, the pseudo data is needed to examine the VAR approximation issue which will be discussed in Chapter 8. Table 7.1 provides a ready reckoner of the different types of data considered in this thesis.

Besides generating the simulated data, this chapter will show how well the simulated data replicate the actual data. In particular, what it takes to ensure the simulated data exhibit the same properties as the actual data.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Chapter(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual data</td>
<td>Historical series</td>
<td>3, 4 and 5</td>
</tr>
<tr>
<td>Simulated data</td>
<td>Data generated from the VAR model based on the actual data</td>
<td>7</td>
</tr>
<tr>
<td>Pseudo data</td>
<td>Data generated from the G-Cubed model</td>
<td>8</td>
</tr>
</tbody>
</table>

Figure 7.1 below maps the direction of the ensuing chapters of this thesis. The ultimate aim is to see how well a VAR estimated on the pseudo data (generated from G-Cubed) approximates the G-Cubed model (Step 10). To do this involves comparing the impulse responses of the two models. In order to generate the pseudo data based on G-Cubed, a key input in the form of the covariance-variance matrix of reduced form errors of an actual VAR model is required. Ideally the case would be to utilise a VAR model estimated based on the actual
quarterly data, such as that in Chapter 4. However, since G-Cubed is an annual model, this option is not feasible. A simpler solution is to estimate a VAR based on the actual annual data. This also has its problem because there is simply not enough annual Malaysian data. Comprehensive annual data can only be obtained starting from the late 1970s, which may be problematic given the number of parameters to be estimated in a system of 12 variables. More importantly, estimating over such a long period of time is likely to make the results more susceptible to various structural shifts in the economy. Another solution is to convert the existing quarterly data to annual data, but this is an even weaker option as the quarterly series only start in 1981:Q1.

Figure 7.1 Ensuing Chapter Outline

- Actual quarterly data
- 1. VAR with recursive structure
- 2. Simulate quarterly data
- 4. Aggregate into annual data
- 3. Simulated quarterly VAR vs. actual quarterly VAR
- 5. Simulated quarterly VAR vs. simulated annual VAR
- 6. Simulated annual VAR with bank loans
- 7. Simulated annual VAR with bank loans vs. without bank loans
- 8. Covariance matrix of simulated annual VAR
- 10. Impulse Responses of VAR on pseudo data versus G-Cubed's
- 9. Pseudo data based on G-Cubed
After much thought and investigation, a simple yet powerful solution has been found. It takes the form of stochastic simulation based on the parameter estimates from the preferred actual quarterly VAR model of Chapter 4. This method can literally generate any number of observations or what is termed simulated quarterly data (Step 2). Through appropriate aggregation and transformation, simulated data with annual frequency can be obtained (Step 4). It is important to ask how good the technique is. Specifically, how close do the simulated quarterly data share the properties of the actual quarterly data, when comparisons are made between their covariance-variance matrices and impulse responses (Step 3)? Similarly, having transformed the simulated quarterly data into annual data, it is important to know how close the VAR on the simulated annual data resemble the VAR on the simulated quarterly data (Step 5). The VAR with and without bank loans will also be examined (Steps 6 and 7). Bank loans have to be excluded since G-Cubed does not explicitly model the banking sector. With the VAR without bank loans estimated, its reduced form covariance-variance matrix can be obtained (Step 8). This will then be applied to the generation of pseudo data such that the data share the same stochastic shocks as the annual simulated data (Step 9). The covariance-variance matrix is basically a device that captures the properties of the shocks in the annual simulated data. Using the pseudo data, an annual VAR can be estimated and compared with G-Cubed (Step 10). A salient feature of this comparison is to assess how well a VAR, being a substantially scaled down representation of G-Cubed, can match G-Cubed. (Steps 8 to 10 will be covered in the next chapter).

The rest of the chapter is structured as follows. Section 7.1 discusses the simulation methodology, which in essence is based on the reduced form VAR model of Section 4.2.3, Chapter 4. Section 7.2 compares the results of the simulated quarterly VAR model with the actual quarterly VAR model. Results pertaining to the robustness of different simulated draws and different simulated sample sizes are also presented. Section 7.3 transforms the simulated quarterly data to the simulated annual data, and presents the results of a new VAR with and without bank loans. Then using the simulated annual data, Section 7.4

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1 I am most grateful to Professor Adrian Pagan for making this suggestion. This method is similar to that used by Christiano and Ljungqvist (1988).

2 Specifically, the pegged exchange rate model (AO7).
examines the relative importance of the different monetary policy transmission channels when each channel is shutdown. Concluding remarks are contained in Section 7.5.

7.1 Simulation Methodology

The simulation process employed assumes the data generating process of the actual data can be captured by a VAR representation. The estimated reduced form VAR on the actual data has the following structure:

\[ Y_t = \hat{C}_t + \hat{\Phi}_1 Y_{t-1} + \hat{\Phi}_2 Y_{t-2} + \epsilon_t, \]  

(7.1)

where \( \hat{C}_t \) is a matrix of deterministic terms that contains a constant term, a time trend, a crisis dummy for the Asian Financial Crisis of 1997/98, two interaction dummy variables to account for the fixing of the ringgit from 1998:3 onwards; \( Y_t \) is the 12x1 vector of endogenous variables following the order; \( \hat{\Phi}_1 \) and \( \hat{\Phi}_2 \) are the 12x12 matrices of the estimated autoregressive coefficients; and \( \epsilon_t \) is the reduced form error term (with \( E(\epsilon_t, \epsilon_t) = \hat{\Omega} \)). As before, the VAR is estimated with a two-lag order. Note that the only difference between this estimation and that used in the earlier chapters is the inclusion of the time trend. It is felt that this is needed to interpret the impulse responses with reference to some baseline/long-run path, in line with the modelling practice in a dynamic intertemporal general equilibrium model like G-Cubed.

Figure 7.2 shows the impulse responses of the Malaysian variables based on actual data to the monetary policy shocks of R3M and M1 with and without the

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3 The VAR model used is the one that accounts for the pegging of the ringgit to the US dollar (AO7). For more details, please see Section 4.2.3, Chapter 4.
4 Two interaction dummy terms are included reflecting the lag order of two chosen for the specification. The dummy variable takes on the value of "0" from 1981:1 to 1998:2, "1" from 1998:3 to 2004:1.
5 CP (commodity price index), PFUS (US inflation), YUS (US real GDP), RUS (US Federal Funds Rate), PFMY (Malaysian inflation), YMY (Malaysian real GDP), M1 (Malaysian M1), R3M (3-month interbank interest rate), ER (ringgit/US dollar exchange rate), KLCI (Kuala Lumpur Composite Index), BLR (Malaysian commercial bank's base lending rate), and L (Malaysian bank loans).
time trend. By and large, the impulse responses between the two scenarios are similar. However, parameters in the VAR with time trend appear to have been more precisely estimated – the asymptotic errors bands are somewhat narrower, especially with respect to the M1 shock. Unlike the R3M shock, the inclusion of the time trend also seems to have weakened somewhat the magnitude of the impulse responses to M1 shock, although the general shapes remain the same.

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6 Throughout this chapter, results involving M1 shocks as an alternative monetary policy indicator to R3M will also be presented. This is done in the interest of empirical comparisons for BNM has never officially or unofficially identified M1 as a monetary policy instrument. Previous results using actual quarterly data show that M1 is capable of providing comparable results to R3M. Likewise, as has been the practice in earlier chapters, only the impulse responses of Malaysian variables are shown.
Figure 7.2 IRFs of R3M and M1 Shocks: With and Without Time Trend
The simulated data can be generated by making use of the parameters estimated in Equation (7.1) and its associated estimated covariance-variance matrix of errors, \( \hat{\Omega} \). Letting \( Y_t \) be \( Y_{t}^{sim} \) to represent the simulated data, then \( Y_{t}^{sim} \) is just a function of its past values and an error term (\( \epsilon_{t}^{sim} \)). The trick to obtain \( Y_{t}^{sim} \) is to feed the equation a set of random numbers (that captures the properties of \( \hat{\Omega} \)) to the error term (\( \epsilon_{t}^{sim} \)) and provide a set of initial values for the lagged \( Y^{sim} \). To generate the random errors having the properties of \( \hat{\Omega} \), the following command is included in *Gauss*: \( \text{rndn}(T,12) \times \text{chol}(\Omega) \), where \( T \) is the number of simulated observations. The initial values are set to equal the actual value of the variables starting from 1981:1. The simulation can also be initialised by using zeros and the results do not differ.

The simulation process is demonstrated by the following steps:

\[
\begin{align*}
Y_{1}^{sim} &= \hat{C}_{t} + \hat{\Phi}_{1}0 + \hat{\Phi}_{2}0 + \epsilon_{1}^{sim} \\
Y_{2}^{sim} &= \hat{C}_{t} + \hat{\Phi}_{1}Y_{1}^{sim} + \hat{\Phi}_{2}0 + \epsilon_{2}^{sim} \\
Y_{3}^{sim} &= \hat{C}_{t} + \hat{\Phi}_{1}Y_{2}^{sim} + \hat{\Phi}_{2}Y_{1}^{sim} + \epsilon_{3}^{sim} \\
Y_{4}^{sim} &= \hat{C}_{t} + \hat{\Phi}_{1}Y_{3}^{sim} + \hat{\Phi}_{2}Y_{2}^{sim} + \epsilon_{4}^{sim}
\end{align*}
\]

In period one, assuming the initial values are set to zero, \( Y_{1}^{sim} \) will just take on the value of the random error in period one. In period two, \( Y_{2}^{sim} \) becomes the sum of the value of the random error in period two and \( Y_{1}^{sim} \) multiplied by \( \hat{\Phi}_{1} \). In period three, \( Y_{3}^{sim} \) becomes the sum of the random error in period three, \( Y_{2}^{sim} \) multiplied by \( \hat{\Phi}_{1} \), and \( Y_{1}^{sim} \) multiplied by \( \hat{\Phi}_{2} \). The constant term is of course added to each simulated observation. This process continues iteratively with a new random error value being fed in each period. The simulated sample size is

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7 In terms of the estimated components in \( \hat{C}_{t} \), only the constant term is included—the results are no different even when it is excluded. Excluding the crisis dummy and the fixed exchange rate dummies are obvious since Malaysia is no longer in crisis and has unpegged its currency. Even including them does not make any difference; it is equivalent to adding an additional constant number to the series. All parameter estimates used are contained in Appendix 7-1.
therefore equal to the number of random errors included. Because the current simulated variable is dependent on past values of simulated data, and the past values of the simulated data are dependent on even earlier simulated data, it takes some time before the simulated data start to capture the data generating process of the actual variables. As such, it is customary to delete some initial observations from the simulated data to overcome such start-up problems.

### 7.2 Omega Comparison

One way to ascertain whether the simulated data inherit the data generating process of the actual series is to examine the simulated data’s covariance-variance matrix ($\Omega^{\text{sim}}$) after running them through the same VAR specification. To do this, two draws or repetitions of simulated data are generated, each having a total number of 50,000 observations. In each draw, the first 1,000 observations are trimmed to account for the initial condition effects, giving a total of 49,000 observations. Then from each draw, five different samples are chosen. The first sample comprises the subsequent 200 observations (this shall be denoted as 1.2k). The second, the subsequent 1,000 observations (2k); the third, up to observation 10,000 (10k); the fourth, up to observation 30,000 (30k); and finally, the fifth, up to observation 50,000 (50k) (see Table 7.2). The first sample size is chosen as it roughly reflects the largest sample size of available historical data. The rest are chosen arbitrarily for comparisons.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Observation No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2k</td>
<td>1001-1200</td>
</tr>
<tr>
<td>2k</td>
<td>1001-2000</td>
</tr>
<tr>
<td>10k</td>
<td>1001-10,000</td>
</tr>
<tr>
<td>30k</td>
<td>1001-30,000</td>
</tr>
<tr>
<td>50k</td>
<td>1001-50,000</td>
</tr>
</tbody>
</table>

To compare the covariance-variance matrices (omegas) and to summarise the differences between the simulated and actual data, instead of comparing 10 different matrices and reading each elements contained therein, bar charts are
used to capture the information in each sample for each draw (see Figure 7.3). In each chart, the y-axis measures the difference between the true omega and the simulated omega, while the x-axis represents the 12 variables in the model. Of interest is the size of the bars and their occurrences. Smaller bars indicate that the simulated omegas are closer to the true omega. Clearly, from both the draws, as the sample size gets bigger, the differences become smaller. The 1.2k and 2k samples show large differences compared to the true omega, while the 50k sample is almost identical to the true omega. Interestingly, there are also noticeable differences between the simulated omegas of the 1.2k (and the 2k) samples in the first and second draws (see last column of Figure 7.3). This suggests that choosing a small sample from any draw may be problematic as it may lead to diverging impulses from the true impulses. This will be examined in more detail in the next section.

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8 Although it is invisible from the charts, there are 12 bars in each entry on the x-axis representing each element in the 12 by 12 covariance-variance matrix. For example, the first bar in each entry of the x-axis represents the covariance of CP with itself, with PFUS, with YUS, with RUS, with PFMY, ..., and with L, respectively. The second bar in each entry represents the covariance of PFUS with CP, with PFUS, with YUS, with RUS, with PFMY, ..., and with L, respectively. Note the values of the true omega matrix can be found in Appendix 7-1.
Figure 7.3 Difference between the True Omega and the Simulated Omega, First Draw (col.1) and Second Draw (col.2); Difference between the Simulated Omega of the First and Second Draws (col.3)

(For an explanation of the legend see footnote 8).
7.2.1 Comparison between Simulated and Actual Impulses

The above section distinguishes the simulated and actual data in terms of their omegas. In this section, the focus is on the differences in their impulse responses. To do this, the different sample sizes (1.2k, 2k, 10k, 30k and 50k) from each draw are estimated based on the same specification as the actual data VAR. Their impulse responses are then contrasted with the actual data VAR impulse responses.

7.2.1.1 First Draw

With respect to R3M shock (Figure 7.4), what is clear is that as the sample size of the simulated data gets bigger, the simulated impulse responses are able to better track the actual impulse responses. This is clear across all impulse responses. With a sample size of 50k, the simulated impulses are hardly differentiable from the actual impulses. In fact, with 30k observations, the results are already very close to the actual impulses. Choosing a typical maximum historical sample size of 200 observations would be problematic as its impulses behave erratically and differ markedly from the actual impulses. To a lesser extent, this is also evident with 2k observations.

Likewise, the same results are seen with M1 shocks (Figure 7.5). In almost all cases, 10k observations would produce the desired impulses with the possible exceptions of the responses of real output and bank loans. And with the intermediate variable shocks⁹ (Figure 7.6), it is more obvious that estimation with 10k observations would suffice – choosing anything less would be ill-advised.

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⁹ Recall the intermediate variable shocks refer to shocks to the variables used as proxy for the channels of monetary policy transmission, namely, ER, KLCI, BLR and L.
Figure 7.4 IRFs to R3M Shock, Various Samples (First Draw)

Response of PFM to R3M

Response of YMY to R3M

Response of M1 to R3M

Response of R3M to R3M

Response of ER to R3M

Response of KLCI to R3M

Response of BLR to R3M

Response of L to R3M
Figure 7.5 IRFs to M1 Shock, Various Samples (First Draw)
Figure 7.6 IRFs of PFMY and YMY to Intermediate Variable Shocks, Various Samples (First Draw)

- **Response of PFMY to ER**
- **Response of PFMY to KLCI**
- **Response of PFMY to BLR**
- **Response of PFMY to L**
- **Response of YMY to ER**
- **Response of YMY to KLCI**
- **Response of YMY to BLR**
- **Response of YMY to L**
7.2.1.2 Second Draw

Likewise, the second draw (Figure 7.7- Figure 7.9) conveys the same message: the more the observations, the closer the replication to actual impulses. With 50k, the simulated impulses are indistinguishable from the actual impulses. In most cases, 10k observations would suffice to replicate the actual impulses. Hence, it is a safer bet to utilise a sample size of no less than 10k observations.
Figure 7.7 IRFs to R3M Shock, Various Samples (Second Draw)

Response of PFM Y to R3M

Response of YM Y to R3M

Response of M1 to R3M

Response of R3M to R3M

Response of ER to R3M

Response of KLCI to R3M

Response of BLR to R3M

Response of L to R3M
Figure 7.8 IRFs to M1 Shock, Various Samples (Second Draw)
Figure 7.9 IRFs of PFMY and YMY to Intermediate Variable Shocks, Various Samples (Second Draw)
7.2.2 Comparison between First and Second Draws

How would the impulse responses change if a small sample from any one draw was utilised? To see this, the impulses of 1.2k (or 200) observations from the first draw and the second draw are plotted on the same chart. (The true impulse response is also included as a benchmark, see Figure 7.10). At a glance, both the first and second draws' impulses share roughly similar dynamics/shape, but that is as far as the similarity goes. Using either sample would likely lead to incorrect interpretations of the size of the initial shock impact, the extent of the shock (how long it lasts), and its turning point, vis-à-vis the true impulses. For example, the initial size of the R3M shock to itself is smaller in the first draw than the second draw (albeit the second draw is visually identical to the true impulse). In another example, the impact response of the exchange rate to M1 shock is much smaller in both the first and second draws compared to the true impact. For the turning points and the extent of a shock, take the example of the response of real output (YMY) to the interest rates shock (R3M): the true impulse troughs in period five by 0.5% compare to a decline of 0.7% in the same period in the second draw; on the other hand, the first draw shows an even larger decline of close to 0.9% and in period six. A similar sort of discrepancy can also be seen from the response of real output (YMY) to the money shock (M1). In this instance, the true impulse peaks at 0.3% in period eight, while the first draw peaks at 0.4% in period 10, and the second sample at 0.28% in period seven.

In sum, these results suggest that to produce a set of simulated data that closely resembles the data generating process of the actual data, the appropriate strategy is to choose a large sample size – in this case, the decision is to utilise 50k observations. Again as shown above, this can be obtained from just one draw – either the first or the second draw. Although the results are not presented here, these findings are also invariant to different lags (four and eight) especially in the larger sample size.
Figure 7.10 IRFs to R3M and M1 Shocks: Comparison between First and Second Draws

Response of PFM Y to R3M

Response of YMY to R3M

Response of M1 to R3M

Response of R3M to R3M

Response of PFM Y to M1

Response of YMY to M1

Response of M1 to M1

Response of R3M to M1
7.3 Annual VAR Estimation

Having settled with the sample size of 50k, the next task is to convert the simulated quarterly data to annual data. Recall this is done so that the covariance-variance matrix of an annual VAR can be obtained.

All annual series are constructed by taking the average of the four quarters of the simulated data, except for real output, which is the sum of the four quarters. This gives a total of 12,500 observations. Parallel to the quarterly VAR, the first 250 observations are trimmed. A VAR is then estimated based on these annual data. Figure 7.11 shows the impulse responses of the same VAR specification as the quarterly model. The lag order chosen is four lags because unlike the other recommended lag orders of two (SC and HQ) and three (FPE and AIC), it satisfies the standard autocorrelation test of up to 12 lags. All specifications however satisfy the heteroscedasticity test and do not violate the model stability condition.

From the figure, the standard impulse responses to R3M and M1 shocks have the expected outcome. A positive R3M shock leads to lower inflation, a fall in output, a fall in M1, a fall in the stock price and a rise in the base lending rate; while a positive M1 shock leads to higher inflation, higher output, a fall in R3M, a depreciation of the ringgit, a rise in the stock price, and a fall in the base lending rate. Also note the exchange rate puzzle, which is pervasive with the R3M shock, but not the M1 shock, is also apparent here. In addition, the impulse responses hardly change with the choice of other lag order, specifically from two to six lags (though the results are not shown). In terms of the intermediate shocks and the responses of inflation and real output, again the results are consistent with the quarterly model – inflation rises with a depreciation in the ringgit, a rise in the stock price, a fall in the base lending rate and a rise in bank loans; while real output rises with a rise in the stock price, a fall in the base lending rate and a rise in bank loans. Likewise, the so called “output/ exchange rate puzzle” that is observed in the quarterly model is also evident. Note that because of the large sample size used, the asymptotic standard error bands are not included for they

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10 The equivalent of 1,000 quarterly observations. Note the conversion is made before the quarterly data are trimmed. Hence, there are a total of 12,500 annual observations.
are very narrow and practically sitting alongside the impulse responses and thus serve no real purpose.

7.3.1 Without Bank Loans

Another modification has to be made to the VAR to make it consistent with G-Cubed. Since G-Cubed does not explicitly model the banking sector, bank loans have to be substituted out from the VAR specification. Recall this has to be done because G-Cubed will be used as the theoretically consistent model that generates the pseudo data set – from which a VAR will be estimated and its impulse responses compared with the G-Cubed impulse responses.

Figure 7.12 shows the impulse responses without bank loans to the usual monetary policy shocks. Comparing this with Figure 7.11, the case with bank loans, there is virtually no difference between the impulse responses of the two. Although, the information criteria recommend VARs with a lag order of two (SC), three (HQ) and four (LR, FPE and AIC), they nonetheless fail to reject autocorrelation at various lags.\(^\text{11}\) The results in Figure 7.12 are based on the VAR with a lag order of five which passes the autocorrelation test. Again, it is interesting to note that the impulse responses with the different VAR lag orders are hardly any different. One final remark, which is consistent with the findings on the experiments with different sample sizes of the simulated data, is that even with a smaller sample size from observation 250 to 7,500 (or the equivalent of the 30k quarterly sample above), the impulse responses again do not differ much from the current results. This also holds for the case of the VAR model with bank loans.

\(^\text{11}\) This can be expected since in theory we can substitute bank loans out of the VAR, which implies a potentially different lag structure.
Figure 7.11 IRFs to R3M (col.1) and M1 (col.2); and IRFs of PFMY and YMY to Intermediate Variable Shocks (col.3)
Figure 7.12 VAR without Bank Loans: IRFs to R3M (col.1) and M1 (col.2) Shocks; and IRFs of PFMY and YMY to Intermediate Variable Shocks (col.3)
7.4 Relative Importance of the Transmission Channels

When a transmission channel is shutdown, this says the effects of the monetary policy shock as transmitted via that channel are switched off or muted. For example, in the plots, the constrained impulse response for the interest rate channel is labelled as “W/O (without) Interest Rate Channel”, and for the asset price/wealth channel, it is “W/O Wealth Channel”. In contrast, under normal circumstances, when all transmission channels are operating, the impulse response is labelled as “Baseline”. Therefore, a channel is identified as more important relative to another if its constrained impulse response deviates much more from the baseline impulse response than another channel’s constrained impulse response.

Figure 7.13 and Figure 7.14 plot the impulse responses of output and inflation to R3M and, M1 shocks, respectively, with all 12 variables (that is, including bank loans). Generally, the interest rate channel followed by the asset price/wealth channel seems to dominate, while the exchange rate channel is less so and the credit channel is somewhat important. These results are also in line with the findings using actual quarterly data as presented in Chapter 5. Examining the results in greater detail, and in the case of R3M shock, real output appears to have been strongly influenced by the interest rate and the wealth channels and only somewhat by the exchange rate channel, especially in the first two years, and then the credit channel several years later.\textsuperscript{12} On inflation, the impact of the interest rate channel and the wealth channel last longer, while that of the credit channel is much muted; the exchange rate channel also has notable contributions in the first three years. In the case of M1 shock, in the initial years, inflation is both strongly influenced by the wealth and interest rate channels, and less so by the exchange rate channel, while the credit channel is more important at a longer-horizon. The only oddity in the overall results relates to the M1 shock on output, where the interest rate channel appears to have an opposite impact – muting the interest rate channel leads to a larger response in real output, instead of a smaller increase following a positive M1 shock.

\textsuperscript{12} These are similar to the overall result on output in Chapter 5.
Figure 7.13 IRFs of YMY and PFMY to R3M Shock: Comparison of Different Channels based on Annual Simulated Data

**IRF of YMY to R3M Shock**

**IRF of PFMY to R3M Shock**
Figure 7.14 IRFs of YMY and PFMY to M1 Shock: Comparison of Different Channels based on Annual Simulated Data

IRF of YMY to M1 Shock

IRF of PFMY to M1 Shock
Figure 7.15 and Figure 7.16 also compare the importance of the different channels, but with bank loans excluded from the VAR specification. On the whole, both the interest rate and wealth channels continue to dominate, with the exchange rate channel less so. Nonetheless, there are also two notable differences vis-à-vis the case with bank loans. First, the dominance of the interest rate channel over the wealth channel is less stark. Only in the case of the response of inflation does the interest rate channel appear to be more important, while the response of real output appears to be dominated by the wealth channel. Second, in effect, the exclusion of bank loans from the model heightens the importance of the wealth channel and somewhat suppresses the interest rate channel, particularly in the case of R3M shock. (The anomaly of the response of real output to M1 shock when the interest rate channel is shutdown is also present). Overall, however, one should be comfortable with the robustness that the interest rate channel and the wealth channel remain the two most prominent channels of monetary policy transmission, with the exchange rate channel less so – a result that sits well with the findings from the actual quarterly data.

If anything, the main difference between the simulated annual results and the actual quarterly results is the stronger support of the asset price/wealth channel as the second most relevant conduit behind the interest rate channel in both the responses of output and inflation. In the actual quarterly results, the exchange rate channel appears to be more dominant than the asset price channel in influencing inflation. However, overall, the interest rate channel is still the most important.
Figure 7.15 IRFs of YMY and PFMY to R3M Shock (Without Bank Loans): Comparison of Different Channels based on Annual Simulated Data

IRF of YMY to R3M Shock

IRF of PFMY to R3M Shock
Figure 7.16 IRFs of YMY and PFMY to M1 Shock (Without Bank Loans): Comparison of Different Channels based on Annual Simulated Data

IRF of YMY to M1 Shock

IRF of PFMY to M1 Shock

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7.5 Conclusions

In this chapter, results showing how well the simulated data stack up against the actual data are presented. The need for the simulated data arises in an effort to bridge the frequency mismatch between the actual quarterly VAR model and the annual G-Cubed model. It is found that as the number of observations reaches 50k, the covariance-variance matrix of the simulated model closely resembles the true covariance-variance matrix. This is further supported by a near identical replication of the impulse responses of the Malaysian variables to the monetary policy shocks as well as the impulse responses of output and inflation to the intermediate variable shocks. In fact, by 30k observations, the simulated impulse responses are already very close to the true impulse responses. These results are invariant to the number of draws – generating one draw of 50k observations is adequate to replicate the true data generating process. Put differently, it would be a serious mistake to only use a sample of just 200 observations from one particular draw. It is interesting to note that if the “true” underlying data generating process was indeed approximated by the covariance-variance matrix of the actual data, these results would be suggestive of the weakness in empirical VAR work, where realistically no more than 200 quarterly observations are normally available.

Having generated the simulated quarterly data, the simulated annual data are obtained by appropriate transformations. On the whole, the impulse responses of the Malaysian variables to the monetary policy shocks and the impulse responses of output and inflation to the intermediate variable shocks continue to exhibit a similar behaviour to those of the quarterly VAR. Even when bank loans are excluded from the VAR specification, the impulse responses hardly differ. When experiments are carried out to test the relative importance of the different transmission channels, the interest rate channel and the wealth/asset price channel are by far the most dominant conduits, with the exchange rate channel less so, while the credit channel tends to be more important in the longer-horizon. Encouragingly, these results are also largely consistent with the actual quarterly VAR model.
Appendix 7-1 Selected Simulation Statistics

Parameter Estimates of VAR used for Simulation

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<td>-0.00147</td>
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<td>-0.00807</td>
<td>0.10147</td>
<td>0.00014</td>
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<td>0.00000</td>
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<td>0.00003</td>
<td>-0.00006</td>
<td>0.00014</td>
<td>0.00006</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 8
Pseudo Data VAR

How do we know whether a VAR model is a good approximation of an economy? This is the question which this chapter seeks to explore. In the real world, such answers can never be found since no researcher knows the true dynamics of the interconnectedness of the real world's variables. For instance, no one knows exactly what the path of the real world's impulse response of output to an interest rate shock looks like. In the absence of such knowledge, it is extremely difficult to know whether a VAR model is suitable for the task at hand. However, if a representation of the real world can be captured by some sort of theoretically consistent model, then a laboratory experiment can effectively be conducted to shed some light on this question. The theoretically consistent model chosen for this task is the G-Cubed model. Therefore, continuing with the theme of this thesis, this chapter will assess how well a VAR model can uncover the G-Cubed's representation of the Malaysian monetary policy transmission mechanism.

In the real world, there are actual historical series, which can be collected and used for empirical studies. What about in the G-Cubed world? To do this, new series have to be generated (they will be called pseudo data), and they must mimic the properties of G-Cubed, just like the actual historical series represent the real economy. One methodology that does this is attributed to Masson (1988) and adopted by Kapetanios, Pagan and Scott (2005). Likewise, this methodology will be used here and is discussed in Section 8.1. In particular, the section will describe in detail how the G-Cubed pseudo data are generated in the context of the monetary policy transmission VAR model used in this thesis. It is helpful to mention from the outset that the strategy adopted by Kapetanios et al. avoids the complication of dealing with identification in VAR modelling.\(^1\) Instead, it focuses squarely on the VAR approximation issue. To date, there

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\(^1\) The criticisms on identification in VAR modeling apply to all forms of restrictions viz. recursive, short-run and long-run, see Section 1.2, Chapter 1.
have only been a handful of papers which focus on the VAR approximation issue, eg., Chari, Kehoe and McGratten (2004), Erceg, Guerriri and Gust (2005) and Christiano, Eichenbaum and Vigfusson (2005). All of them have only involved several variables and studied the relationship between technology shocks and labour input. In contrast, the VAR model of interest here has double or triple the number of variables and focuses on the issue of monetary policy transmission mechanism in Malaysia.

Section 8.2 presents the results of the various experiments undertaken to compare the fitting capability of the VAR model estimated using the pseudo data vis-à-vis the actual G-Cubed impulse responses. It attempts to examine whether the standard information criteria are helpful in identifying an appropriate lag length for the VAR; whether if the only available data comprise just 40 annual observations (roughly the number of historical observations available in Malaysia) would the results have been reasonable; and would more observations, an increase in lag length or an increase in the number of variables included in the VAR help to improve the overall results. Section 8.3 rounds up one of the main interests of this thesis, where the relative strength of the different monetary policy transmission channels is investigated from the perspective of the G-Cubed world. Before concluding the chapter in Section 8.5, some remarks on the use of the contemporaneous impulse response function of G-Cubed and the Cholesky decomposition as identifying restrictions are made in Section 8.4.

8.1 Pseudo Data Methodology

In essence, the pseudo data are generated based on the impulse response functions of G-Cubed. The intuition is that since what is of interest in a model can usually be summarised from its impulse response functions, it is possible to make use of the impulse response functions to generate the pseudo data (Kapetanios et al.). In particular, the pseudo data can be generated as follows:

\[ y_{t}^{\text{pseu}} = D(L)\eta_{t}, \]  

(8.1)
where \( \eta_t \), the error terms or shocks, are i.i.d. \((0, \Sigma)\), and \( D(L) \) are the impulse response functions of G-Cubed at \( L \) lags. The two key variables/matrices are: \( \Sigma \) and \( D(L) \). \( \Sigma \) can be obtained from:

\[
\hat{\Sigma} = D_o V D_o', \tag{8.2}
\]

where \( \hat{\Sigma} \) is the reduced form covariance-variance matrix of the simulated annual VAR obtainable from the previous chapter, and \( D_o \) is the contemporaneous impulse response matrix of G-Cubed. Calculating \( \Sigma \) as such implies that the pseudo data are subjected to the same shocks as the simulated data (as has been captured by the VAR on simulated data), and by extension, the actual data. As an aside, it is useful to note that Equation (8.1) is akin to the structural vector moving average representation of a VAR model, and Equation (8.2) allows for the solving of the structural covariance-variance matrix (as denoted by \( \Sigma \) in this equation) given the contemporaneous identification restriction, \( B_0^{-1} \) (or following Kapetanios et al., denoted by \( D_o \) in Equation (8.2)).

\( D_o \) is easily obtained, once \( D(L) \) is known. To obtain \( D(L) \), two factors have to be considered. The first is the length of \( L \). Second is the choice and size of exogenous shocks to apply in G-Cubed in order to retrieve the impulse responses of the endogenous variables of interest. To capture the true model structure, \( L \) is chosen to be quite long and is set at 200 periods. The choices of exogenous shocks are described in Table 8.1, together with corresponding endogenous variables of interest, and the 10 VAR variables used in this chapter. Note that apart from excluding the bank loan variable since G-Cubed does not explicitly model the banking sector, the money variable is also left out. The latter follows the approach in G-Cubed which assumes central banks adopt an interest rate type rule.\(^2\)

\(^2\) Recall in earlier chapters, M1 and the 3-month interbank rate (R3M) were used interchangeably as indicators of the monetary policy stance.
Table 8.1 Exogenous Shocks Chosen in G-Cubed

<table>
<thead>
<tr>
<th>No</th>
<th>Exogenous Shock</th>
<th>Endogenous Variable</th>
<th>Comparable VAR Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>SHL2MMXC: Labour productivity shock in sector 2 (mining) of the non-oil developing countries</td>
<td>PRD2LLNC: Price of domestic output in sector 2 (mining) of the non-oil developing countries</td>
<td>Commodity price index (CP)</td>
</tr>
<tr>
<td>2.</td>
<td>WAGEUUSC: US nominal wage shock</td>
<td>INFLUUNC: US inflation rate</td>
<td>US inflation rate (PFUS)</td>
</tr>
<tr>
<td>3.</td>
<td>SHL1UUXC-SHL6UUXC: US labour productivity shock in sectors 1 to 6</td>
<td>GDPRUUNC: US real GDP</td>
<td>US real GDP (YUS)</td>
</tr>
<tr>
<td>5.</td>
<td>WAGEMMSC: MY nominal wage shock</td>
<td>INFLMMNC: MY inflation rate</td>
<td>MY inflation rate (PFMY)</td>
</tr>
<tr>
<td>6.</td>
<td>SHL1MMC-SHL6MMXC: MY labour productivity shock in sectors 1 to 6</td>
<td>GDPRMMNC: MY real GDP</td>
<td>MY real GDP (YMY)</td>
</tr>
<tr>
<td>7.</td>
<td>INFLMMXC: MY target inflation rate</td>
<td>INTNMNC: MY nominal interest rate</td>
<td>MY 3-month interbank interest rate (R3M)</td>
</tr>
<tr>
<td>9.</td>
<td>RISEMMXC: MY equity risk premium shock</td>
<td>TOB5MMNC: MY Tobin’s q in sector 5 (non-durable manufacturing)</td>
<td>MY Kuala Lumpur Composite Index (KLCI)</td>
</tr>
<tr>
<td>10.</td>
<td>GOVSMMXC: MY total government consumption shock</td>
<td>NB02MMNC: MY nominal 2-year bond yield</td>
<td>MY base lending rate (BLR)</td>
</tr>
</tbody>
</table>

All exogenous shocks are a one-off one unit increase in the base period, except the non-developing countries labour productivity shock (SHL2MMXC), US and Malaysian inflation target shocks (WAGEUUSC and WAGEMMSC respectively), and the Malaysian equity risk premium shock (RISEMMXC), which are one unit decreases. This is done mainly for ease of interpretation and compatibility because a positive rise in these shocks carries an opposite meaning to a positive rise in the VAR shocks. For example, a rise in the inflation target translates into lower interest rates since a central bank can now reduce interest rates to achieve a higher inflation target (see Equation 6.36 in Chapter 6). Hence, to obtain an increase in the interest rate (equivalent to the R3M shock in the VAR), the inflation target shock must fall, not rise. Similarly, for the equity risk premium shock, a rise in the risk premium means investors are demanding higher returns to hold shares, so share prices fall. Conversely, in the VAR case, a positive shock to the stock price index (KLCI) represents a rise in share prices.

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Therefore, for both shocks to be interpreted as an increase in the share price, a negative equity risk premium shock has to be applied.

Having identified the exogenous shocks, each of these shocks is then applied one at a time in G-Cubed and the impulse responses of the 10 endogenous variables are collected. Thus, for each shock, there are 10 rows of endogenous variables times 200 periods of impulse responses. Since, there are 10 shocks, $D(L)$ is a $(10 \times 10) \times 200$ or a $100 \times 200$ matrix. To apply $D(L)$ in Equation (8.1), $D(L)$ has to be transformed to the correct form, which means obtaining $D_0, D_1, \ldots, D_{199}$, each being a $10 \times 10$ matrix, where the subscript corresponds to the contemporaneous, first, second, ….. the 199th period impulse responses:

$$Y_t^\text{seq} = D_1 \eta_t + D_2 \eta_{t-1} + D_2 \eta_{t-2} + \ldots + D_{199} \eta_{t-199}.$$  \hspace{1cm} (8.3)

$D_0$ and $V$ are shown in Appendix 8-1. As can be seen, $D_0$ contains non-zero elements in the block where the Malaysian variables influence US variables, albeit the magnitudes are small; and $V$ is not a diagonal matrix contrary to what is normally assumed in structural VAR modelling. In Kapetanios et al., $V$ is also found to be non-diagonal.

Each $\eta$ in Equation (8.3) is a $10 \times 1$ structural shock corresponding to the same shocks as the VAR system in Table 8.1. To generate the pseudo data, the values for $\eta$ are drawn using random numbers that exhibit the covariance-variance properties of $V$. Drawing random numbers with the covariance-variance matrix $V$ can be approached in two ways. First is to use the Cholesky decomposition. Second is to use the eigenvalues-eigenvector approach. In Gauss 5.0, the former is applied by invoking the following command:

$\text{rndn}(T, 10) \times \text{chol}(V)$, where $T$ is the number of pseudo observations needed and 10 refers to the 10 shocks. Note $\text{chol}(V)$ decomposes $V$ into a lower triangular matrix: if $P = \text{chol}(V)$, then $PP' = V$. Alternatively, one can just take the square root of $V$: if $P = \sqrt{V}$, then $PP = V$, where $P$ is not a lower

3 To do this involves reshaping the 100x200 matrix of $D(L)$. Specifically, each column is extracted, transposed, and then reshaped into a 10x10 matrix (by arranging each number from left to right). Hence, the first reshaped column is $D_0$, the second reshaped column is $D_1$, etc.

4 This may reflect some omitted world variables which affect both countries.
triangular matrix (and note $P$ is not multiplied by $P$ transpose to get $V$). This is the eigenvalues-eigenvector approach. $P$ can be estimated from $P=EAE'$, where $E$ is the eigenvector of $V$, and $A$ is the diagonal matrix with the square root of the eigenvalues of $V$ lying along its main diagonal. Nonetheless, neither approach affects the overall results. The Cholesky decomposition approach is used here in the generation of the pseudo data, as was the case in generating the simulated data in the previous chapter. Likewise, because of the long lag effects (recall $L$ in $D(L)$ is set at 200 periods), some initial observations have to be deleted. In all ensuing experiments, the first 10,000 observations of the pseudo data are deleted.

8.2 Results

Having discussed how to generate the pseudo data, this section presents the different experiments undertaken to see how well the VAR estimated on the pseudo data (generated from G-Cubed) can approximate the impulse responses of G-Cubed.

8.2.1 First experiment: 200 observations

The first experiment comprises 200 pseudo observations (following the first exercise in the previous chapter) of 500 samples. In other words, 500 samples of 10,200 observations are generated, of which the first 10,000 observations of each sample are dropped. Two fundamental questions that arise in estimation are: what identification restrictions should one use; and what is the appropriate lag length. In Kapetanios et al., the authors sidestep the issue of identification and focus on the dynamic approximation problem. They assume that the impact impulse response is known and given by $D_0$. In effect, this says the contemporaneous identification restriction, $B_0^{-1}$, is equivalent to $D_0$, and any incorrect impulse responses from the pseudo data VAR will reflect the misspecification caused by the reduction of G-Cubed in $N$ variables to a VAR in $n$ variables. Recall, a structural VAR model with $p$-lag can be written as follows:
Multiplying both sides by $B_0^{-1}$ gives the reduced form VAR representation, which allows for direct estimation of the system. Once a proper structural identification restriction in $B_0^{-1}$ is made, the shocks ($\eta$) in Equation (8.4), can be given some economic interpretations. To obtain the impulse response functions, it is necessary to write Equation (8.4) as the structural error moving average representation:

$$B_0 Y_t = K + B_1 Y_{t-1} + \ldots + B_p Y_{t-p} + \eta_t.$$  \hspace{1cm} (8.4)

The various $\Theta_j$'s are the impulse response functions. To get to Equation (8.5), it is necessary to start from the reduced form moving average representation (as shown by the first line below):

$$\tilde{Y}_t = \mu + \psi_0 \epsilon_t + \psi_1 \epsilon_{t-1} + \psi_2 \epsilon_{t-2} + \ldots \hspace{1cm} (8.6)$$

Multiplying all terms by $B_0^{-1}B_0$ and noting that $\eta_t = B_0 \epsilon_t$, transforms the first line into the last line, which is the structural form as per Equation (8.5), which yields the impulse response functions, $\Theta_j$. Note that $\Theta_0 = B_0^{-1}$ (since $\Psi_0 = I$), and $\Theta_j = \Psi_j B_0^{-1}$. Therefore, if $D_0 = B_0^{-1}$, any differences in the subsequent (VAR-on-pseudo-data) impulse responses from G-Cubed impulse responses can be explained by the inability to estimate $\Psi_j$ accurately - the misspecification problem highlighted by Kapetanios et al. Also note that since $D_0$ is taken to be $B_0^{-1}$, the concern related to different units of measurements between the variables in G-Cubed and the simulated data becomes irrelevant. In fact, this

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5 For more details, see Section 3.2, Chapter 3.
ensures the impulse responses in G-Cubed and the VAR-on-pseudo-data share the same units.

For the choice of lag length, AIC suggests about five lags and SC, three.\textsuperscript{6} The AIC seems to recommend an increasing lag order. Up to 10 lags were tried. Even at this lag order, the AIC continues to decline; the SC has no such problem. Five is chosen, since at lag five AIC appears to have reached some sort of a trough – its magnitude of decline becomes smallest; before diving further with increasing lags. See Figure 8.1 for a graphical representation.

\textbf{Figure 8.1 AIC and SC at Various Lags}

Despite these findings, the results based on the impulse responses show that both the AIC and SC may not have provided a good recommendation. In Figure 8.2, the impulse responses of the Malaysian variables to the 3-month interbank rate (R3M) shock show that fitting a VAR with lag order three (L3) or five (L5) fails to match the impulse responses of G-Cubed by quite a wide margin.\textsuperscript{7} In contrast, the VAR with lag order one (L1) seems to better capture the properties

\textsuperscript{6} The AIC and SC formulae are based on pages 129 and 132, respectively, of Lütkepohl (1993). In particular, the numbers presented in Figure 8.1, are an average of the 500 AICs and SCs, each estimated based on the 200 observations. It is typical that AIC recommends a higher lag order than the SC because the latter penalises the inclusion of additional lag terms. What is surprising is even at 15 lags, the AIC is still declining, before all observations are used up for its calculation. Presumably, as the lag order increases, the reduction in the determinant of the covariance-variance matrix continues to be larger than the increase in the number of lag terms (see page 129, ibid).

\textsuperscript{7} All the plotted impulse responses are the average of all the repetitions.
of G-Cubed. Higher lag orders appear to lead to greater oscillations in the impulse responses. These findings are also largely supported by Figure 8.3, which shows the impulse responses of inflation (PFMY) and real output (YMY) to the intermediate variable shocks (ER, KLCI and BLR), albeit with lesser conviction. Generally, compared to Figure 8.2, the results in Figure 8.3 show the different lag orders are incapable of closely matching G-Cubed’s impulse responses. Yet the VAR with L1 still tends to be better than the VARs with L3 and L5, especially with respect to the responses of YMY to all the intermediate variable shocks, as well as the response of PFMY to the BLR shock. Only in the case of the response of PFMY to ER shock, does the VAR with L5 seem to be better. Also, on the whole, the different lag orders fail to match the G-Cubed impulse response of PFMY to KLCI shock.

In sum, in this first experiment with 200 observations, the VAR appears to do a reasonable job in matching G-Cubed’s impulse responses mostly in terms of the impulse responses of the Malaysian variables to R3M shock (Figure 8.2). Contrary to the recommendations of AIC and SC, L1 seems to fit better than L3 or L5. Further, by letting $D_0 = B_0^{-1}$, the contemporaneous impulse response in all the plots start on the same point, and the scales on the y-axis take on the units in G-Cubed, which is expressed in percent (%)\(^8\).

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\(^8\) Strictly speaking, in G-Cubed, the units are either in percentage point deviation, or percentage change, from the baseline. Nonetheless, they are all expressed in percent (%).
Figure 8.2 IRFs of Malaysian Variables to R3M Shock, Different Lag Orders (200 obs)
Figure 8.3 IRFs of PFMY and YMY to Intermediate Variable Shocks, Different Lag Orders (200 obs)
8.2.2 Second Experiment: Increasing the Sample Size

In the next set of experiments, the small sample size problem that might confluence the approximation errors of the VAR is addressed. The number of pseudo observations is increased to 30k in the first exercise and in the second, to 50k, both after having deleted the first 10k observations. However, due to the shortage of computer memory, the first exercise is carried out with only 300 repetitions, and the second, 150 repetitions.\(^9\)

With 30k observations, again in terms of the impulse responses of Malaysian variables to R3M shock, the impulse responses of the VAR with L1 tend to more closely resemble the G-Cubed impulse responses than either the VAR with L3 or L5 (see Figure 8.4). Both the VARs with L3 and L5 continue to have great difficulty in matching G-Cubed's YMY impulse response to R3M shock. In spite of this, their overall fits appear to have improved compared to the first experiment with 200 observations. On the other hand, in terms of the intermediate variable shocks (Figure 8.5), the findings are less conclusive. While the impulse responses of YMY to ER and KLCI shocks with L1 continue to be a more reasonable match than L3 and L5, the impulse responses of YMY to BLR shock, and PFMY to KLCI shock are less so. In fact, similar to the evidence from the first experiment, all three lag orders do not seem to be able to generate impulse responses of PFMY to the intermediate variable shocks that match well with G-Cubed's impulse responses.

The same implications can be found from the corresponding Figure 8.6 and Figure 8.7 of the 50k-observation experiment. In fact, there does not seem to be any visible difference in the impulse responses between these two larger data sets. It appears that asymptotic results are achievable with 30k observations.

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\(^9\) A computer with Pentium IV (3 GHz) and 1GB RAM is used. To give an indication of the length of time of a simulation, the last exercise takes more than an hour to complete.
Figure 8.4 IRFs of Malaysian Variables to R3M Shock, Different Lag Orders (30k obs)

- Response of PFMY to R3M
- Response of YMY to R3M
- Response of R3M to R3M
- Response of ER to R3M
- Response of KLCI to R3M
- Response of BLR to R3M
Figure 8.5 IRFs of PFMY and YMY to Intermediate Variable Shocks, Different Lag Orders (30k obs)

Response of PFMY to ER

Response of YMY to ER

Response of PFMY to KLCI

Response of YMY to KLCI

Response of PFMY to BLR

Response of YMY to BLR
Figure 8.6 IRFs of Malaysian Variables to R3M Shock, Different Lag Orders (50k obs)

Response of PFMY to R3M

Response of YMY to R3M

Response of R3M to R3M

Response of ER to R3M

Response of KLCI to R3M

Response of BLR to R3M
Figure 8.7 IRFs of PFMY and YMY to Intermediate Variable Shocks, Different Lag Orders (50k obs)

Response of PFMY to ER

Response of YMY to ER

Response of PFMY to KLCI

Response of YMY to KLCI

Response of PFMY to BLR

Response of YMY to BLR
8.2.3 Third Experiment: 40 observations

Realistically, it is never possible to have 200 annual historical observations, let alone 30k or 50k. So, how would the results differ if there was only about 40 years of data (roughly what Malaysia has)? These are presented in the corresponding Figure 8.8 and Figure 8.9, and by way of summary, the results from the other experiments with 200 and 30k observations are also presented in the same plots.\textsuperscript{10} All results refer to VARs with a lag order of one.

From Figure 8.8, in general, the impulse responses of the VAR with 40 observations quite closely resemble G-Cubed's impulse responses, except in two cases of the responses of YMY and KLCI to R3M shock. Otherwise, its impulse responses are fairly close to the impulse responses from the larger VARs (with more observations). On the other hand, in terms of the intermediate shocks (Figure 8.9), it is most interesting to note that the impulse responses of the VAR with 40 observations seem to perform remarkably well vis-à-vis the other large observation experiments. Only in the impulse response of YMY to KLCI and to BLR shocks, it comes out short. (Like the results from the larger VARs, it continues to match the impulse response of PFMY to the KLCI shock poorly). Equally notable, but in contrast to Figure 8.8, is that with 30k observations, all the impulse responses seem to be moving farther away from the true impulse responses. In a nutshell, the results show the VAR with 40 observations seem to perform quite well in comparison with other VARs with larger sample size.

\textsuperscript{10} For the 40-observation experiment, only the results of the VAR with L1 are shown. With L2, the impulse responses are quite different and higher lag orders run into the degree of freedom problem. (Results with the 50k-observation experiment are not shown since they are very close to 30k-observation experiment).
Figure 8.8 IRFs of Malaysian Variables to R3M Shock, Different Sample Size (Lag 1)
Figure 8.9 IRFs of PFMY and YMY to Intermediate Variable Shocks, Different Sample Size (Lag 1)
8.2.4 Fourth Experiment: VAR(50)

Here the issue for which the AIC recommends an increasing lag order is revisited. Arbitrarily, a 50 lag order (L50) is chosen with a sample size of 50k observations and again 150 repetitions are used. The results are presented in Figure 8.10 and Figure 8.11, alongside the VARs with L1 and L5. From Figure 8.10, it is clear that the L50 tends to fit the G-Cubed impulse responses better (except maybe for the response of YMY to R3M shock), albeit with a higher degree of fluctuations after several periods compared to L1 or L5. And in terms of Figure 8.11, which relates to the intermediate variable shocks, the fits have become almost an exact resemblance of G-Cubed impulse responses, especially with respect to the responses of PFMY to all the intermediate variable shocks, a result that is found to be particularly problematic from earlier experiments. Even among the responses of YMY, the plots are closest to what have been evident hitherto. It is worth highlighting that L1 also performs quite well even in comparison with L50, especially in terms of the impulse responses of the Malaysian variables to the interest rate shock (Figure 8.10). Only in terms of the intermediate shocks, does it perform less well, though still resembling the shapes of the G-Cubed impulse responses; the only exception being the response of PFMY to KLCI shock, where L1 completely misses the mark (Figure 8.11). Overall, these results suggest a very high lag order is required for the VAR to closely match the G-Cubed impulse responses.
Figure 8.10 IRFs of Malaysian Variables to R3M Shock, Different Lag Orders (50k obs)

Response of PFMY to R3M

Response of R3M to R3M

Response of KLCI to R3M

Response of YMY to R3M

Response of ER to R3M

Response of BLR to R3M
Figure 8.11 IRFs of PFMY and YMY to Intermediate Variable Shocks, Different Lag Orders (50k obs)

Response of PFMY to ER

Response of PFMY to KLCI

Response of PFMY to BLR

Response of YMY to ER

Response of YMY to KLCI

Response of YMY to BLR
8.2.5 Reducing the Number of Variables

Would the VAR-on-pseudo-data perform better if more variables were included instead of just the 10 used hitherto? And perhaps with more variables less lags would be needed? The intuition is to better capture the properties of G-Cubed, either more variables in the VAR can be included or its lag order increased. To answer this, the methodology employed is structured such that only the Malaysian variables are included (CP and the US block are taken out), since it is computationally easier and faster to reduce the number of variables than to increase it. Hence, a VAR(6) is estimated on the six Malaysian simulated variables to obtain $\hat{\Omega}$ (see Equation (8.2) and Appendix 8-1). And the corresponding six pseudo variables are generated in the usual manner. Here, as in the previous experiment, the VAR-on-pseudo-data estimation is based on 50k observations with 150 repetitions.

Figure 8.12 and Figure 8.13 show the results of the VAR on the six Malaysian pseudo variables that correspond to Figure 8.10 and Figure 8.11 with 10 pseudo variables, respectively. Two features stand out. First, among the Malaysian VAR estimations, L1 again seems to correspond more closely to the G-Cubed impulse responses than L5. And it is also generally true that L50 performs better than both. Second, in contrast to the 10 pseudo variables VAR (Figure 8.10 and Figure 8.11), even at L50, the impulse responses of the Malaysian VAR still do not generally closely match the G-Cubed impulse responses. This is evident from Figure 8.12, particularly the impulse responses of PFMY and KLCI to R3M shock, and from Figure 8.13, in almost all the impulse responses except the impulse response of YMY to the ER shock. The second feature emphasises the importance of the number of variables being included – for a given lag length, the more variables included, the better the match to the true impulse responses. In particular, incorporating the open economy concept (including the US block) into the VAR model appears to be a sensible approach.

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11 VAR(6), lag order of six, is chosen as it meets the stability condition and the standard diagnostic tests on autocorrelation and homoscedasticity. It is also recommended by AIC. On the other hand, SC recommends VAR(4) but this fails the autocorrelation test from lag one to six.
Figure 8.12 VAR with Malaysian Block Only: IRFs of Malaysian Variables to R3M Shock, Different Lag Orders (50k obs)

Response of PFMY to R3M

Response of YMY to R3M

Response of R3M to R3M

Response of ER to R3M

Response of KLDI to R3M

Response of BLR to R3M
Figure 8.13 VAR with Malaysian Block Only: IRFs of PFMY and YMY to Intermediate Variable Shocks, Different Lag Orders (50k obs)

Response of PFMY to ER

Response of YMY to ER

Response of PFMY to KLCI

Response of YMY to KLCI

Response of PFMY to BLR

Response of YMY to BLR
On the whole, the above experiments highlight five important lessons, the first three essentially lend further support to the findings in Kapetanios et al. First, to correctly match the impulse responses of an actual economy, the necessary lag order required in a VAR appears to be much larger than is normally used in practice. In fact, it seems infeasible given the length of the available historical series. The same sentiment is echoed by Pagan (2003b), where he fits a VAR to six pseudo variables generated from the Reserve Bank of New Zealand’s FPS model of the New Zealand economy. Second, it is inadequate to rely on the standard information criteria to choose the appropriate lag order as they are unable to produce accurate estimates of the impulse responses. Note in many cases, L1 performs better than L3 or L5, even when the information criteria seem to be suggestive of the latter. Of course, L50 performs even better. Third, it is perhaps a good idea to start from a theoretically consistent model like G-Cubed and try to modify it, instead of from the opposite direction of imposing short or long-run restrictions based on some loose theoretical underpinnings in standard structural VAR modelling. As page 38 of Kapetanios et al. puts it:

“Even a relatively simple CM [conceptual model] produces a complex set of inter-relationships in an economy and these are hard to capture when little prior information is used.”

One such experiment or modification to the G-Cubed model is presented in the following section on the investigation into the relative strength of the different transmission channels from the perspective of G-Cubed. It is important to recognise the G-Cubed model in itself lacks the flexibility to undertake such an experiment. However, the approach by Kapetanios et al. provides a useful technique in dissecting the model into a manageable component from which a more flexible tool like the VAR can be applied to study the issue of interest.

Fourth, unlike Kapetanios et al., it is perhaps premature to discard the VAR methodology, because the results with L1 seem to perform remarkably well. One plausible reason may be due to the lack of dynamics in G-Cubed impulse responses; they are very smooth, especially those with respect to the impulse responses of Malaysian variables to R3M shock. Granted, it also has some

---

12 The variables are: short-term interest rate, real exchange rate, inflation rate, terms of trade, aggregate demand and foreign demand.
weaknesses. Plotted alongside the 95% confidence band, it is obvious the G-Cubed impulse responses lie inside the band (see Appendix 8-2). Unfortunately, the band is too wide to give much meaning on how close the VAR-on-pseudo-data impulse responses are to the true impulse responses. If anything, it suggests an estimated impulse response could be far away from the true impulse response. Then again, this is a typical feature of VAR models. Fifth, the number of variables to be included in the VAR-on-pseudo-data estimation seems to matter if it is only possible to work with a lower lag length. Of course, exactly how many and what variables to include depends on the context of a study, and remains a vital unknown that requires input from theory or some theoretical-consistent model.

Chari, Kehoe and McGratten (2004) and Erceg, Guerriri and Gust (2005) also look at the VAR approximation issue but in relation to a standard RBC model. In particular, their focus is to illuminate the controversial empirical finding using SVAR of a negative relationship between a positive technology shock and labour input (hours worked), which contradicts the prediction of the standard RBC model (see Gali (1999), Francis and Ramey (2003), Gali and Rabanal (2004), and Christiano, Eichenbaum and Vigfusson (2003), though the latter is supportive of the RBC model). Erceg et al. find that their four-variable SVAR model as opposed to the two-variable model of Chari et al. tends to perform better. Fry and Pagan (2005) show that the failure to incorporate capital stock can explain why many SVAR studies fail to uncover the theorised positive relationship between technology shocks and labour input. Although Erceg et al do not explicitly include capital stock as one of the four variables, they acknowledge the inclusion of investment and consumption shares in their model helps to proxy for the omitted capital stock, and also avoids the problem that the VAR process might not be of a finite order as faced by Chari et al. Recently, however, Christiano, Eichenbaum and Vigfusson (2005) return to the debate to show that a two or three-variable SVAR model, depending on specifications, with short-run restrictions, not long-run restrictions as in Erceg et al. and Chari et al., perform remarkably well, despite the omission of capital stock. In addition,

13 Recall the impulse response functions plotted refer to the mean of all impulse responses calculated from the many repetitions. Similarly, the 95% confidence band is calculated based on the 0.025-quantile and 0.975-quantile of the impulse responses from the many repetitions.
they argue that the poor results obtained by Chari et al. are due to the choice of "a standard RBC model" which is actually not quite standard in contrast to Kydland and Prescott's (1991). Consequently, in Chari et al's case, it produces "exotic" and "uninteresting data generating processes".

8.3 Relative Importance of the Monetary Policy Transmission Channels in the Theoretical World

This section encapsulates the main question of this thesis on the relative importance of the different channels of monetary policy transmission from the theoretical perspective of G-Cubed. Figure 8.14 plots the results of what would be now the familiar comparison between the relative strength of the different channels of monetary policy transmission mechanism namely, the interest rate, the asset price/wealth, and the exchange rate channels. As usual, the impulse responses of YMY and PFMY to R3M shock are analysed in line with the central bank’s objective of achieving sustainable economic growth with price stability.

From Figure 8.14, for both the impulse responses of YMY and PFMY, it can be seen that the interest rate channel is clearly the most important channel, as it deviates most markedly from the baseline, followed by the exchange rate channel, albeit only marginally better than the asset price channel. The finding that the interest rate channel is the most important channel reinforces the result from the actual and simulated data. The only difference between the G-Cubed world and the actual/simulated data world is the finding of the relative weakness of the asset price channel in the former. Intrinsic to the model is that a unit change in the equity risk premium has a much smaller impact on both output and inflation than a unit change in the exchange rate risk premium. This is so because an equity risk premium shock applies to equities only, whereas an exchange rate risk premium shock encompasses all ringgit assets including equities. As such, the former has a smaller impact on the economy than the latter.

Another subtle point to note is the position of the "Without Interest Rate Channel" line which is below the baseline (the first plot of Figure 8.14), where
normally the reverse is expected. This owes to the choice of the exogenous shock (total Government consumption) applied in G-Cubed to obtain the endogenous variable (2-year bond yield) which is used to proxy for BLR (see Table 8.1). Essentially, the "Without Interest Rate Channel" can be thought of as "Without Government Spending" – if the Government spends, output will be higher (the baseline case), and if this channel is shutdown (Government is not spending), then output will be lower (the "Without Interest Rate Channel" case).
Figure 8.14 IRFs of YMY and PFMY to R3M Shock: Comparison of Different Channels (G-Cubed's World)
8.4 Some Remarks on Using $D_0$ and the Cholesky Decomposition as Priors

It is unfortunate that $D_0$ cannot be used straightforwardly as the identification restriction on a VAR. Otherwise the "S" component of the SVAR could have been easily obtained. The problem is because $D_0$ is not unique to ensure the structural shocks ($V$) are orthogonal. Put simply, if an interest rate shock is applied to, say, output, it will not reveal the true impact of interest rate on output, for the interest rate shock is a confluence of other shocks. Hence, the response of output to the interest rate shock will be a mixed effect of the interest rate shock plus other shocks that also affect interest rates. Indeed, if $D_0$ is used as an identification restriction, the impulse responses obtained are quite atypical of the standard dynamics (results are not shown). If it was that simple, McKibbin, Pagan and Robertson (1998) would not have concluded the following on page 136:

"Our study has thrown up a lot of issues about the possibilities of imposing theory models upon a VAR, and we have not been able to resolve many of these. The problem that the paper addresses seems to be an important one and we hope that our paper will stimulate more work on the topic".

If a VAR on the pseudo data is estimated based on a recursive identification à la Cholesky, such that $B_0^{-1}$ is a lower triangular matrix, then the impulse responses obtained are quite different from the G-Cubed impulse responses. This is expected since $D_0$ does not have a recursive structure ($D_0$ is not a lower triangular matrix). In addition, there is also an added difficulty in interpreting the scale of the impulse responses. Therefore, to abstract from both these difficulties, the methodology employed here assumes $B_0^{-1}$ is known to be $D_0$. Therefore, if G-Cubed is indeed the true Malaysian economy, this suggests the inadequacy of the recursive identification used in a Malaysian VAR model.

8.5 Conclusions

The chapter provides a lens through which light can be shone on whether a VAR would work well in the real world, at least in the world of G-Cubed. The findings
seem to suggest that it works better if there are more lags or more variables included in the VAR. Unfortunately, the lag order is so large as to make it impractical in most circumstances. The standard information criteria also do not offer much guide as the lag order of one seems to perform better than the recommended three or five lags.

Having said that, when the relative strength of the different channels of monetary policy transmission mechanism are tested, the interest rate channel still shows up as the most important conduit, reinforcing the findings from the actual/simulated data. The asset price/wealth channel, which is second in importance after the interest rate channel in the actual/simulated data, becomes less significant in the G-Cubed world vis-à-vis the exchange rate channel. This is expected given the assumptions built into the model. By the same token, because G-Cubed does not have a recursive structure, it will be incorrect to employ a recursive identification scheme on the VAR. Although, it appears that $D_0$ can easily be used as priors on the actual/simulated data, alas in actual practice, this is not the case as it fails to ensure the structural shocks for VAR purposes are orthogonal.
Appendix 8-1 Selected Pseudo Data Statistics: $D_0$, $V$, $\hat{\Omega}_S$

$D_0$, the contemporaneous impulse response function of G-Cubed

<table>
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<tr>
<th></th>
<th>CP</th>
<th>PFUS</th>
<th>YUS</th>
<th>RUS</th>
<th>PFMY</th>
<th>YMY</th>
<th>R3M</th>
<th>ER</th>
<th>KLCI</th>
<th>BLR</th>
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Note: For convenience, the labels follow the VAR variables.
$V$, the structural covariance-variance shock matrix from Equation (8.2)

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The reduced form covariance-variance errors matrix of the simulated annual VAR model with 10 variables is given by:

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\( \hat{\Omega} \), the reduced form covariance-variance errors matrix of the simulated annual VAR model with 6 Malaysian variables

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Appendix 8-2 Impulse Response Functions with 95% Confidence Band: VAR of Lag Order One

IRFs of Malaysian Variables to R3M Shock, 40 obs. (Lag 1)

- Response of PFMY to R3M
- Response of R3M to R3M
- Response of KLCI to R3M
- Response of YMY to R3M
- Response of ER to R3M
- Response of BLR to R3M
IRFs of PFMY and YMY to Intermediate Variable Shocks, 40 obs. (Lag 1)
Chapter 9
Conclusions

The overall goals of this thesis have been two-fold. First, to investigate the relative importance of the four main monetary policy transmission channels in Malaysia, viz. the interest rate, asset price/wealth, exchange rate and credit channels (Chapters 3, 4 and 5). Second, to investigate whether a VAR can adequately approximate the “true” economy. This is tested by seeing if the VAR can adequately represent the large scale G-Cubed model (Chapters 6, 7 and 8). In some sense, the two objectives are quite separate. Findings from the first objective have direct contributions to the literature on VAR modelling and monetary policy in Malaysia, as well as important policy considerations for Bank Negara Malaysia (BNM), the central bank of Malaysia. On the other hand, the second objective’s contributions relate to the methodological question on the use of VAR models in general. The thread that ties the two objectives together is the choice of the monetary policy transmission mechanism VAR model used with reference to Malaysia.

The apparent void observed between the VAR and the “true” economy is suggestive of the limitations of the monetary policy transmission mechanism VAR model and VARs in general. This overall finding is echoed by Kapetanios, Pagan and Scott (2005), who use the same VAR approximation methodology adopted here but the Bank of England Quarterly Model as a proxy for the true UK economy. If anything, this suggests the results pertaining to the first goal should be interpreted with caution. Nonetheless, since the interest of the first goal is on the relative difference (strength) not absolute difference, the problem is perhaps less of an issue. In addition, although the two objectives share a similar VAR specification, the similarity only exists in so far as the selection of variables is concerned; for in the case of the second objective, the identifying

\[1\] Incidentally, they estimate a VAR with only five variables: domestic output, real exchange rate, inflation, real interest rate and foreign demand. In contrast, the VAR used to answer the second objective comprises 10 variables.
restriction for the VAR is assumed to be given by the G-Cubed model. Moreover, to study the VAR approximation issue, the G-Cubed model is chosen as a proxy for the Malaysian economy, but ultimately no attempt has been made to explore how accurately G-Cubed represents the true Malaysian economy.\(^2\) From a modelling perspective, the void observed between the VAR and the “true” economy appears to favour the approaches on the theoretical side of the modelling frontier (see Figure 1.1). In effect, it provides another piece of evidence in the perennial debate between theoretical and data coherence, and a strategy to bring theory and data closer together. At the same time, it should provide further fruit for thought for improving VAR modelling.

The rest of this chapter is structured as follows. Section 9.1 summarises the main findings, policy considerations and possible research agenda relating to the first objective. Section 9.2 does the same for the second objective.

### 9.1 Monetary Policy Transmission Mechanism

The objective of monetary policy in Malaysia is to ensure sustainable economic growth with price stability. There has always been a tendency for the central bank to favour higher economic growth over price stability for understandable reasons. Malaysia has never had any problems with run-away inflation. Since independence in 1957, the inflation rate has averaged 3.9% per annum. All three occasions when inflation rose beyond 5% were due to external shocks – two oil price shocks and contagion from the Asian crisis. Prudent fiscal management, the absence of monetisation, a generally abundant labour workforce and the flexibility to allow migrant labour from neighbouring countries to work locally, have all helped contain potential sources of inflationary pressure. The one significant event that swung the pendulum towards favouring higher economic growth was the 1969 racial riot. The event instilled a strong belief within the Government of the quintessential need to ensure the continued

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\(^2\) In spite of this, when the relative strength of the different transmission channels is examined from the perspective of the G-Cubed economy, the overall conclusion is also largely supportive of the results based on the actual data (see Section 8.3, Chapter 8), that is, the interest rate channel is the most important channel in influencing output and inflation.
enlargement, and more equitable distribution, of economic wealth, in order to maintain social harmony. This view is also pervasive in the central bank and reflected in its monetary policy deliberations and the various monetary tools available to meet the nation's social/economic objective. These suggest that although monetary policy goals may focus on both economic growth and inflation, greater relevance should be placed on the impact of monetary policy actions on output over inflation.

9.1.1 Preliminary Results

The VAR model built in Chapters 3 and 4 follow an open economy approach. The choice of variables, the identifying restriction and the estimation methodology employed are in the spirit of this line of empirical research. As in other similar studies, the model is estimated at levels, albeit the variables are non-stationary but co-integrated. Altogether there are 12 variables ordered as follows: four foreign (commodity price/oil price index, US consumer inflation rate, US real GDP and US interest rate); and eight domestic (Malaysian consumer inflation rate, real GDP, money, interbank interest rates, exchange rate (ER), stock price index (KLCI), bank lending rate (BLR) and bank loans (L)). The commodity price index/oil price index is ordered first because it is assumed to be capturing future inflationary pressures. Prices and real GDP (and money in the case of the domestic block) are ordered ahead of the interbank interest rate with the view that these are the factors monetary policy responds to. Moreover, prices and real output are goals of monetary policy. The four variables representing the transmission channels are ordered after money and the interbank interest rate as they represent the conduits which transmit monetary policy actions, where in particular the financial variables (ER and KLCI) are expected to respond faster than the non-financial variables (BLR and L). The overall results are quite sensitive to this ordering. Placing the target variables (prices and output) right at the end affects the overall results. But swapping the position of the financial and non-financial transmission variables does not. Although, the open economy concept is assumed, a robustness check shows that a complete closed economy model is clearly inadequate; it does not always conform to a priori expectations, and fails the model stability, no autocorrelation and homoscedasticity tests. Nonetheless, of the other versions of open
economy model examined, only the one including the US interest rates performs comparably to the original open economy model.

An important decision to make in VAR modelling of this nature is the choice of variable to use as a proxy for monetary policy stance. This difficulty is compounded when the sample period studied purportedly covers two different monetary policy regimes – one based on a monetary targeting framework and, the other on interest rate targeting. BNM never made any official announcement about the monetary target. In fact, there is adequate evidence to suggest the monetary targeting framework was never actually adopted and instead an interest rate targeting framework has been the *modus operandi*. In practice, the central bank is unlikely to have complete control over base money. It is not quite possible for the central bank to refuse public demand for money, say, during festivities, on the pretext that it will violate the target monetary growth rate. Similarly, the central bank has to ensure sufficient liquidity in the system during the period when banks have to meet their statutory reserves requirement, or else banks which are short will borrow from the interbank market and push-up interest rates. Frequent disruptions like this would be detrimental to the financial system. This is precisely why the central bank ultimately has to revert back to controlling interest rates.

Likewise, in the sample period under study, when the central bank adopted the interest rate targeting framework, there was no official announcement of a monetary policy rate. However, generally, the 3-month interbank interest rate was taken as the *de facto* policy rate. For comparisons, all the possible candidates of monetary policy indicator are examined. It is found that both the 3-month interbank rate (R3M) and money supply (M1) are the most reasonable

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3 These are the scaled down versions of the original open economy model. The first version deletes all US variables except the US interest rates (AO4). The second does the same but replaces the nominal US interest rates with real US interest rates (AO5). The third is the same as the second and adds real US GDP (AO6).

4 Recall since April 2004, the official policy rate is the Overnight Policy Rate, but the sample size used in this thesis ends in the first quarter of 2004.

5 These are the overnight interbank interest rate (RON), the statutory reserve requirement ratio (SRR), and monetary aggregates (M0, M1, M2 or M3). When examining the potential of the first two candidates, in each case the particular variable replaces the 3-month interbank rate. In the case of the monetary aggregates, each measure of money is included individually in the model specification, while the 3-month interbank rate continues to be present in each specification.
variables for the task. It is difficult to know why M1 stands out instead of other monetary aggregates. But, the clear absence of base money (M0) provides additional evidence to refute the claim that the monetary targeting framework was once adopted. On the other hand, when R3M, not M1, is used as the monetary policy instrument, the exchange rate puzzle emerges. Presumably, the inclusion of the US variables, particularly the US interest rate, is not able to control for what is known as the leader-follower effect in interest rate setting.

Typically, in VAR modelling, a commodity price index or an oil price index is taken as proxy for inflationary expectations to control for the price puzzle. In Malaysia’s case, the commodity price index is found to be most suitable – a positive commodity price index shock leads to higher domestic prices and subsequently higher interest rates. These effects are not evident for the oil price index shock. Nevertheless, the price puzzle only completely disappears when the inflation rate is used instead of the consumer price index. In this regard, the commodity price index is found to be crucial in controlling for the price puzzle when the monetary policy instrument is represented by M1. The price puzzle has also been conjectured to be a result of model misspecification caused by the omission of the output gap variable. That is, the price puzzle can potentially be solved by using the output gap variable as replacement for the real GDP variable. However, the results for Malaysia are unsupportive of this hypothesis.

Overall, the impact of the monetary policy shocks on all Malaysian variables exhibit consistent responses as per a priori. A contractionary monetary policy leads to lower inflation, lower output, lower money supply, an appreciation in the ringgit (applies to M1 shock only), lower stock prices, higher bank lending rate and lower bank lending (after several quarters). The evidence that bank loans only decline after several quarters is more supportive of the view that its decline is attributed to a fall in the demand for bank loans rather than the supply of bank loans. This questions the presence of the credit channel. Ultimately, however, this issue is best resolved via research using bank or firm-level data. In terms of shocks to the transmission or intermediate variables and the impulse response of inflation and output, again the results are largely in conformity with a priori. Higher inflation is evident from a depreciation in the ringgit, higher stock prices, a fall in the bank lending rate and a rise in bank loans. Meanwhile, higher output
is evident from higher stock prices, a fall in the bank lending rate and a rise in bank loans. The only seemingly puzzle is that output falls initially, instead of increasing, after a depreciation of the ringgit. This is indeed counterintuitive when analysed from the standard expenditure-switching/trade linkages perspective. On the other hand, if the depreciation in the ringgit is taken to mean an increase in the ringgit risk premium which leads to sell-offs of ringgit assets, capital outflows, and subsequently, an increase in interest rates to defend the currency, then such an outcome is certainly quite intuitive as vividly demonstrated during the Asian crisis. Estimation with only the pre-crisis sample period shows the conventional expenditure-switching argument remains dominant.

9.1.2 Relative Strength of the Transmission Channels

The above results do not reveal the relative strength of the different transmission channels. To do this involves comparing the baseline impulse responses of the target variables (as per above, when all channels are operating) versus their constrained impulse responses (when a specific channel is being shutdown). The constrained impulse response with a specific channel being muted that deviates most markedly from the baseline impulse response is interpreted as the most important transmission channel. Five different specifications have been tested and the overwhelming result shows the interest rate channel is the most important conduit at the short-horizon of less than eight quarters and the credit channel beyond that. These results are also consistent across the impulse responses of both the target variables and the choice of monetary policy instruments (R3M and M1). Nonetheless, the different specifications also reveal some interesting findings. A scaled-down open economy model that only includes the commodity price index and the US interest rate apart from the Malaysian variables seems to show a heightened importance of the exchange rate channel at the longer-horizon vis-à-vis the original specification. In comparison, in the specification based on the pre-crisis sample, the importance of the exchange rate channel, as found in both the original and the scaled-down open economy specifications, is very clearly absent. Thus, incorporating the full-sample period, or more specifically the Asian crisis period, seems to have elevated the importance of the exchange rate channel. To the extent that in the
impulse response of inflation to R3M shock, in both the original and the scaled-down open economy specifications, the exchange rate channel becomes even more dominant than the credit channel.

Two limitations with the original specification are that it disregards the pegging of the ringgit to the US dollar and the invocation of complete block exogeneity. Incorporating the first element brings about two notable differences. First, the relative importance of the exchange rate channel at longer-horizon found in the original specification has clearly disappeared, especially in the case of the impulse response of inflation to R3M shock. Second, there is a clearer agreement relating to the transmission channels of secondary importance. Besides providing further support to the overall result that the interest rate channel is most important in the short-horizon and the credit channel thereafter, now the asset price/wealth channel followed by the exchange rate channel are also found to be influential in transmitting monetary policy shocks to output in the short-horizon. For inflation, the exchange rate channel appears to be the second most important channel after the interest rate channel, while the role of the asset price channel becomes negligible. Compared to the original specification, incorporating the pegged exchange rate appears to have provided sharper results and one that is better able to control for the exchange rate effects. Qualitatively, these results are also similar to the pre-crisis sample. The original specification follows a strict recursive identifying structure which, at best, can only be interpreted as partial block exogeneity since the foreign block is ordered before the Malaysian block. Nonetheless, even after invoking complete block exogeneity and incorporating the pegged exchange rate, the results do not differ much from the case which only accounts for the pegged exchange rate.

9.1.3 Policy Considerations

The above results provide greater assurance as well as encouragement to BNM. Most reassuringly, it implies the interest rate channel remains a very potent conduit in influencing output and prices. This bodes well with the bank’s recent move towards a new interest rate framework which plans to rely more on the use of indirect instruments in the conduct of monetary policy. The findings should also boost the bank’s confidence to press forward with further
developments in the money market, such as, the issuance of more money market securities, and the liberalisation of securities borrowing and lending. Both will facilitate greater interests and price discovery in the market place. In order for the monetary policy actions to be transmitted to the wider economy, developments in the government and private debt securities should be further intensified. This allows monetary policy to have far-reaching influence beyond the sphere of the banking sector. In addition, a deep and broad debt market can act as additional shock absorber and diversifier of risks away from the over-reliance on the banking sector. It also provides useful information, among others, on the state of monetary conditions and the outlook for the economy and inflation, which will further enhance the quality of input into monetary policy decision makings.  

The finding that the interest rate channel is most relevant is strong evidence against those who continue to hold the view that monetary policy is only effective if the central bank has direct control over the quantity of credit. The absence of the credit channel at the short-horizon is evidence challenging this view. In fact, the finding that the credit channel is only important at the longer-horizon is suggestive of the opposite. That is, the credit channel may not be important altogether, as the fall in bank loans may be due to the fall in the demand for loans (as higher interest rates constrain economic activity) rather than the fall in the supply of loans. No doubt this finding is not conclusive due to the nature of the macro variable used. Nevertheless, as the fact remains that the interest rate channel is more relevant than the credit channel, the central bank should be confident enough to push ahead with reforms to allow greater flexibility in the lending and deposit taking practices, away from the distortionary credit control regime, as envisaged in the Financial Sector Masterplan.  

What seems quite unexpected though are the results relating to the transmission channels of secondary importance. The relative strength of the asset price channel in influencing output at the shorter-horizon, or the lack of evidence to

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6 This is an area of research in itself. See among others, Ang, Piazzesi and Wei (2005), Estrella and Mishkin (1995, 1996), Brooke, Cooper and Scholtes (2000), Breedon and Chandra (1998) and Rudebusch (1997).

7 The masterplan outlines the central bank’s "vision, strategies and sequence of actions to be taken to build a more diversified, robust, efficient and resilient financial system" in Malaysia. For more details, see BNM (2001b).
support the importance of the exchange rate channel, stand out glaringly. At the very least, this provides justification for the central bank to be more vigilant on developments in the stock market. The events surrounding the 1993/94 stock market bull-run bore testimony to this – even as interest rates were at high levels, the economy was close to overheating, spurred on by the booming stock market. In other words, the state of the stock market conveys useful information on monetary conditions. On the other hand, contrary to popular belief, the above finding shows that the exchange rate has not been a tool commonly used to raise output. Alternatively, if the central bank had indeed used the exchange rate to artificially boost the country’s competitiveness, the finding shows it has largely failed to achieve that goal. On a positive note, the exchange rate channel appears to have more success in influencing inflation. Either way, the evidence points to the futility of using the exchange rate to affect output. Hence, it would be proper for the central bank to recognise its action of lowering interest rates has a good chance of exposing the economy to greater imported inflationary pressures with little benefit of higher output.

9.1.4 Future Research

One promising area of research is to look into what actually represents the credit channel – the bank lending channel or the balance sheet channel. The absence of the bank lending channel can put to rest the contention to continue with the quantity and price control on credit. Also, after many years of tentative starts, it can provide the ultimate boost for the central bank to move forward towards a market-based framework in the conduct of monetary policy. On the other hand, if the balance sheet channel is more important, this suggests the monitoring of the financial health of both banks and their customers alike should be further enhanced. There should also be some mechanism in which the central bank has better knowledge about the financial health of large non-bank borrowers. Equally crucial is information on the general financial health of the public. There is no financial survey of any kind undertaken by the central bank on individuals. As such, it is difficult to have any appreciation on how monetary policy actions actually affect individuals and their well-being and how they will respond in turn. In future, as more micro-level data become available, this research agenda will become more promising.
Another area for improvement would be to apply a more structural identifying restriction to the VAR model. The recursive assumption seems particularly problematic for R3M shocks as evident from the emergence of the exchange rate puzzle. Being a small and highly open economy, Malaysia is likely to be concerned about the impact of a rising US dollar on domestic inflation. In response, the central bank may increase interest rates when the dollar appreciates (ringgit depreciates). There is evidence to show that interest rates in fact rise following the ringgit’s depreciation. This implies interest rates may have a contemporaneous relationship with the exchange rate, instead of a recursive one.\(^8\) Notwithstanding this, the overall results on the relative strength of the different transmission channels are robust to the choice of monetary policy instrument. Recall in the case of M1 shocks, no exchange rate puzzle is found and yet the results are in line with the case of R3M shocks.

### 9.2 Approximating the “True” Economy

The Asia-Pacific G-Cubed model has been chosen for the task to represent the Malaysian economy. G-Cubed is a dynamic, intertemporal, general equilibrium, multi-country, multi-sectoral, econometric and macroeconomic model. Within G-Cubed, the demand and supply sides of major economies are explicitly modelled. These are based on a combination of intertemporal optimisation behaviour and liquidity constrained behaviour. Households are assumed to be liquidity constraints or myopic which allow for short-run deviations from optimal behaviour and to better track empirical reality. Money is introduced as a component of financial assets (apart from bonds, equities and foreign assets) and for transaction purposes. Central banks follow the Henderson-McKibbin-Taylor rule with different degrees of responsiveness to exchange rate movements depending on whether a country is pure-floating or leaning against the wind. Short-run wage rigidity gives rise to periods of unemployment. Capital is divided into physical and financial components. Physical capital is sticky while financial capital is mobile moving to the avenue of highest expected returns. This means there can be large short-run effects on asset prices but little short-run effect on capital stocks.

\(^8\) The 3-month interbank rate (R3M) is ordered ahead of the exchange rate.
The model also makes extensive use of econometric estimation on key consumption and production substitution elasticities. Because of its theoretical richness, each shock in the model carries a specific interpretation and its impact on the economy can be comprehensively explained through the various linkages between variables. In contrast, this is a weakness of the VAR methodology. In addition, for example, in a VAR, a positive shock to output can mean either a rise in productivity, a rise in aggregate demand or any other factor that increases output. In G-Cubed, one can specifically specify the shock to be, say, a rise in the augmented labour productivity. This will have a different impact on the economy over time compared to, say, a positive shock to government spending, even when both shocks lead to an immediate rise in output. Hence, in policy simulations in G-Cubed, asking the right questions (selecting the right exogenous shocks to apply) are as important as finding the right answers. The diverse areas in which G-Cubed has been applied are proof of this – from US trade imbalances to China’s accession to WTO, from global climate change to the Iraq war cost and the impact of SARS.9

9.2.1 Preliminary Results

The methodology adopted for the VAR to approximate the true economy follows Kapetanios et al. It involves estimating a VAR on the data derived from G-Cubed (termed pseudo data) and then comparing its impulse responses with G-Cubed’s impulse responses. To generate the pseudo data, the shocks that hit the G-Cubed economy are assumed to be the same as those hitting the actual Malaysian economy. These shocks can be summarised by the covariance-variance matrix of the estimated reduced form VAR errors. The snag, however, is that the VAR model estimated to examine the relative strength of the transmission channels is a quarterly model, whereas G-Cubed is an annual model. To bridge this mismatch, the actual quarterly VAR model is taken to be the data generating process. This model is then used to generate many new observations (termed simulated data). With appropriate transformation of these simulated quarterly observations, annual simulated data can then be obtained. Later, a VAR on the annual simulated data can be estimated to obtain the

covariance-variance matrix of errors, which will subsequently be used to generate the pseudo data.

How many observations does it take for the simulated quarterly data to capture the properties of the actual quarterly data? It is found that as the number of simulated quarterly observations reaches 50,000, its covariance-variance matrix is almost identical to the actual covariance-variance matrix. This is further supported by the near exact resemblance of the impulse responses of the Malaysian variables to the monetary policy shocks as well as the impulse responses of output and inflation to the intermediate variable shocks. In fact with 30,000 observations, the impulse responses are already indistinguishable from the actual VAR's impulse responses. These results are obtained from just one repetition of 50,000 observations estimated with a lag order of two. Even at four and eight lags, the results do not change. The 50,000 observations are later transformed into annual frequency and a VAR is estimated on the annual data. The impulse responses from this simulated annual VAR also resemble the same qualitative behaviour as the simulated quarterly VAR (and the actual quarterly VAR). Even in the case when the relative strength of the transmission channels is examined, the overall results are largely consistent with the actual quarterly VAR. Likewise, dropping bank loans from the estimation does not change the overall results. (This is done since G-Cubed does not explicitly model the banking sector).

9.2.2 Final Results

Apart from assuming the shocks that hit the G-Cubed economy are the same as those that hit the actual Malaysian economy, another important element needed to generate the pseudo data is a set of impulse response functions of endogenous variables from G-Cubed. The endogenous variables in G-Cubed are selected to correspond to the variables in the simulated annual VAR (or actual VAR). Only three endogenous variables in G-Cubed do not correspond exactly to the variables in the VAR. To obtain the impulse responses of the endogenous variables, decisions have to be made on the choice of specific exogenous shock to apply to each endogenous variable (for more details see Table 8.1). Having made these decisions and chosen the length of the impulse
responses to be quite long (200 periods), the pseudo data can finally be generated. A VAR can then be estimated on the pseudo data to see whether its impulse responses match the corresponding G-Cubed impulse responses.

A key advantage of the Kapetanios et al. approach is that it bypasses the controversy surrounding the identification problem in VAR by assuming the contemporaneous identifying restriction is known and given by the contemporaneous impulse response function of G-Cubed. In terms of the choice of lag order for the VAR, based on a sample size of 200 observations, the Schwarz Criterion recommends three lags and the Akaike Information Criterion about five.\(^\text{10}\) Notwithstanding these recommendations, a VAR with a lag order of one is estimated for comparison. Besides the sample size of 200 observations (chosen because it is commensurate to roughly the maximum number of quarterly observations available, albeit the pseudo data here are of annual frequency), several other experiments are also undertaken to gauge the fitting capability of the pseudo data VAR. These experiments are: increasing the sample size of pseudo observations to 30,000 and 50,000; reducing it to 40 observations or the equivalent of the maximum available annual historical series in Malaysia; increasing the number of lags to 50 instead of one, three or five lags; and reducing the number of variables in the VAR to comprise only the Malaysian variables. The latter two experiments are undertaken in response to work done by, among others, Zellner and Palm (1974) and Fry and Pagan (2005), respectively. Zellner and Palm show when a smaller VAR with \(i\) variables is estimated from the original finite order VAR(\(p\)) system with \(j\) variables where \(j > i\), the smaller system will usually follow a vector autoregressive moving average (VARMA) process. To alleviate this misspecification, a very high order VAR can be estimated. On the other hand, Fry and Pagan show that the selection of variables that appear in a VAR matters as much as whether the process follows VARMA.

Overall, the above experiments reveal some interesting findings and implications. First, to accurately match the G-Cubed impulse responses, the lag order

\(^{10}\) Actually, the AIC continues to decline with higher lag order to the extent of exhausting all the 200 observations. Five is chosen because it appears to be the first trough before the AIC falls further.
required appears to be much larger than normally used in practice. VAR(50) has
the best overall fit vis-à-vis other lag orders. This means that in most
circumstances, the standard information criteria are unlikely to recommend the
appropriate lag length. In addition, the lag order of 50 is unlikely to be fitted to
any real world data because there is just not enough actual historical series
available for this exercise. Second, rather surprisingly, the VAR with lag order
one seems to perform quite well compared to lag order three or five, especially
in terms of the impulse responses of Malaysian variables to R3M shocks. This is
also true when the sample size comprises 40 observations. A plausible
explanation for this finding is due to the smoothness of the G-Cubed impulse
responses which is well suited to an autoregressive of order one process. Third,
it seems to matter whether a 10-variable open economy VAR or a six Malaysian-
variable closed economy VAR is estimated. Other things being equal, having
more (US) variables (the open economy VAR) seems to match the G-Cubed
impulse responses better than having fewer variables (the closed economy
VAR). In general, deciding what variables to include will be context specific;
without any theoretical guidance, the task will never be straightforward.

9.2.3 Future Research

The above findings appear to put the VAR methodology in an unfavourable light.
But this is by no means a pronouncement on the death of VAR models. What it
does do is allow for rethinking the VAR modelling approach; one that leans
towards the models that belong to the theoretical-end of the modelling frontier as
depicted in Figure 1.1. In fact, the Kapetanios et al. methodology adopted here
can be applied to any theoretically consistent model to generate pseudo data
representative of the model, and from which smaller VAR models can be
estimated to study inter-linkages in the economy.

Another potential area of research is to use a theoretically consistent model as a
basis to impose identifying restrictions on VARs. This is found to be less than
straightforward by McKibbin, Pagan and Robertson (1998) in their attempt to
build a “hybrid” model that combines the short-run characteristics of the actual
data and long-run characteristics of the MSG2 model. Recently, Del Negro and
Schorfheide (2004), building on the earlier work by Ingram and Whiteman (1994),
have made some headway in producing a DSGE-VAR capable of forecasting and policy analysis. They impose priors from a small DSGE model in a Bayesian framework. Very loosely, it involves estimating a VAR on a combination of simulated data obtained from the DSGE model and actual historical data. Following a different tack, a series of new studies have used sign restrictions based on some theoretical models as priors for VARs (Canova and De Nicolo 2002, Peersman and Straub 2004, Peersman and Straub 2005). Sign restrictions are imposed on a VAR based on the signs/shapes of shocks as stipulated by theoretical models, as opposed to the zero-type restrictions commonly used in the literature. Hence, it avoids the many criticisms directed at the zero-type (including both the short and long-run) restrictions. Normally, researchers using sign restrictions will experiment with different specifications until the impulse responses look reasonable.\footnote{This technique is not free from criticisms. For example, Fry and Pagan (2005) highlight the non-uniqueness of the impulses as one of the problems.}

Sign restrictions have also recently been used as a way to validate DSGE models (Canova 2002, Peersman and Straub 2005). In this case, instead of moving down along the modelling frontier which has been the theme throughout this thesis, the approach moves up from the direction of VARs. This approach leverages on the strength of VARs in data description which has been widely accepted as a reliable tool in every day use (Stock and Watson 2001). In fact, sign restrictions can also be used as an alternative identifying restriction to the recursive assumption used in the monetary policy transmission mechanism VAR model for Malaysia. The obvious question then is which theoretical model should the signs be based upon? As there is no theoretical model which incorporates so many different channels together in an open-economy context, an attempt to use sign restrictions is likely to be based on some loose theoretical underpinnings or economic intuitions.

On the more specific issues to improve the approximation of VAR to the G-Cubed economy, it would also be interesting to examine whether a VARMA process works better. In Kapetanios et al., the authors find that a VARMA process does no better than a VAR model in reproducing the impulse responses. Another possibility is to convert G-Cubed into a quarterly model, and work
directly with the actual quarterly VAR model. It is understood from the builder of G-Cubed that such plans are already in the pipeline.

A potentially very useful area of research, which is also of policy relevance, leverages on the strengths of the G-Cubed model, the VAR approach and the Kapetanios et al. methodology. For instance, G-Cubed can be used to perform counterfactual experiments such as the impact of an oil price shock or a massive renminbi appreciation on the Malaysian economy. The Kapetanios et al. methodology can then be used to generate some artificial data from which a VAR can be estimated to study the relative importance of the main transmission channels pertaining to the particular counterfactual scenario. Consequently, changes in the relative strengths of the transmission channels, if any, can be identified to facilitate more informed monetary policy decision makings.
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