OPEN-ECONOMY RELATIONSHIPS AMONG THE EXCHANGE RATE, PRICE LEVEL, OUTPUT AND MONEY IN THREE ASEAN COUNTRIES: EVIDENCE BASED ON COINTEGRATION AND ERROR-CORRECTION MODELLING ANALYSIS.

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A Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

Department of Economics
The University of Sydney
August, 2005
This Thesis is dedicated to my ailing mother Shahida Begum

And

Late father Momtaz Uddin Ahmed
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ABSTRACT

This Thesis examines the open-economy relationships among the exchange rate, price level, output and money for three ASEAN economies namely Malaysia, Indonesia and Thailand. To analyse the relationships, this thesis develops a theoretical background within the framework of a small open economy version of an IS-LM, AS-AD model. Empirically, the analysis was conducted using structural vector-autoregression (SVAR) along with cointegration and error-correction modelling. This type of modelling technique provides an appropriate framework for examining the existence of both long-run and short-run relationships among the time-series variables in the model, each of which is individually non-stationary.

In analysing both theoretical and empirical relationships, this thesis addresses the following research issues for each country: (1) Are there any long-run relationships among the exchange rate, price level, output and money? (2) Is it possible to derive open economy money supply functions (policy reaction function) from the estimated results? (3) What can we say about monetary neutrality in the long-run? (4) What is the nature of short-run dynamic relationships among each of the endogenous variable in the ECM model? Especially, in the short-run what is the impact of exchange rate changes on output and the price level and money? (5) What is the role of the foreign interest rate both in the short-run and long-run?

The main findings of this thesis are as follows. Firstly, stable long-run relationships among the exchange rate, price level, output and money are found in all three countries
data. Secondly, money is found neutral in the long-run for all the three countries. This monetary neutrality could be the results of 'bottlenecks' and/or subsistence real wage. Thirdly, in the long-run, for all the three countries, the foreign interest rate plays a minimum role indicating limited capital account openness of these economies. Fourthly, the short-run ECM results vary across the countries. For Malaysia, with the exception of the monetary policy reaction function, other three markets react in a manner such that the system is brought back to the long-run equilibrium path once shocked. The other interesting findings are (i) depreciation has substantial positive impacts on output in the short-run (ii) depreciation increases inflation in the initial quarters but this effect is reversed after eight quarters (iii) monetary expansion increases output and inflation in the short-run. (iv) the relationship between money and foreign interest rate indicates that Malaysia used sterilization policy in the short-run. For Indonesia, the error-correction terms for the exchange rate and monetary policy reaction function are significant indicating possible return to the long-run equilibrium once shocked. Results from monetary policy reaction function also indicate that Indonesia used sterilization policy during our study period. But error-correction terms for the other two (output and price level) equations are very small (close to zero) indicating that these two variables play little or no role in restoring equilibrium once shocked. The other interesting findings show that depreciation increases output and inflation in the short-run. Moreover, an expansionary monetary policy increases output and inflation in the short-run. For Thailand, the error-correction terms for the price level equation, exchange rate equation and monetary policy reaction function indicate that adjustment towards long-run equilibrium is possible once the system is shocked. Moreover, results from the monetary
policy reaction function indicate absence of sterilization policy during our study period. However, insignificant output market error-correction terms indicate that output plays no role in returning the system to long-run equilibrium. Depreciation increases output and inflation in the short-run. Money supply growth increases output, and it has a negative impact on inflation in the short-run implying, in the short-run, the output response to monetary shock is larger than the increase in demand.
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# GLOSSARY

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<td>AD</td>
<td>Aggregate Demand</td>
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<tr>
<td>ADF</td>
<td>Augmented Dicky-Fuller</td>
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<tr>
<td>AIC</td>
<td>Akaike Information Criterion</td>
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<tr>
<td>ARDL</td>
<td>Autoregressive Distributed Lag</td>
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<td>ARMA</td>
<td>Autoregressive Moving Average</td>
</tr>
<tr>
<td>AS-AD</td>
<td>Aggregate Supply-Aggregate Demand</td>
</tr>
<tr>
<td>ASEAN</td>
<td>Association of South East Asian Nations</td>
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<tr>
<td>BI</td>
<td>Bank Indonesia (Central Bank)</td>
</tr>
<tr>
<td>BNM</td>
<td>Bank Negara Malaysia (Central Bank of Malaysia)</td>
</tr>
<tr>
<td>BOT</td>
<td>Bank of Thailand (Central Bank)</td>
</tr>
<tr>
<td>CAMEL</td>
<td>Capital Adequacy, Asset Quality, Management, Earning and Liquidity (used in Indonesia)</td>
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<tr>
<td>CPI</td>
<td>Consumer Price Index</td>
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<tr>
<td>CUSUM</td>
<td>Cumulative Sum</td>
</tr>
<tr>
<td>CUSUMSQ</td>
<td>Cumulative Sum of Squares</td>
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<td>DF</td>
<td>Dicky-Fuller</td>
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<td>EC</td>
<td>Error Correction (term)</td>
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<td>ECM</td>
<td>Error-correction Modelling</td>
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<td>EG</td>
<td>Engle and Granger</td>
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<td>EURO</td>
<td>European union single currency</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GNP</td>
<td>Gross national Product</td>
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IFS  International Financial Statistics (data in CD-ROM)
IMF  International Monetary Fund
KPSS Kwiatkowski, Phillips, Schmidt and Shin
LPG Liquefied Petroleum Gas
LR  Likelihood Ratio Tests
LRAS Long-run Aggregate Supply
ML  Maximum Likelihood
OECD Organization of Economic Co-operation and Development
OLS Ordinary Least Square
PP  Phillips Perron
PPI Producer Price Index
PPP Purchasing Power Parity
RE  Rational Expectations
RM  Ringgit Malaysia
SBC Schwarz Bayesian Criterion
SC  Seasonal Dummy Variable
SRAS Short-run Aggregate Supply
SSE Sum Square Error
SVAR Structural Vector Autoregression
TCE Theories of Consistent Expectations
U.K. United Kingdom
UIP Uncovered Interest Parity
USA United States of America
VAR  Vector Autoregression

VECM  Vector Error-Correction Modelling
Chapter One

Introduction of Study

1.1 General Introduction

The fluctuations of exchange rates and the subsequent effects on major macroeconomic variables such as the national price level, output and money are controversial issues in international monetary economics. Economists have studied the issue both theoretically and empirically and found different results which fueled controversies. The studies by Sriram (1999), Dornbusch (1987), Dornbusch and Fischer (1986), Papell (1994), Woo (1984), Gordon (1982), Froot and Klemperer (1989) and Hooper and Mann (1989), Kamin and Rogers (2000), Upadhyaya and Upadhaya (1999) on this issue have received considerable attention.

Since the introduction of flexible exchange rates in 1973, most developing countries moved to more flexible exchange rate regimes\(^1\) and have subsequently experienced considerable exchange rate volatility. Moreover, most of them went through economic reforms which structurally changed these economies from agriculture based to industry (and trade) based. Between 1970 and 2000, the agricultural sector of most developing countries shrank whereas the industrial sector contribution increased. Among the developing countries, this study focuses on three major countries of ASEAN (Association

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\(^1\) See Caramazza and Aziz (1998, p.2). For example 87 per cent of developing countries had some period of pegged exchange rate policy in 1975 but by 1996 this had fallen to well below 50 percent.
of South East Asian Nations) namely Malaysia, Indonesia and Thailand. These three economies experienced on an average 8 per cent growth in the 1970s, 6 per cent in 1980s, recovery in the period 1991-96, followed by economic contraction in 1997-1998, due to the Asian crisis. Over 1970-1996, these three countries' average economic growth was much higher than the world average economic growth.² The official classification of exchange rate regimes for these three countries are reported in Table 1.1.

**Table 1.1: Official Exchange Rate Regimes for Malaysia, Thailand and Indonesia**

<table>
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<th>Country</th>
<th>Period</th>
<th>Exchange Rate Regimes</th>
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<td></td>
<td>b. 1998-2000</td>
<td>b. Fixed</td>
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<tr>
<td>Indonesia</td>
<td>a. 1978-1997</td>
<td>a. Managed Float</td>
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Source: Based on Hernandez and Montiel (2001).

Table 1.1 suggests that none of the countries had a market based exchange rate system before the Asian crisis in 1997 although these countries did experience exchange rate fluctuations, largely because of government intervention. Moreover, all three countries undertook open economy policies to promote economic growth and development. The degree of openness varies among the countries in terms of exchange rate regimes, extent of protectionism and trade liberalization measures. All three countries have liberalized

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² This is based on the information contained in various issues of World Economic Outlook, International Monetary Fund.
their banking and financial sectors to enhance the effectiveness of open economic policies. Malaysia had a fairly well developed system in the 1970s, while financial liberalization did not occur in Indonesia and Thailand until the 1980s.

Economic policy changes, including the monetary and exchange rate policies of these countries are aimed at integrating them with the world economy while maintaining domestic macro-economic stability. The major objectives of these policies are:³

- Exchange rate policies are designed to promote economic growth and prosperity through international trade. Moreover, a stable exchange rate is regarded as vital for economic progress.⁴ Most of the adjustments to the exchange rates in these countries are made in response to imbalances in the balances of payments in order to restore international competitiveness.
- Monetary policies are designed to promote economic growth with macro economic stability. Higher domestic and foreign investment as well as low inflation are the primary targets of monetary policies in these countries.
- Although these countries pursued open-economy policies, government frequently intervene to maintain macroeconomic stability, especially price level stability was frequent in our study period.

Whatever the economic policies and degree of exchange rate fluctuations, the impact on major macro economic variables such as the price level, investment, money and output

³ A brief review of economic policies is introduced for each country in chapters Five, Six and Seven.
⁴ One of the main reasons for managed (or some kind of fixed) exchange rates in these countries.
are noticeable. Since these countries' industrial production largely depends on imported raw materials, costs of production are also likely to be affected by these policies.

The ways open economy policies affect the major macro economic variables are outlined theoretically in Chapter Four. The main aim of this thesis is to analyse the empirical relationships among major macro variables such as the exchange rate, price level, output and money for each country separately.

1.2 Statement of Problem

Before the Asian crisis in 1997, Malaysia, Indonesia and Thailand had been in the limelight as success stories in the developing world. One of the main reasons for the impressive economic performance of these countries was a policy shift towards a more liberalised, open economy.

While there has been much empirical work on the linkages among exchange rate, price level and output, there have been few studies on the linkages among exchange rate, price level, money, output and foreign interest rates (e.g. Chowdhury, 1997, Sriram (1999) etc.). The countries in this study exhibit small open economy characteristics due to their monetary and exchange rate policies which attracted large capital inflows with profound effects on major macro economic variables. Most empirical studies have been directed at explaining the causes, nature and impact of exchange rate fluctuations for developed countries where exchange rates are more flexible. Little research has been done on the
developing world where countries maintained managed floats (or some kind of fixed exchange rate). As Warner and Kreinin (1983) argued, even if developing countries peg their currencies to major currencies, their effective exchange rates will still vary so long as major currencies fluctuate against each other. If the effective exchange rates of developing countries vary because of variations in major currencies, then they may also have effects on macroeconomic variables similar to those observed in developed countries. Following their arguments several studies were undertaken by Alba and Papell (1998), Rana and Dowling (1985), Rana (1981), Cooper (1971), Chowdhury and Dowling (1982), Woo (1984), Rittenberg (1993) and others on the issue in developing countries. These studies of the price level impacts of exchange rate movements were based on the analysis of dynamic models that link only the exchange rate and the price level giving less importance to other macroeconomic variables. None of the study explained the importance of open economy relationships among the exchange rate, price level, output and money relating to emerging ASEAN economies. Moreover, these studies did not investigate the proposition of ‘monetary neutrality’ from developing countries point of view\(^5\). Therefore, while there is a near consensus that excess money supply is a necessary cause of inflation there is uncertainty as suggested by Dornbusch (1987) about the link between exchange rates and the price level.

In a small, open, emerging economy, exchange rate movements can influence domestic prices through their effects on aggregate supply and demand. On the supply side, exchange rates should affect prices paid by the domestic buyers of imported goods

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\(^5\) Monetary neutrality may not necessarily imply market clearing or rational expectations as in the new classical models. Rather as explained later in chapter Four, it may arise due to structural rigidities or subsistence real wage.
directly. In general when a currency depreciates it will result in higher import prices if the country is an international price taker, while lower import prices result from appreciation. However, the strength and timing of this direct effect on domestic prices is not clear, given the nature of long-term contracts, the possible short-run non-price responses of foreign firms to sizable exchange rate changes and the relative proportion of imports in the overall economy.

Exchange rate fluctuations could also induce indirect supply effects on domestic prices. The potentially higher cost of imported inputs associated with an exchange rate depreciation (devaluation) increases marginal costs and leads to higher prices of domestically produced goods. Further import-competing firms might increase prices in response to foreign competitor price increases to improve profit margins. The extent of such price adjustment depends on, among other things, the government monetary and exchange rate policies. Most of the existing studies failed to investigate such price adjustments incorporating monetary and exchange rate policies for the developing countries.

Exchange rate variations can also affect aggregate demand. To a certain extent, exchange rate depreciations/appreciations increase/decrease foreign demand for domestic goods and services producing an increase/decrease in net exports and hence aggregate demand. Further, the expansion in domestic demand and gross national product may bid up input prices and accelerate wage demands by workers seeking a higher money wage to maintain real wages. The wage rise may result in further price increases. Except for Kahn
(1987) and Hafer (1989), most of the studies are not specific about this way of raising the price level.

Exchange rate fluctuations can affect output in a small open economy through international trade. A depreciation/devaluation can effectively lower the price of domestic goods in the foreign market, raising exports which eventually has a positive effect on aggregate income. Empirical studies on the output effect of exchange rate movements by Agenor (1991), Kyereme (1991), Edwards (1986), Kamin and Rogers (2000), Upadhyaya and Upadhaya (1999), attracted considerable attention with mixed empirical findings which make the issue controversial. Moreover, none of the above studies examined any of the ASEAN countries.

The relationship between the exchange rate and money is important for these three emerging countries as money plays a significant role in these economies during our study period. All these countries experienced huge capital inflows which could affect money market equilibrium. The relationships among exchange rate regimes, high capital inflows and domestic money supply for these three economies are often referred to as the “open economy trilemma” (Dean, (1996), Glick et al. (1995)). There are many studies on the “open economy trilemma” but one direct approach to test trilemma was taken by Rose (1996). Rose compared the predictions of a monetary model of exchange rates, based on money aggregates and outputs, with actual exchange rate movements, conditional on capital controls and the exchange rate regimes. His results were somewhat consistent with

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6 “Open Economy Trilemma” implies the inability of policy makers simultaneously to pursue a fixed exchange rate, open capital markets and autonomous monetary policy.
the trilemma but not strong findings\textsuperscript{7}. Except for Deravi \textit{et al.} (1995), Keran (1979), Yurtsever (2003), most of the studies somehow skipped the money-exchange rate relationships. Deravi \textit{et al.} (1995) partially examined the money-exchange rate relationship using a VAR model of the exchange rate, money and price level for the USA. Moreover, several studies such as Frankel (1981), Haynes and Stone (1981), Mees and Rogoff (1983\textit{a, b}) and Driskill and Sheffrin (1981) point to considerable uncertainty, irrespective of empirical studies, regarding the proper dynamic specification of the exchange rate and other macro equations.

Finally, exchange rate, price level and output issues have been mostly studied for developed countries. Only a few studies such as Alba and Papell (1998) and Rana and Dowling (1985), Kamin and Rogers (2000), Upadhyaya and Upadhaya focused on developing countries. Among those, Alba and Papell’s study is on three ASEAN countries (i.e Malaysia, Singapore and Philippines) and Upadhyaya and Upadhaya’s (1999) study is on India, Malaysia, Pakistan, Philippines, Sri Lanka and Thailand. But again none of the studies investigated specifically the linkages among the exchange rate, price level, money and output for major ASEAN countries such as Malaysia, Indonesia and Thailand.

Against the above background, it is worth examining the linkages among the exchange rate, money, output, price level and foreign interest rate in the context of small, open, fast-growing economies. The main aim of this thesis is to examine the short and long-run

relationships among mentioned variables with a view to deriving some sensible open
economy money supply (policy reaction function) and to a lesser extent, testing long-run
money demand functions. These results would, in future, help the respective countries to
formulate and implement effective monetary and exchange rate policies. The thesis uses
the popular time-series econometric technique, Johansen's multivariate cointegration
analysis, followed by vector error correction modelling to examine the above
relationships.

1.3 Objective of the Thesis

The main objective of this thesis is to provide empirical assessments of linkages among
the exchange rate, price level, money and output for Malaysia, Indonesia and Thailand
during the period of their rapid economic expansion. The periods under investigation are
theoretical background of the above mentioned empirical assessment is outlined in
Chapter Four within the framework of an open-economy, and IS-LM, AS-AD style
analysis. So the principal objectives are outlined below:

(i) Examining the long-run relationships among the exchange rate, price level,
output and money for each country within the theoretical framework.

(ii) Investigate the extent to which long-run money demand and PPP relationships
hold in the AS-AD model.

(iii) To test long-run monetary neutrality for each country.
(iv) To derive a short-run money supply function (policy reaction function) by ECM techniques for each of the country.

(v) To examine the short-run dynamic specifications for each of the endogenous variables for each country. Especially, examine the relative impact of exchange rate changes on output, inflation and money in the short-run.

(vi) Finally, to estimate the forecasting performance and dynamic adjustment process of ECM models of exchange rate, price level, output and money.

Although the period of analysis is different for each country, examining the linkages within the same framework will help us evaluate and compare the short and long-run implications of open-economy policies for the emerging economies of East Asia. This could be of help for the policy makers and the economists in designing effective monetary and exchange rate policies.

1.4 Structure of the Thesis

The thesis is divided into eight chapters.

Chapter One is the introduction to the study.

Chapter Two reviews past relevant studies on the relationships among exchange rate, price level and output covering a wide range of countries from developing to developed
economies. This is particularly important for identifying gaps in the literature on the subject.

Chapter Three provides discussions on the major time-series techniques to be applied in the empirical chapters (Chapter Five, Six and Seven) of the thesis. These are (i) Vector Autoregression (VAR) (ii) Unit Roots tests (iii) Lag length determination test procedures (i.e AIC, SBC, LR) (iv) Cointegration techniques (v) Vector Error Correction Models. There are also some discussions on related concepts such as Causality, Impulse Response and Variance Decomposition.

Chapter Four provides the theoretical background for the empirical model. The Theoretical model is essentially a standard open economy model without fiscal policy variables. The empirical analyses of the thesis are based on this theoretical background.

Chapter Five, Six and Seven contain empirical examinations of the theoretical model outlined in Chapter Four in the context of Malaysia, Indonesia and Thailand respectively. The periods covered are 1973-1999 for Malaysia, 1978-200 for Indonesia and 1978-2001 for Thailand. Each Chapter begins with a short review of related studies and a brief discussion of monetary, exchange rate and fiscal policies respectively. The empirical examination is carried out within the framework of structural VAR concentrating on cointegration and error-correction modeling. The principal issues to be investigated in each Chapter are whether it is possible to derive a money supply function for the country under study from open economy relationships outlined in Chapter Four. If possible, then
testing (i) monetary neutrality in the long-run (ii) the nature of short-run dynamic specifications for each endogenous variables (iii) the nature of short-run money supply function (policy reaction function) using ECM techniques and (iv) forecasting performance and dynamic adjustment process of VECM models.

Chapter Eight summarizes the conclusions of the thesis and points out the implications for policy and future research.
Chapter Two

Literature Review

2.1 Introduction

This chapter provides a literature review of the development, and the empirical evidence relating to, the relationships among the exchange rate, price level, output and money for the three ASEAN countries. Both the mechanism through which this relationship takes place and the subsequent results of the relationship are still disputable both theoretically and empirically. Therefore, the review presented in this chapter focuses specifically on the relationships among the above mentioned variables and presents previous theoretical and empirical evidence regarding this. This literature review will establish that there is a knowledge gap in the context of the thesis objectives outlined in Chapter One and this thesis hopes to contribute to that gap.

This chapter is organised as follows: Section 2.2 focuses on the theoretical literature, Section 2.3 focuses on the empirical evidence from developed countries, Section 2.4 focuses on the empirical evidence from developing countries, and Section 2.5 is the conclusion of the chapter.
2.2 Review of the Theoretical Literature

The theoretical model presented in chapter Four is an open economy model and therefore it is important to start with a review of open economy macro models. Among the open economy models, the Mundell-Fleming (MF) model is the best known and most widely used.

The Mundell-Fleming model is regarded as a benchmark model and is an extension of the standard IS-LM model. The model was developed on a few basic assumptions. The assumption of fixed money wages and prices is the key feature of the model, implying a perfectly elastic aggregate supply (AS) curve where output is determined by the position of the aggregate demand curve. The degree of capital mobility in the MF model is determined by the sensitivity to interest rate differentials. Following Argy (1994), the model can be expressed in three equations: (i) the first equation represent commodity market equilibrium i.e. IS curve, (ii) the second equation represent money market equilibrium i.e. LM curve and (iii) the third equation represents overall balance of payments over initial exports and defines the balance of payments curve i.e. BP curve. These three equations can be solved for three variables, domestic income ($y_d$), the domestic interest rate ($r_d$), and either the exchange rate ($e$) if the system is flexible or the balance of payments position for a given ($e$) if the exchange rate regime is fixed. For a fixed exchange rate regime coupled with an unsterilized and fully flexible exchange rate regime, both internal and external balance require that all three markets are always in equilibrium. This model is very useful in analyzing the effectiveness of fiscal and
monetary policies under different exchange rate regimes. But the MF model has one specific flaw which is lack of the supply side.

Engel (2002) developed open economy general equilibrium models to show the responsiveness of consumer prices to exchange rate variations. In the first model, which is a sticky price model, prices are set in the currency of the producer. This means that there is full pass through of nominal exchange rate changes to consumer prices. That is, price in the home country of a foreign good moves one-for-one with changes in the nominal exchange rate. The second model assumes home and foreign markets are segmented and firms set two different prices – one in domestic currency for home consumers and the other in foreign currency for foreign consumers. In this model changes in the nominal exchange rate have no short-run effect on prices faced by consumers and therefore no influence on the relative demand for home versus foreign goods. The third model incorporates the distribution sector that imports goods and sells them to consumers. In this model final prices are set in the consumer’s currencies and exchange rate changes affect distributors, (distributors’ relative demands for home and foreign goods) not consumers’ demand. We have not come across any empirical estimation of these models.

Dornbusch (1976) developed a macroeconomic model to study exchange rate movements when movements are large and consistent with rational expectations. The paper shows how adjustment takes place in goods and asset markets under capital mobility and expectations. The formal model has four interrelated sub-sections, each of which shows
steps to derive final equations. These four sub-sections are; (i) capital mobility and expectations; (ii) The money market conditions; (iii) The goods market conditions and, (iv) equilibrium exchange rate conditions. With the above conditions and consistent expectations assumptions, Dornbusch shows the effect of monetary expansions on the entire structure of the economy. Based on the model results, the author concludes that the effect of monetary expansion is an equiproportionate increase in prices and exchange rate in the long-run. In the short-run, monetary expansion has a real effect on interest rate, terms of trade and aggregate demand. Dornbusch’s analysis of monetary expansion confirms the Mundell-Fleming results that under conditions of capital mobility and flexible rates, a small country can conduct, in the short-run, an effective monetary policy. Exchange rate, in this study, proves to be a critical channel for the transmission of monetary changes to an increase in aggregate demand and output. This is one of the best theoretical works on open economy macro models. However, it ignores the role of fiscal variables in the model.

Dornbusch (1987) developed equilibrium pricing models that explain price movements as a result of changes in exchange rate, e.g. a dollar appreciation lowers the foreign unit labour costs of the dollar. As a result market equilibrium is disturbed in each industry and price and output adjustment must occur. The nature of the adjustment depends on three factors: (1) market integration and separation (2) substitution between domestic and foreign variants of a product (3) market organization. The study developed three models namely the Cournot Model, the Dixit-Stiglitz Model and the extended Dixit-Stiglitz Model. These models explain how appreciation leads to a decline in the price of imports.
In the case of homogeneous goods the decline in price fully matches appreciation. In the case of product differentiation, the relative price of imported goods declines in response to appreciation while the price of exportable goods will be increased. The extent of the decline/increase depends on the measurement of competition and on the relative number of home and foreign firms. Although these models are developed for exchange rate questions they can also be applied with few modifications to measure the short run effect of trade liberalization.

2.3 Empirical Evidence from Developed countries

(a) Studies on the USA & Canada

Saunders (2002) examined the nominal and real output effects of monetary changes on the U.S. economy both in the long-run and short-run. The study used annual data for the period 1959-1999 and cointegration and vector error-correction techniques. Johansen's cointegration test results indicate that a long-run relationship between money (M1) and nominal GDP is cointegrated. But there is no relationship between real GDP and the money supply (M1) in the long-run suggesting monetary changes have no significant role in the determination of real output growth in the U.S.A. This result further suggests that in the USA, monetary policy is a useful tool in determining prices in the long-run. The VEC test results indicate the existence of short-run unidirectional causal flow from M1 to nominal GDP. The major shortcoming of this study is that it only considered M1, ignoring the role of M2, M3 or broad money.
Gali, J (1992) developed an extended IS-LM model to fit postwar US data for four major macroeconomic variables’ money, interest rates, prices and GNP. Accordingly, he estimated a simple macroeconometric model driven by four exogenous disturbances. The major conclusion from the findings was that the dynamic response of the economy to different types of disturbances matches closely most of the qualitative predictions of a Phillips curve-augmented IS-LM model.

Miller (1991) examined monetary dynamics for U.S. using quarterly data for the period 1959-1987. Using the Engle and Granger method of cointegration, the study used four alternative monetary aggregates M1, M2, M3 and liquid assets (L). Trivariate cointegration regressions suggest that only M2 has a long-run relationship with real GDP, the implicit price deflator, interest rate and price level. None of the other monetary aggregates is cointegrated with the determinants of money demand. These findings indicate the usefulness of M2 as monetary policy implementation for the United States. The error correction model results (in post 1973) provide evidence that the growth rate of money stock and the interest rate are significantly affected by the error-correction term. But for error-correction models, using Akaike’s FPE criteria provides weak evidence – the ECM term is only significant in the money growth equation.

Louis (2002) estimated a modified version of the monetary policy reaction function for Canada. The model incorporates a dynamic structure for price adjustment and a term structure of interest rates into a basic AS-AD framework. Among six equations, the model estimates only the inflation adjustment equation and policy reaction function using
OLS techniques for the Canadian data for the period 1970-2000. The findings show that the Bank of Canada had a consistent monetary policy over the years, with Bank rate rather than monetary aggregates as the principal instrument. One of the problems of this study is that it considers the Bank rate as the only relevant variable to link the Canadian economy to the rest of the world. It ignores the significant role of the exchange rate and other foreign variables such as foreign interest rate.

Deravi et al. (1995) estimated the effects of exchange rate depreciation on the price level using a vector autoregressive (VAR) model of exchange rates, price level and money supply. The study used a three variables VAR model, in which the variables are the nominal level of money supply, the exchange rate and the consumer price index. And for the exchange rate three different prices were used i.e. trade-weighted dollar exchange rate, the deutschmark price of the dollar and the yen price of the dollar. The study estimated the model for the USA using data for the period January 1975 to February 1990. To trace the links between the above mentioned three variables, the study used variance decomposition and impulse response analysis. Findings from the study are: (1) changes in exchange rates lead to changes in the general price level and inflation, even when one accounts for the effects of the money supply on the price level. (2) the explanatory power of these exchange rate effects on the inflation rate are comparable in size to the predictive power of monetary shocks. (3) Dynamic response to shocks is robust to alternative decompositions. These results are confirmed by impulse analysis which indicates that a depreciated dollar leads to a higher rate of inflation over a two year period.
Driskill (1981) examined the questions of whether there is short-run exchange rate overshooting, whether the intermediate run exchange rate and price level adjustment are monotonic and whether the long run proportionality holds among money supplies, price levels and exchange rates. In order to test the above hypotheses against Swiss/U.S. data, the study used reduced form exchange rate and price level equations which are consistent with the structural model. This structural model has two parts: one based on the Dornbusch model and another based on a stock/flow model. Both models imposed a priori constraints on the reduced form parameters which can be in principle rejected by the nature of the data. But neither structural model is sufficiently complex and a true structural model may impose few theoretical predictions about apriori reduced form constraints. This possibility emphasizes the fact that the reduced form empirical estimates are more general than either of the structural models. The major conclusions of the study are: (1) the exchange rate overshoots in the quarter in which a monetary change takes place by a factor of about two (2) The exchange -rate adjustment path to full equilibrium is not monotonic as predicted by the original Dornbusch fixed-output model but rather exhibits periods of appreciation and depreciation. However, the study found that the price level adjusts monotonically. And finally the study concluded that Purchasing Power Parity holds in the long run.

Kaplan (1992) examined the hypothesis that at the industry level expected exchange rate movements have impacts upon the domestic price level if manufacturing industries respond to actual and expected fluctuations of the dollar. The study also tests for determinants of observed pass through. The study used 14 years of US data for four digit
standard manufacturing industries. It chose to analyze price responses to real exchange-rate changes, as the links from currency movements to domestic prices derive from supply responses on the part of foreign firms which in turn influence the demand and cost conditions facing domestic firms and these foreign supply responses are determined both by nominal exchange rates and by relative inflationary pressures. This implies that it is the real value of the foreign exchange movements that matters. With this, the study developed a new index of exchange-rate expectations and explored its role in determining domestic producer prices. The study observed that both actual and expected future exchange rates have independent impacts on price level determination at the industry level. However, these effects are not mutually reinforcing, nor are the industry determinants of the two price effects the same. Major findings of the study are that the sustained periods of appreciation and depreciation over a certain period may have tended to inhibit the pass-through into domestic prices. In an appreciation period, while domestic firms continued to see an unpleasant future, they kept prices relatively high despite competitive and cost incentives for price reductions. In a depreciation period, the pursuit of market share to enjoy in the (expected) continued good times kept prices lower than otherwise expected. Only when a turning point is forecast would one expect to see reinforcing effects with quick price reductions as the end of a period of appreciation.

sectors they found no evidence of a long-run relation between the value of the dollar and the sectoral output.

Woo (1984) empirically examined the effects of exchange rate changes on the price level for the United States for the period 1971-1975 using quarterly data. The study outlined four channels through which the exchange rate can affect the price level. The first is through the prices of imported consumer goods which directly affect the consumer price index. The second is the prices of imported inputs which directly affect costs of production. The third is aggregate demand via the trade multiplier. The fourth is foreign prices which affect the prices of domestically produced import competing goods. The study adopts a fairly standard structural approach of estimating markup price equations for both import prices and domestic consumer prices. It also includes an export price equation in the model. The import price equation tests for the impact of exchange rates on import prices, correcting for other factors that directly influence import prices and in a similar way the domestic price equation tests for the impact of import prices on domestic prices. The study finds that a significant relationship between non-food, non-oil import prices and domestic consumer prices emerges when the domestic price equation is refined by removing services and automobiles (in addition to food and oil) from the left hand side variable. However, the coefficient estimate obtained for import prices indicates a much smaller impact on domestic prices than conventional estimates suggest. The main weakness of the study is that it uses the single equation approach which is basically incapable of giving a precise estimate. A more disaggregated approach that separates imports into consumer goods, capital goods and intermediate goods and traces each
component through the economy would be theoretically more satisfying. Moreover, as the PPP relationship ought to hold in the long run, and the fact that equations outlined in this study do not yield this results, it clearly indicates that they are mis-specified.

(b) Studies on the United Kingdom and the G-7 countries

Elyasiani and Zadeh (1995) examined open economy money demand using United Kingdom monthly data for the period 1975-1990. The study applied the Box-Cox model to the UK money demand relationship within an open economy model. The money demand specification employed is based on the assumption that demand for real money balances, M, is dependent on a scale variable (income Y, or consumption CNS), an opportunity costs proxy (interest rate, r) and an exchange rate variable EXR. It uses time series techniques of unit root and cointegration to the data. The log-likelihood ratio and the non-nested PE tests (Kmenta, 1986) are employed to examine the functional form of the money demand function for the UK. Both tests reject the linear and log-specifications. The study also tests Mankiw and Summer’s proposition that money demand is consumption based which is rejected for the UK data while the income based model remains unscathed. The study used the Engle and Granger (1987) method of cointegration which has many shortcomings as mentioned later in Chapter Five. Moreover, the open economy money demand equation does not have any theoretical background which may have led to misleading conclusions.
Ericsson (1998) examined several key issues of the money demand using the U.K. data. The study tested issues of economic theory regarding money demand, data measurement, parameter constancy, opportunity costs of holding money and financial innovation and deregulation, cointegration and model specifications. This study provides a practical "Check-list" for empirical studies of money demand using the U.K. narrow money demand to illustrate each issue. But the major problem of this study is it concentrates on "closed economy" money demand ignoring open economy variables. Moreover, the study used the UK narrow money (instead of broad money) data which are not free from controversy.  

Meher (1993) developed a link between exchange rate instability and the domestic price level, measurement of variations in the structure of relative prices, the impact of real exchange rate changes on world trade and the extent to which exchange rates are forecastable. The approach is broadly empirical and applies econometric and modelling techniques to a wide range of data of G-7 and other OECD countries. The central theme of this study is that strict PPP implies that the exchange rate is determined exclusively by prices at home and abroad. The rate is largely independent of real factors such as differential growth among sectors, oil embargoes, supply shocks, commodity booms and shortages. Prices of goods are spatially arbitrated and, after being adjusted for trade

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8 Two issues are here. First: the issue of parameter constancy. As Judd and Scadding (1982) and Goldfield and Scihel (1990) showed that parameter constancy is a primary issue in empirical money demand studies. And parameter non-constancy can arise from mis-specification of money demand model. Using M1, instead of M2, may produce parameter non-constancy in the money demand model. Rose (1985) examined US money demand function using M1 data and found mis-specified ECM that produced non-constancy of the parameter. But using annual data, Macdoanld and Taylor (1992) found a constant U.S. money demand function for the period 1874-1975. Second issue is about opportunity cost of holding money. In Ericsson’s (1998) discussion focused on the opportunity cost of holding narrow money. But calculation of opportunity could be different if one uses broad money (see Wolters et. al.(1998).
barriers and transport costs, are equalized across countries when expressed in terms of a common currency.

Papell (1994) estimated the effects of exchange rates on prices in the context of a semistructural model of exchange rate determination in which both exchange rates and prices are determined endogenously. Papell assumed that the exchange rate is co-integrated with its fundamentals. Using quarterly data for G-7 countries (i.e. Canada, France, Germany, Italy, Japan, the United Kingdom and the United States), the author utilized three measures of the price level, GNP deflator, Consumer Price Index (CPI) and Producer Price Index (PPI). The model was examined by Full System Maximum Likelihood methods, because these methods are asymptotically optimal and a valid basis for inference if they incorporate the correct restrictions that n-r unit roots are present in the system where n is the number of variables and r is the number of cointegrating vectors. ML estimates show that exchange rate depreciation has small and insignificant short run effect on domestic prices when measured by the GNP deflator. For Canada and the USA the relationship is positive, i.e. higher depreciation causes inflation to rise and become significant. For the UK it is slightly higher and marginally significant. For other countries it is negative and marginally significant. The effects are somewhat stronger when prices are measured by the consumer price index. These positive values are both significant and larger than results with GNP deflator for Canada, the UK and the USA. For Germany, Italy and Japan the relationship is insignificant and negative. When measuring PPI, the relationship is positive and significant for the UK and the USA and marginally significant for Germany. For Italy and Japan it is negative, fairly large and significant. In short, we
can say that the study finds considerable variations in the effects of exchange rate on prices depending on the measure of price index, with effects strongest for PPI, followed by CPI and the GNP deflator. Variations are also found across countries with the effects strongest for the UK, followed by Canada and the United States.

(c) Studies on Monetary Neutrality

Olekalns (1996) applied 'a reduced form test for long-run neutrality' to the Australian data for the period 1900-1901 to 1993-1994. The test procedure was based on a bivariate, autoregressive representation of output and money. Output was defined as real gross domestic product (GDP) and two different measures of the nominal money stock M1 and M3 were used. The results show that M1 was neutral in the period while M3 non-neutral indicating that M3 had a role in variations of Australian real output during the period. The major problem with this study is that it considered only two variables i.e. money and output ignoring the possible effects of other major macro variables on real output in the long-run.

Boschen and Mills (1995) developed tests of Long Run Monetary Neutrality based on permanent innovations in the money supply using an empirical framework that is multivariate and cointegration based. The study used a multivariate framework because shocks with potential long-term effects on output are likely to come from multiple sources. The authors used the Johansen and Johansen and Juselius method of cointegration and applied it to the US data for the period 1951-1990. Results show that
monetary aggregates play no role in explaining permanent movement in GNP. The study also concluded that shocks from exogenous labor supply play a prominent role in the stochastic trend in GNP. This study is one of the excellent works in the area of monetary neutrality.

2.4 Empirical Evidence from Developing Countries including ASEAN Countries

Empirical literature from developing countries is ordered on the basis of literature on (i) Non-Asian countries; (ii) Non-ASEAN countries; and (iii) ASEAN countries. Moreover, ASEAN countries literature is organized as follows: (a) Multi country studies; (b) studies on Malaysia; (c) Studies on Indonesia, and (d) Studies on Thailand.

(i) Literature on Non-Asian Countries

Agenor (1991) estimated the effect of exchange rate changes on economic activity by using a formal model of output determination and estimating the model for 23 developing countries using the fixed effect estimation procedure to a pooled sample of cross section and time series data. The study developed an output equation where real output depends on unanticipated movements in the real exchange rate, the money supply, government spending, foreign economic activity as well as on actual changes in the real exchange rate. Empirical estimation of the above output equation shows that (i) unanticipated movements in money supply and government spending have an insignificant effect on output while unexpected changes in world economic activity have a significant effect. (ii)
unanticipated changes in the real exchange rate have a positive effect on output while anticipated changes in real exchange rate have a negative effect on output although they are not highly significant. The result remains the same when the current real exchange rate is replaced by its once-lagged value. The methodological approach used in this paper is controversial and therefore subject to several limitations. As Kamin (1988) argued, time series regression analysis of exchange rate effects on output may not be totally appropriate for characterizing devaluation episodes. First they do not tell us what has happened historically during a devaluation episode. Real exchange rates move more or less continuously over time; they merely show more exceptional movement during devaluations. Second normally devaluations are associated with other stabilization policies, but they are large, isolated events that occur sporadically and their effects may differ qualitatively from slower more routine exchange rate adjustment.

Arestis and Demetriades (1991) empirically estimated Cyprus money demand using cointegration and error correction modeling for the period 1963-1988. The variables in the money demand function essentially represent a closed economy function. Moreover, the study utilized income and consumption as scale variables. The Engle and Granger cointegration tests suggest that there exists a long-run relationship among money, consumption, interest rate and inflation. The result supports the hypothesis of long-run proportionality between money and prices. The short-run models suggest that ‘Dynamic’ demand for money appears to respond to any deviation from the long-run equilibrium position with the adjustment being completed in just one year. The coefficients of other variables in the ECM have expected signs. The study is not free from criticism,
particularly because using two scale variables in one money demand function may have ambiguous conclusions on estimated results.⁹

Kamin and Klau (1998) examined an empirical relationship between the rate of inflation and the level of the real exchange rate in a group of 39 countries from Asia, Latin America and the industrialized world. Using an inflation equation which is a single equation and a simple two-good model, the estimation was based on annual data for the period 1970 to 1996. The major conclusions from the study are that (1) there is clearly a role for the level of the real exchange rate, along with the output gap, in the determination of inflation in many economies. And (2) the responsiveness of inflation to the real exchange rate appears to have been much higher in Latin America than either in Asia or in industrialized countries. Finally (3) the differences in the responsiveness of inflation to the real exchange rate between the regions do not appear to be the result of estimation problems induced by changes in equilibrium real exchange rates, nor are these differences accounted for by the two most obvious possible determinants of inflationary responsiveness (a) the prior inflation history of a country and (2) the openness of the economy.

Kamin and Rogers (2000) attempted to establish the relationship between exchange rate depreciation and output using Mexican data. In order to establish the relationship they first disentangled the various factors which could be leading to negative correlation

⁹ For example, comparing two equations (because of two scale variables) one may tentatively suggest that the estimated equation with consumption as a scale variable performs better on the statistical criteria and diagnostics than the equation where the scale variable is income. But whether the differences between the two sets of results are significant enough to conclude confidently that the equation with consumption is preferred outright to the one with income is not a clear cut question, therefore, needs further investigation.
between exchange rate depreciation and output. These are (1) reverse causation (2) spurious correlation with third factors and /or (3) temporary contractionary effects of devaluation that determine whether one of the factors that accounted for a positive, long run effect of real depreciation on output can be identified. Their study starts with the evaluation of the bivariate correlation between quarterly Mexican output in terms of real seasonally adjusted GDP and the real exchange rate in terms of the CPI adjusted peso price of the US dollar. In the first stage the study analyzed the correlation between real exchange rate and output at various leads and lags and found a negative correlation between these two variables. While using bivariate Granger causality tests the study indicates that lags of real GDP do not help to explain movements in the real exchange rate but lagged exchange rates do help to explain real GDP. Hence estimates support the view that the correlation between real exchange rates and output reflects causality running from exchange rates to output, not vice-versa.

The major findings of Kamin and Rogers come from the VAR estimation where multiple models were used to identify the relationship between exchange rate, price level and output. The study focused on a core model containing three key endogenous variables-output, the real exchange rate and inflation and one key exogenous variable – the US interest rate. The model was estimated in two stages. In the first, the variables were regressed on lags of all the variables in the system and in the second stage the Cholesky decomposition technique was used to orthogonalize the residuals. The study concludes that in Mexico, sustained real devaluations have been associated with persistent high inflation and contraction in economic activity (output). Findings also indicate that this
effect is merely reflective of a spurious correlation of output and devaluation with other shocks.

Kyereme (1991) examined the dynamic inter-relationships among the currency exchange rate, consumer price inflation and real output growth as well as roles of money and interest rates in output and price determination in the context of Ghana. The study used time series annual data for the period 1960 to 1988 and vector auto regression techniques. Empirical results suggest that there is a more significant relationship between exchange rate and price inflation than exchange rate and real output.

Rittenberg (1993) examined the relationship between exchange rate changes and price level changes in Turkey during the 1980s using Granger Causality Tests. The estimated results show that Granger-causality runs from price level changes to exchange rate changes but there is no feedback causality from exchange rate changes to price level changes. Hence Turkey's experience with managed floating exchange rates in the 1980s appears to be not only that domestic inflation contributed substantially to exchange rate movements as predicted by the doctrine of Purchasing Power Parity or by a government decision rule to maintain purchasing power parity, but that exchange rate movements had a negligible effect on inflation. This conclusion, moreover, was not altered by the inclusion/exclusion of the money supply variable. So the author concluded that exchange rate adjustment does not seem to have created a vicious cycle of currency depreciation leading to inflation which is often feared by academics and policy makers. Since Turkey is fairly advanced among developing countries with large domestic market, this result,
does not guarantee whether the same will hold for other developing countries which adopt flexible exchange rate regimes.

Sanchez-Fung (2002) estimates a hybrid monetary policy reaction function for the Dominican Republic for the 1969-2000. Using annual data and ARDL econometric techniques, the study finds that the Central Bank has been biased towards targeting the gap between parallel and official exchange rates especially after mid 1980s. This implies that authorities are well aware of economic changes and assumed to behave rationally. The relevance of the rules verses discretion literature for the case under analysis is obvious although the way this study outlines policy reaction function is subject to serious limitations. There are mainly two limitations: (i) the Central Bank of Dominican Republic is not free from government influence\(^\text{10}\). Therefore, their policy reaction function, in other words, represent government’s view, not the actual macroeconomic conditions of the economy, (ii) The framework for monetary policy reaction function used in this study is not consistent with the standard framework in the literature. The standard framework (McCallum, 1999) for monetary analysis should rely on macroeconomic models with three basic components (a) an IS-type relation (or set of relations) that specifies the effects of monetary policy on aggregate demand and output; (b) a price adjustment equation (or set of equations) that specifies the effects of the output gap and price expectations on inflation; (c) a monetary policy rule that specifies the policy makers’ setting of a short-term instrument (usually the interest rate) in response to the state of the economy as given by expected, current and lagged values of the system’s variables.

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\(^{10}\) See page 2 of this paper. The Governor of the Central Bank is appointed by the constitutionally elected President of the country, and can be removed at any moment.
Tanner (2001) examined the relationship between exchange market pressure and monetary policy in selected Asian and Latin American countries. More specifically, it examined how contractionary (expansionary) monetary policy affects exchange market pressure in the way that monetary framework predicts. Using VAR techniques, the study derived impulse response functions for each country and pooled estimates for all countries. Estimated results show that one measure of monetary policy, domestic credit growth, has powerful impacts on Exchange Market Pressure (EMP) in the "right" direction, i.e. a reduction in the domestic credit component of the money supply helps to reduce EMP either by increasing the value of a country's currency, or its stock of international reserves or both. Evidence regarding the response of EMP to interest shocks was somewhat weaker than that linking EMP and domestic credit growth. There is also some evidence for a few countries that positive interest differential shocks also help reduce EMP. On the whole the study provided some evidence that monetary authorities respond to increases of EMP by expanding rather than contracting domestic credit. The major weakness of this study is the limited variables in the VAR system. Only three (monetary aggregate, interest rate differential, EMP) variables are there. But there are more than two variables, which may affect EMP.

(ii) Literature on Non-ASEAN Countries

Bahmani-Oskooee and Shin (2002) examined Korean money demand stability using cointegration and vector error correction modeling. Using quarterly data for the period 1973-1999, the money demand function uses three versions of money (M1, M2 and M3)
to determine the stability of its relationships with income, interest rate and the nominal effective exchange rate. The cointegration test suggests that neither M1 nor M3 is cointegrated with income, interest rate and nominal effective exchange rate. But one cointegration vector is found for M2, income, interest rate and nominal effective exchange rate relationships. The study found that the M2 money demand function was unstable throughout the study period. The study failed to discuss the coefficients of estimated money demand. The study only used the CUSUMSQ statistic and error-correction model to determine the stability which may be insufficient.

Bahmani-Oskooee and Chi Win Ng (2002) examined the long-run money demand for Hong Kong using a different econometric technique i.e ARDL method. The open-economy money demand includes broad money, income, domestic interest rate and foreign interest rate and nominal effective exchange rate variables. Using cointegration and the ARDL representation of an error correction model, the estimated coefficients suggest that there are long run relationships among real broad money, real income, domestic interest rates, foreign interest rates and foreign exchange rates. Moreover, the estimated money demand is found to be stable. The study lacks theoretical arguments in developing an open economy money demand function for Hong Kong.
(iii) Literature on ASEAN Countries

(a) Multi Country Studies

Alba and Papell (1998) study on three ASEAN countries (i.e. Malaysia, Singapore and Philippines) examined effective exchange rate determination and the factors that affect domestic prices of these three countries. The study used a small open economy model and two versions of the estimated model. One is the Constrained Rational Expectations (RE) model and another is a Semi-constrained model, compatible with the concepts of Theory Consistent Expectations (TCE). Both versions of the model were estimated using Full System Maximum Likelihood Methods with quarterly data from 1979(I) to 1995(II). The RE model has mostly significant results with coefficients with expected signs and plausible magnitudes, but the likelihood ratio test rejects the RE model in favor of the TCE model. The study found that exchange rate expectations are affected mainly by the current exchange rate. Variations of effective exchange rate significantly affect inflation in the three Southeast Asian countries but with a lesser magnitude for Malaysia and Singapore. Results of the study also show that foreign prices affect inflation in Malaysia while foreign income has a positive effect on inflation in the Philippines. The foreign interest rate has a negative effect on inflation in Singapore but a positive effect in the Philippines. The study further concluded that during the period Malaysia and Singapore experienced high growth and stable prices while the Philippines experienced low growth and high inflation. Inflation in all three countries is shown to be affected by different external factors, Malaysia and Singapore, avoided high inflation despite high levels of
economic growth through tight or anti-inflationary monetary policy whereas 'loose' or partly accommodative monetary policy in the Philippines resulted in high inflation.

Rana and Dowling (1985) examined exchange rate and price level relations in nine low-to-moderate inflation Asian countries. In particular, the study examined whether small but continuous changes in effective exchange rates such as those frequently encountered in the generalized floating period influence the inflation rate in small open economies. The study used Bautista's (1980) hybrid monetarist model in a modified form. The single equation model consists of demand and cost-push factors and estimation of the model was done using OLS and cross section data from nine Asian developing countries - India, Indonesia, S. Korea, Malaysia, Nepal, Philippines, Singapore, Taiwan and Thailand during the period 1973 to 1979. Three major findings of the study are: (1) there is no relationship between small but continuous changes in effective exchange rate and inflation rate, (2) During the period much of the inflation in the Asian countries was imported due to the increased price of imports. (3) Asian countries excess money supply did not have a significant effect on inflation rates, which supports the findings of Saini (1982).

Upadhyaya and Upadhyaya (1999) examined the effect of devaluation on output for six developing countries of Asia (three countries from ASEAN & three from South Asia). They examined the effect of devaluation in two different ways. First: Nominal devaluation affects output only if it leads to real devaluation. Since this approach considers only the effect of a movement in the real exchange rate, it disregards the
combination of nominal exchange rate and foreign-to-domestic price ratio that generates such a movement. If prices rise at the same rate as the rate of nominal devaluation then the real exchange rate is constant leaving no room for output adjustment. Second: Instead of including just the real exchange rate, they also included both the nominal exchange rate and the relative price level in their regressions. Authors used annual time series data for 30 years from 1962-1992, and carried out tests for stationarity and found that data are non-stationary. Results show that there is no positive and significant contemporaneous effect of real devaluation on output. Countrywise, the relationship in Pakistan is negative and significant at 5%, Thailand is at 20% level and in all other countries the relationship is insignificant at the 20% level. The two-year lag doesn’t effect the output of any country either. When they separated the real exchange rate into nominal exchange rate and the relative price-ratio, the results showed nominal devaluation by itself has no significant effect on output at 10% level or better. Moreover, the contractionary effect of nominal devaluation is visible only for Malaysia at an insignificant level. The study could not find any significant effect of nominal exchange depreciation after a one-year or a two year lag.

Dekle and Pradhan (1997) examined the impact of financial market development and liberalization on money demand behavior in four ASEAN countries namely Indonesia, Thailand, Singapore and Malaysia. Using the Johansen maximum likelihood test for cointegration and annual data, the results suggest that one long-run relationship exists among income, price, interest rate and money for all countries except Malaysia. But the estimated results, by and large, do not provide strong evidence for a stable relationship
among the variables. The major shortcoming of this study is that it uses annual data and a closed economy model. When economies are open, estimating a closed economy model in that scenario could produce inappropriate results and that is the case here.

(b) Studies on Malaysia

Ibrahim (2001) analyzed the roles of financial factors in the behavior of M1 and M2 demands for Malaysia. The determinants of money demand functions are real income (y), nominal interest rate (r), exchange rate measure (e), real stock prices (s). Due to the inclusion of the exchange rate variable, money demand function represents open economy money demand. Using monthly data from 1977:1 to 1998:08 for two sub-sample periods, Johansen-Juselius cointegration suggests that there is two cointegrating vectors for Malaysia for the period 1987:01 to 1998:08 while the first sub-sample period does not have any long-run relationship. This indicates a long-run relationship exists among money (both M1 and M2), income, a domestic interest rate, the exchange rate and real stock prices only after 1987. The error-correction estimation results suggest that the overall M1 model has satisfactory explanatory power for the dynamic money demand function only in the post 1986 period. The whole sample money demand function fails diagnostic tests. In the case of M2 money demand function, the estimated results suggest that the real income and stock prices have positive impact on M2 demand while interest rate and exchange rate have negative impact on M2 demand. The study lacks a proper theoretical specification of money demand function, a specially the relationship with real stock prices and the foreign interest rate.
Beng (1991) evaluated the extent to which an effective exchange rate of a small open economy like Malaysia conforms to the PPP relationship, both in the short-run and the long-run. Using four sub-sample periods from 1973 to 1987, the cointegration tests suggest the absence of any long-run relationships. The major findings of this study are that the Ringgit effective real exchange rate follows a random walk and that the deviations from PPP are highly persistent with little or no evidence of mean-reverting behaviour even in the long-run.

Marashdeh (1993) tested the proposition\textsuperscript{11} that unanticipated policy changes affect real economic variables while anticipated ones do not influence them. He used Malaysian quarterly data for the period 1970 to 1990. He imposed several restrictions on the coefficients of the estimated equation implied by the proposition. The relevant findings of the stepwise estimation of the autoregressive model for output growth, money growth, net foreign asset growth, inflation and government expenditure growth were as follows: (i) the estimated output equation showed that anticipated changes in money supply and inflation affects output. No relation between output changes and government expenditure and net foreign asset was found. (ii) the estimated money-supply growth equation showed that anticipated movements of output affect money growth. (iii) the estimated foreign asset equation showed that anticipated changes in money growth, output growth, inflation and government expenditure growth affect net foreign assets directly. (iv) the estimated inflation equation showed that anticipated changes in money growth and output growth

\textsuperscript{11} This is, in other words, Lucas (1972), and Sargent and Wallace (1975) proposition. Theoretically they found that anticipated monetary changes have no impact on real economic variables, neither in the short-run nor in the long-run whereas unanticipated changes in the money supply have a profound impact on real economic variables.
affect inflation directly. The author imposed several restrictions to test the neutrality propositions. One of the major problems of this study is the absence of any theoretical framework.

Tan and Baharumshah (1999) examined the dynamic causal chain linking money, real output, interest rate, and inflation in the context of Malaysia. They used multivariate cointegration analysis with vector error-correction modeling, multivariate Granger causality, variance decomposition and impulse response functions. The sample period broadly covers the period from 1975 to 1995. The estimated results by Granger-causal suggest that money supply has short run effects on economic activity. However, among the various definitions of money (M1, M2, and M3) used in the study, M3 appears to have the strongest effect on output and a moderate effect on price level. M1 has the strongest effect on inflation while M2 does not lead prices in the short-run. The absence of any significant Granger-causality from real output to price level suggests that the excess aggregate demand generated by the increase in income is absorbed by the expansion of aggregate supply in the economy. The main problems of this study are: (i) it does not give any theoretical background to the empirical analysis (ii) the study did not explain the long-run relationships among money, income, price level and interest rate although it found one cointegrating relationship among the variables, and (iii) no open economy aspect is incorporated in the model.

Sriram (1999) examined the money demand function for Malaysia in a most comprehensive way. The paper empirically tested the money demand function both in
closed and open economy formats using cointegration and error correction modeling. Using monthly data the study covers the period from August 1973 to December 1995. The closed economy model results suggest that one cointegrating vector, i.e. a long-run relationship exists among money (M2), industrial production (proxy for income), inflation and two versions of the interest rate (time deposit rate and treasury bill rate). The estimated result supports the theory of money demand in a closed economy format. The paper linked the money demand results with the Malaysian financial system development over the last two decades. Although the estimated money demand function is stable, the cointegration system as a whole including the interest rate measures shows some vulnerability during 1985-87 and 1993-95 periods. The cointegration tests for the open economy model suggests one vector after few modifications of the initial model. The open-economy formulation provides additional information by looking at the direct effect of the changes in exchange rate on money demand which appears to be very small. One of the problems of this money demand function is that it uses two versions of the domestic interest rate while ignoring the impact of the foreign interest rate on Malaysian money demand.

(c) Studies on Indonesia

Affandi (2004) estimated the monetary policy reaction function for Indonesia using the Generalized Method of Moment (GMM) of Hansen (1982). The theoretical framework of the paper is based on three equations of the monetary model, in which households and firms' behaviors are assumed to have New Keynesian features and the Central Bank is
assumed to solve well-defined optimization problems. The study used monthly data for
the period 1993:03 – 2003:09 of nominal (domestic) interest rate, consumer price index,
consumer price index for non traded goods, exchange rate, and industrial production
index as proxy for monthly output. The estimated results suggest that Central Bank puts
more weight on inflation than on output, clearly indicating its main task was to achieve
(or maintain) price stability. The study also found the factors that contribute to a long run
inflation rate are as follows: (i) the response of monetary authority to expected inflation;
(ii) the depreciation rate; and (iii) the long run real interest rate. The empirical results
show that Central Bank used aggressive measures to control inflation rate. This is also
evident from higher interest rates during the period of Asian crisis. This higher interest
rate could have led to a lower output level during the crisis period. The results further
suggest that the Central Bank should target inflation, while at the same time allow the
exchange rate to float, despite the impact of exchange rate variability on inflation. The
main problem with this study is that it used only the interest rate rule of monetary policy.
But as we know, BI has increased money supply during the period which was not
discussed in the study.

Siregar (1999) tested two hypotheses in the light of the real exchange rate and inflation
relationships for Indonesia. Using a small economy model, the study tested the following
two hypotheses: “(i) Does government’s intervention in the foreign exchange market
contribute to the fluctuations in the Rupiah? (ii) Has the exchange rate management in
Indonesia directly and significantly contributed to the high rates of inflation in 1990-95?”
Using monthly data from January 1987 to July 1995 and standard econometric tests, the
author concluded that monetary authority played an active role in maintaining stable rupiah value against the US dollar. Estimated results also suggest that the exchange rate policy of Indonesia designed to stimulate exports through aggressive depreciation has often ended up in a higher domestic inflation. The variables used in this study are the nominal exchange rate, ratio of Indonesian CPI over US CPI, the real exchange rate for Rupiah.

Siregar and Rajan (2004) estimated the impact of exchange rate volatility on Indonesian’s trade performance in both pre and post crisis periods. In the pre crisis period (1980-1997), most (nine out of twelve) estimated regression results show exchange rate volatility affected export and import performances i.e. the poor performance of the trade sector. The “fear of floating” could be the main reason for this poor performance. The performance in the post crisis period shows similar patterns. Despite the dramatic decline in the nominal exchange rate, exports’ did not show a strong pick up; the exports performance shows the reverse.

McLeod (1997) explained the causes of chronic inflation in Indonesia since 1972. Without a well defined model and econometric techniques, the author argued that excessive growth of base money is the cause of chronic inflation in Indonesia. The author outlined this with two important points: (i) Indonesian monetary authorities failed to keep growth of money constant in line with money demand. (ii) Banking deregulation in Indonesia during the study period complicated the estimation of the demand for base money.
(d) Study on Thailand

Chowdhury (1997) examined Thai demand for money emphasizing Thailand's financial structure in an open economy setting. The study analyzed a money demand function in a two-country portfolio balance model. Using quarterly data over the period 1974-1993, the money demand function includes M1 or M2 as dependent variables and income (real GDP), price, exchange rate (nominal effective exchange rate) and the foreign interest rate (EURO represents world interest rate) as independent variables. Johansen cointegration test results suggest that one cointegrating vector is found when the money demand function excludes the foreign interest rate while two cointegrating vectors are found when foreign interest rate is included (full money demand function). In the case of M1, the estimated results indicate that the null hypothesis of a unit income elasticity and zero foreign interest elasticity are not rejected, but the hypothesis of price homogeneity is rejected at a reasonable level of significance. The short-run forecast of the M1 equation is biased. On the other hand, the M2 equation for money demand function is reasonable, the long-run elasticities are consistent within the range reported for other developing countries. Moreover, structural stability and unbiased forecasting ability is found in the M2 equation.
2.5 Conclusion

This chapter has provided a review of the literature that deals with the relationships among the major macro economic variables in an open economy setting. The review reveals a number of interesting issues relating to the theoretical models and empirical findings. Below, the issues which are most relevant for this thesis are listed.

First: The review of the theoretical literature (section 2.2) has shown the importance of choosing appropriate open economy macro variables and of identifying proper theoretical relationships among them. This discussion is important for the adoption of the theoretical framework of this thesis in chapter Four.

Second: The literature review also shows that most of the studies have employed wide range of estimation techniques i.e. from single equation (OLS) to unrestricted/ restricted VAR. These diversified techniques produced results that often attract criticisms on the grounds that they are inappropriate. Therefore, it is important to identify a methodology which is consistent and most appropriate. The discussions of econometric techniques within the empirical studies are integral to the development of the methodological framework in Chapter Three.

Third: It is important to pay attention to whether the data and the empirical model are relevant to economic theory. Many studies in this review estimated empirical models without outlining a proper theoretical framework. This thesis has addressed this issue by
presenting a theoretical background to the empirical model. The structural VAR models in chapters Five, Six and Seven are based on the theoretical background described in Chapter Four.
Chapter Three

Methodology

3.1 Introduction

The main objectives of this thesis are to examine the relationship among exchange rates, price levels, money and output in three ASEAN countries namely Malaysia, Indonesia, Thailand. Most of the Macroeconomic variables are found to be non-stationary, indicating a time trend and non-constant mean and variance. Applying OLS methods to non-stationary data may produce spurious results. Various time series econometric techniques are to be employed in the subsequent chapters of the thesis to overcome this problem. They are: (i) Vector Autoregression (VAR) (ii) Unit Roots (iii) Cointegration and (iv) Error-correction modelling (ECM).

The application of the VAR method enables us to forecast systems of interrelated time series economic variables like output, the general price level, exchange rates, money and other similar macro variables or to analyze the dynamic effects of the different types of random disturbances and controls on systems of these variables. In other words, a VAR is a system of equations in which each endogenous variable is a linear function of its own past values, past values of other endogenous variable in the system, exogenous variables that help determine the endogenous variables and other non-random parts like constant terms or polynomial functions of time.
This chapter is organized as follows: Section 3.2 presents a brief review of the VAR originally developed by Sims (1980) and Hsiao (1981). Section 3.3 reviews the Unit root process with emphasis given to the testing procedures developed by Dicky and Fuller (1976, 1979, 1981), Phillips and Perron (1988) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992). Section 3.4 discusses the procedures of lag length determination. Section 3.5 discusses the cointegration theory. Section 3.6 discusses Vector Error Correction Model. Section 3.7 discusses the concept of Causality. Sections 3.8 and 3.9 discuss Impulse response function and Variance decomposition. Section 3.10 contains concluding remarks.

3.2 The VAR Technique

The VAR is an econometric technique used in situations where one is dealing with a relationship described by a system of more than one equation. Since most macroeconomics variables are interrelated, the VAR provides a very useful tool to capture both dynamic and interdependent relationships among variables. Sims (1980) developed the VAR model based on the argument that no a priori distinction between endogenous and exogenous variables should be made in a model if we assume that there is true simultaneity among a set of variables. All variables should be treated on an equal footing. Hence, the VAR model, in its most basic and general form, considers all
variables symmetrically without making reference to the issue of dependence versus independence, or endogenous versus exogenous.\textsuperscript{12}

A VAR is simply a system of dynamic linear equations in which each variable is written as a function of a serially uncorrelated error term and a number of lags of all variables (endogenous as well as exogenous) in the system. In fact, the term 'vector' in the VAR model refers to vectors with two or more variables in the system whereas the term autoregressive is due to the appearance of the lagged value of the dependent variables on the right hand side. The general mathematical structure of the VAR can be expressed as:

\[ Y_t = D(t) + B_1 Y_{(t-1)} + \ldots + B_m Y_{(t-m)} + C_1 X_{(t-1)} + \ldots + C_p X_{(t-p)} + \epsilon_t \quad (3.1) \]

where

\[ Y = \text{An n x 1 vector of endogenous variables} \]
\[ B = \text{An n x n matrix of coefficients for endogenous variables} \]
\[ X = \text{An j x 1 matrix of exogenous variables} \]
\[ C = \text{An n x j matrix of coefficients of exogenous variables} \]
\[ \epsilon = \text{An n x 1 vectors of error terms (is a vector of innovations that are correlated with each other but uncorrelated with their own lagged values and uncorrelated with } Y_{(t-1)} \text{ through } Y_{(t-m)} \]
\[ m, p = \text{the lag length} \]

\textsuperscript{12} In VARs as developed by Sims, all variables are assumed to be endogenous. Specifying some of the variables to be exogenous introduces restrictions on the model, because such variables will be able to affect the endogenous variables only directly, but not indirectly through the feedback effect from the endogenous variables themselves.
D = An n x 1 vector of deterministic components (these could include a constant term, seasonal dummies for quarterly or monthly data or the dummy variables to represent discrete shifts in policy).

The VAR was developed to overcome the problem of simultaneous equation bias by using the lagged values of endogenous variables on the RHS. The individual equations are thus estimated by OLS. The VAR model imposes minimal theoretical restrictions on the structure of the model. The tools employed by VAR analysis such as impulse response analysis and variance decompositions are useful in understanding the interrelationship among related macroeconomics variables and in the formulation of a more structured economic model. In a VAR model, when unit-root test(s) suggest that the model variables are nonstationary in levels, it is possible that a stationary linear combination of the variables could be found. In such a case, a vector error-correction model (VECM) needs to be estimated. In addition to the traditional VAR techniques described earlier, the VECM shows the long-run and short-run dynamic relationships amongst variables in the system.

The methods used in the VAR are relatively simple in the sense that one needs to specify only two things, the set of variables that are believed to interact and hence should be included as part of the economic system and the largest number of lags that are needed to capture most of the effects that the variables have on each other. However, the use of the VAR technique is not without criticism. The theoretical approach of traditional VAR is often criticized on the ground of inconsistent interpretations of economic theory. Cooley
and LeRoy (1985) have criticized the VAR approach on the grounds that the ordering imposed by a Choleski decomposition is not in fact atheoretical. It implies a particular type of recursive contemporaneous structure for the economy which is not consistent with economic theory. Also shocks are not pure shocks but rather linear combinations of structural disturbances. Therefore it is difficult to assess the dynamic effects on variables because they will depend on all the structural disturbances. Innovation (disturbance) techniques such as impulse response and variance decomposition associated with traditional VAR analysis have no obvious economic interpretation as a consequence of the theoretical approach taken. Moreover, some have pointed out that in practice, VAR modelling for more than four variables is rarely feasible since the number of parameters needed to be estimated becomes huge (Charemza & Deadman, 1992). Unless the sample size is large enough, estimating the parameters will consume a lot of degrees of freedom. To overcome the limitations of unrestricted VAR, a structural VAR (SVAR) is developed in Chapter Five and all the empirical analyses of this study are carried out within SVAR framework.

3.3 Stationary and Non-stationary Process: The tests for Unit Roots

In time series econometric techniques it is important to check whether the data series are stationary or non-stationary. Often time series data are non-stationary and modeling with non-stationary data series may increase the possibility of a spurious regression problem from which no valid statistical inference can be made (Phillips, 1986). Moreover, the
variance of a non-stationary series changes with time and the important assumptions of
OLS estimation break down

So stationarity or lack of it, is an important property of time series processes. In general, a
collection of N-dimensional random vectors... \( y_{t-1}, y_t, ... y_{(t+1)} \) is called a stochastic
*stationary* process if

(i) all the random vectors have the same mean vector

\[ E \left[ y_t \right] = \mu \text{ for all } t, \text{ so that } E \left[ y_t \right] = E \left[ y_{(t+k)} \right] \text{ for any } t \text{ and } k \]

(ii) the variance of all involved random variables is a finite constant \( \sigma_y^2 \)

\[ \text{var}(y_t) = \sigma_y^2 \text{ for all } t, \text{ so that } \text{var}(y_t) = \text{var}(y_{t+k}) \text{ for any } t \text{ and } k \]

(iii) the covariance matrices of vector \( y_t \) and \( y_{t+k} \) that are \( k \) periods apart do not depend
on \( t \) but only on \( k \).

\[ \text{cov}(y_t, y_{t+k}) = E \left[ (y_t - \mu)(y_{t+k} - \mu)^\prime \right] = \Gamma \text{ for all } t \]

so that \( \text{cov}(y_t, y_{t+k}) = \text{cov}(y_{t+n}, y_{t+n+k}) \) for any \( t, k \) or \( n \)

While estimating, the above mentioned conditions imply that the time series under
consideration must not have trends, fixed seasonal patterns, or time varying variances. If
time series variables do not possess the properties (i), (ii) and (iii) the variables are said to
be generated by a non-stationary process. The major difference between stationary and
non-stationary time series lies in the fact that shocks to a stationary time series are
necessarily short-lived. The “carry over” effect of an old shock on the current value of the
series will be insignificant if the shock happened long enough ago. Over time, the effects
of the shock will dissipate and the series will return to its long run mean level. In other
words, a stationary series will have a well-determined mean which will not vary greatly with the sampling period. On the other hand, in the case of a non-stationary series, an old shock will still have a noticeable impact on the current value of the series. The mean and/or variance of a non-stationary series are time-dependent and we cannot in general properly use the term mean without referring to some particular time period. The simplest example of a non-stationary process is the random walk which is well represented by the following equation:

\[ x_t = x_{t-1} + \epsilon_t \]  

where \( \epsilon_t \sim iid (0, \sigma^2) \), so that if \( x_0 = 0 \)

\[ x_t = \sum_{i=1}^{t} \epsilon_i \]  

Equation 3.3 implies that old shocks have equal weight to new shocks in determining the current value of \( x_t \). The variance of \( x_t \) is \( t\sigma^2 \) and this becomes indefinitely large as \( t \rightarrow \infty \). It is also clear that the concept of a mean value for \( x_t \) has no meaning.

While modeling time series data, it is important to know whether or not the underlying stochastic process that generated the series can be assumed to be invariant with respect to time. If the characteristics of the stochastic process change over time, i.e. if the process is non-stationary, it will often be difficult to represent the time series over past and future intervals of time by a simple algebraic model. Moreover, the statistical properties of regression analysis and estimators using non-stationary time series are dubious as evidenced by the substantial literature on "spurious regression."\(^{13}\) The Gauss – Markov theorem would not hold, for example, because a random walk does not have a finite

\(^{13}\) See, for example, Phillips (1986).
variance. Hence, OLS would not yield a consistent parameter estimator. If the series are non-stationary, one is likely to end up with a model showing promising diagnostic test statistics even in the case where there is no sense in the regression analysis.

To overcome the problem of non-stationary data and "spurious regression", a usual and common practice is to difference the time series to achieve stationarity. A non-stationary series is said to contain an integrated component and it should be differenced before the estimation process to achieve stationarity. Following a formal definition by Granger (1980, 1981) who introduced the concept of integrated series into econometrics, a series \( x_t \) is said to be integrated of order \( d \) (denoted \( \text{I}(d) \)) if it is a series which has a stationarity, invertible, non-deterministic ARMA representation after differencing \( d \) times. Based on this definition, a stationary series is said to be integrated of order zero, \( x_t \sim \text{I}(0) \). For a linear combination of two series, each integrated at different levels, the resulting series will be integrated at the higher of the two orders of integration. For example suppose

\[
Z_t = bx_t + cy_t, \text{ where } x_t \sim \text{I}(d_x), y_t \sim \text{I}(d_y) \tag{3.4}
\]

then in general \( Z_t = \text{I}(\max(d_x,d_y)) \).

However, this need not always be the case. The exception to this rule gives rise to the new concept of cointegration. An important exception to this rule occurs when the common integrating factor of two or more variables exactly offset each other to give a stationary \( Z \) series \( Z \sim \text{I}(0) \). The basic idea of a set of cointegrating variables is that if in the long run, two or more series move closely together, even though the series themselves
are trended, the difference between them is constant. Detailed discussion of the concept of cointegration will follow.

3.3.1 Testing for Non-stationarity

A number of alternative tests (commonly known as tests for a "Unit Root") are available to investigate the stationarity in a time series, or to examine the order of integration of a series (that is, the number of times it must be differenced before attaining stationarity). The three most popular unit root tests are the Dicky-Fuller (DF) and the Augmented Dicky-Fuller (ADF) tests, the Phillips-Perron (PP) tests and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests. Since the first two tests are applied in the subsequent empirical analysis of the thesis, it is useful to discuss them in more detail.

The DF and ADF Methods

Dicky and Fuller (1979) developed several tests that can be used to test for the presence of unit root. These tests will determine whether the series is a trend stationary process (TSP) or a difference stationary process (DSP). Starting with DF tests, they involve estimating an autoregressive (AR) model of the form:

\[ y_t = \alpha_0 + \alpha_1 T + \alpha_2 y_{t-1} + \epsilon_t \]  \hspace{1cm} (3.5)

A convenient reformulation of the above equation is:

\[ \Delta y_t = \alpha_0 + \alpha_1 T + \alpha_2^* y_{t-1} + \epsilon_t \hspace{1cm} \text{Where} \hspace{0.5cm} \alpha_2^* = \alpha_2 - 1 \]  \hspace{1cm} (3.6)
where $y_t$ stands for the time series variable in question, $\alpha_0$ represents a constant term, $T$ is linear time trend incorporated to allow for the possibility that the data are trend stationary and is an error term with zero mean and constant variance $\sigma^2$; that is $\epsilon_t \sim \text{iid} \ (0, \sigma^2)$.

In the above formulation, the DF test for unit root is carried out by testing the hypothesis that $\alpha_2^* = 0$. This is equivalent to testing the null hypothesis that $\alpha_2 = 1$ against the alternative hypothesis that $|\alpha_2| < 1$. If the null hypothesis cannot be rejected, the time series in question is said to be generated by a non-stationary process. In this case we cannot apply traditional $t$ and $F$ statistics directly to test the presence of a unit root in equation (3.5) under the null of $\alpha_2 = 1$ since the variance of the limiting distribution of $\alpha_2$ is not well defined (Fuller 1985). In this case the $t$ value of the estimated $\alpha_2$ obtained from equation (3.5) above has to be compared with the $t$-statistic reported in Fuller’s (1976) distribution table. It is important to know that the distribution of the $t$-statistic for the estimated $\alpha_2$ in equation (3.5) differs with the inclusion of a constant term or with a constant and time trend in the regression. These statistics are respectively denoted as $\tau, \tau_\mu$ and $\tau_1$ depending on whether a constant and/ or a constant time trend are included in equation (3.5) respectively. More specifically, the first test statistic $\tau$ is the test for stationarity of the levels of the time series about a zero mean. The second test $\tau_\mu$ is a test for stationarity of the levels of the time series about nonzero mean, while the third one is a test for stationarity about a deterministic time trend.

The Augmented Dicky-Fuller (ADF) test was developed as an improvement on the original Dicky–Fuller (DF) test. A weakness of the DF test is that it does not take into
account possible autocorrelation in the error process $\epsilon_t$. As a solution, the ADF test uses lagged left-hand side variables as additional explanatory variables to eliminate possible autocorrelation in the error process. The test is analysed by running an ordinary least square (OLS) regression equation which can be expressed as:

$$\Delta y_t = \delta y_{t-1} + \sum_{i=1}^k \beta_i \Delta y_{t-i} + \epsilon_t$$  (3.7)

The value of $k$ (the number of lags for $\Delta y_{t,i}$) should be relatively small in order to save degrees of freedom, but should be large enough to eliminate autocorrelation in $\epsilon_t$. The testing procedure is an examination of the Student $t$ ratio for $\delta$. As long as the value of the $t$ statistic is larger than the relevant critical value, we cannot reject the null of $\delta = 0$, the series contains a unit root and thus is non-stationary. The critical values for the distribution of the Student $t$-statistic are given by the Dicky-Fuller table.

The Phillips-Peron Test

Phillips and Peron (1988) have proposed another statistic to test for the existence of unit roots. This test involves non-parametric adjustments of the $t$ statistic into the Phillips-Peron $Z$ statistic. The adjustment procedure uses the residuals from the first order model ($k=1$) to correct the $t$ statistic. The correction requires estimating only one additional parameter $\sigma^2 = E [(\Sigma \epsilon_t)^2]$, which can be interpreted as the value of the spectral density of $\epsilon$ at the origin. The $Z$ statistic will have the asymptotic distribution tabulated by Dicky and Fuller for $t$.\(^{14}\)

\(^{14}\) Phillips and Perron calculate the DF test statistic and then adjust the DF statistic using the autocovariances of the errors with $k=1$. 
Tests for the Null of Stationarity: The KPSS Test

While the above test statistics test the null of non-stationarity, the following section considers tests for the null of stationarity.

Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992) test for the null of stationarity against the alternative of a unit root. In outlining the KPSS test, consider the simple regression model written in its component representation

\[ Y_{1t} = \theta_t + u_t \]
\[ u_t = \gamma_t + v_t \]
\[ \gamma_t = \gamma_{t-1} + \epsilon_t \]

where \( \theta_t \) is a deterministic component of either \{ 0, \alpha, \alpha + \mu t \}

\[ \gamma_t \] is a random walk

\[ \epsilon_t \sim iid N(0,\sigma^2) \]

\[ E(\nu_t \epsilon_t) = 0 \]

The test statistic for the null of stationarity is formulated as

\[ C = T^{-2} \sum S_t^2 / s^2(l) \]

where \( S_t = \sum_{i=1}^{t} \hat{u}_i^2 \) and \( s^2(l) \) denote a partial sum process of the cointegrating residuals and a consistent semiparametric estimator of the long-run variance of the regression error \( \Lambda \), respectively.
Assumption E (v_t e_t) = 0 states that the two disturbances are independent of each other. Shin comments that this assumption is not restrictive under the null but is restrictive under the alternative.

The above model can be rewritten as:

$$u_t = \gamma_0 + \sum_{j=1}^{\infty} c_j + v_t$$

and taking first differences gives

$$\Delta u_t = c_t + v_t - v_{t-1}$$

$$= v_t - \varphi v_{t-1} = (1-\varphi L)v_t$$

under the null of stationarity (i.e. $u_t \sim I(0)$), implying that $\sigma^2 = 0$ and hence that $u_t = v_t$.

Moreover, $\sigma^2 = 0$ implies that $u_t$ has been over-differenced since there is a moving average (MA) unit root, i.e., $\varphi = 1$.

The decision rule under KPSS is to reject the null hypothesis if the computed test statistic is greater than the critical value.

### 3.4 Determining the Optimum Lag Length

The second step in VAR is to choose an appropriate length of lag to be used in the model. The length chosen should be sufficiently large to make serial correlation of the residuals unlikely. However, the longer the lag length, the greater the number of parameters to be estimated and the fewer the degrees of freedom. There are two approaches to choose optimum lag lengths in estimating a VAR. The two approaches are: (1) to set appropriate lag lengths based on some statistical criterion and (2) to specify a few arbitrary
alternative lag lengths as recommended by Sims (1980). The first one is popular and has been used by Hsiao (1981) and McMillin and Fackler (1984) while the second approach has been used by Fischer (1991) and Pearce (1983). This study will follow the statistical criterion to determine optimal lag lengths.

3.4.1 Likelihood Ratio Test

The likelihood ratio statistic is

\[(T-K)\log \left[ \frac{L_r}{L_u} \right]\]

where \(T\) is the number of observations, \(K\) denotes the total number of variables (regression coefficients) in each unrestricted equation in the system, \(L_r\) and \(L_u\) are respectively the restricted and unrestricted matrices of cross products of residuals. To implement this test, VAR systems are initially estimated with an arbitrary lag set, say at “ten” quarters. The unrestricted model is then tested against a restricted model with a lower lag length equal to “nine” quarters. Under the null hypothesis, the test-statistic is distributed as \(\chi^2\) with degrees of freedom equal to the number of restrictions. The acceptance of the restriction that the appropriate lag is equal to “nine” requires a calculated \(\chi^2\) significantly larger than a corresponding figure obtained from the Chi-squared table. Such a procedure is repeated successively until an optimal lag is obtained. The likelihood test is based on asymptotic theory that may not be very useful in small samples. Moreover, the likelihood ratio test is only applicable when one model is a restricted version of the other.
3.4.2 Akaike Information Criterion (AIC)

Let \( \ln(\theta) \) be the maximized value of the log-likelihood function where \( \theta \) is the

Maximum Likelihood Estimator of \( \theta \) based on the sample size \( n \). The AIC for this model

is

\[
AIC_L = L_n(\theta) - P
\]

where \( P = \text{Dimension} \) and \( \theta = \text{number of freely estimated parameters} \).

In the case of single equation linear (or non-linear) regression models, the AIC can also

be written equivalently as

\[
AIC_\sigma = \log(\sigma^2) + 2p/n
\]

where \( \sigma^2 \) is the ML estimator of the variance of regression disturbances, \( u_o \), given by

\( =c'c/n \) in the case of a linear regression model. The above two versions of AIC yield

identical results. When using the first one, the model with the highest value of \( AIC_L \) is

chosen. But when using the criterion based on the estimated standard errors (second one)

the model with the lowest value for \( AIC_\sigma \) is chosen.

3.4.3 Schwarz Bayesian Criterion (SBC)

The SBC is defined as

\[
SBC_L = L_n(\theta) - \frac{1}{2} P \log n \tag{a}
\]

In application of the SBC across models, the model (a) with the highest SBC value is

chosen. An alternative version, based on the estimated standard error of the regression is

\[
SBC_\sigma = \log(\sigma^2) + (\log n/n) p \tag{b}
\]
According to this (b) criterion, a model is chosen if it is has the lowest SBC\(_c\) value. Normally SBC chooses lower lags than AIC.

3. 5 Cointegration

The concept of cointegration applies to a wide variety of economic models. The basic idea of cointegration was first proposed by Granger (1981) and formal analysis was developed by Engle and Granger (1987). Engle and Granger (1987) provide the following definition of cointegration:

The components of the vector \(X_t = (x_{1t}, x_{2t}, \ldots, x_{kt})\) are said to be cointegrated of order \(d, b\), denoted by \(X_t \sim CI(d, b)\) if

a) all components are integrated of order \(d, X_t \sim I(d)\)

b) there exists a vector \(\beta = (\beta_1, \beta_2, \beta_3, \ldots, \beta_n)\) such that the linear combination \(\beta = (\beta_1 x_{1t} + \beta_2 x_{2t} + \beta_3 x_{3t} + \ldots + \beta_n)\) is integrated of order \((d-b)\) where \(b>0\). The vector \(\beta\) is called the cointegrating vector.

There are several important points in this definition. Firstly, cointegration refers to a linear combination of nonstationary variables. Secondly, all variables must be integrated of the same order.\(^{15}\) Thirdly, if \(X_t\) has \(n\) components, there may be as many as \(n-1\) linearly independent cointegrating vectors. If \(X_t\) contains only two variables, there can be at most only one independent cointegrating vector.

\(^{15}\) However, this is true only for a two-variable case. For a two-variable case, if these two variables are integrated at different orders of integration, then these two series cannot possibly be cointegrated. However, it is possible to have a mixture of different order series when there are three or more series under construction in which various subsets may be cointegrated.
Series that are cointegrated are related over time. Any non-stationary series that are cointegrated may diverge in the short-run but they must be linked together in the long run. Therefore, cointegration implies that there must be Granger causality in at least one direction, at least one of the variables may be used to forecast the other. Furthermore, it has been proved by Granger (1983) and Engle and Granger (1987) that if a set of series is cointegrated, there always exists a generating mechanism called an "error correction model" that restricts the long run behaviour of the endogenous variables to converge to their cointegrating relationship while allowing a wide range of short run dynamics. Therefore, the cointegrated variables can always be thought of as being generated by an error-correction model.

3.5.1 Tests for Cointegration

Testing for cointegration combines the problems of the unit root test and a test with parameters unidentified under the null. For the N-dimensional multivariate case in which N variables are jointly determined in a system of equations, there are basically two methods to test for the existence of cointegration among these N variables. They are: the multivariate Engle-Granger two-step procedure and Johansen's Maximum-likelihood Test.

The Multivariate Engle-Granger Two-step Procedure

Engle and Granger proposed a two steps procedure to test for cointegration. Prior to estimation, the variables are pre-tested for their order of integration. Based on the
definition given by Engle and Granger (1987), cointegration necessitates that the variables be integrated of the same order. Therefore, each variable has to be pre tested by using the ADF and the PP test to determine its order of integration. If the variables are integrated of different orders, possibly these variables are not integrated.  

After determining the order of each variable in the model, a cointegration regression is run. Any one of the N variables can be normalized upon (whose coefficient is set equal to unity). The residuals (ε,) obtained from each cointegration regression will then be tested for stationarity by performing ADF and PP tests. If the residuals are found to be stationary, the variables are non-stationary of order 1(1).

If the variables are cointegrated, the second step of the EG procedure involves specifying an error-correction model (ECM) for each equation in the system. The multivariate EG two-step procedure for testing cointegration has some distinct shortcomings. The estimation of the each cointegration regression requires that one variable is placed on the left-hand side while using other variables as regressors. If one regression indicates that the variables are cointegrated whereas reversing the order indicates no cointegration, the meaning of cointegration is violated, since cointegration should be invariant to the choice of the variables selected for normalization. Most importantly, by using the EG method, it is not possible to identify the whole set of cointegrating relationships using this method. The method has no systematic procedure for the separate estimation of multiple cointegrating vectors.

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16 Anyway, it should be borne in mind that with three or more variables, each variable need not be the same order of integration, provided that subsets of the whole regressor set are equal in order (Hall and Henry, 1988).
Johansen's Maximum-Likelihood Procedure

The cointegration test carried out by using the Johansen's Maximum-Likelihood procedure provides more robust results when there are more than two variables in the model. The multivariate maximum likelihood cointegration testing procedure was developed by Johansen (1988) and Stock and Watson (1988) and Johansen and Juselius (1990). The multivariate procedures utilize test statistics that have a unique distribution which is a function of a single parameter and can be used to evaluate cointegration relationships among a group of two or more variables. Thus, it is a superior test in a situation involving three or more variables in which there may be more than one cointegrating vector in the system.

The Johansen procedure sets up the following vector autoregressive models:

\[
\Delta X_t = \sum_{i=1}^{k-1} \Gamma_{0i} \Delta X_{t-i} + \nu_{0t} \tag{3.9}
\]

\[
X_{t-K} = \sum_{i=1}^{k-1} \Gamma_{1i} \Delta X_{t-i} + \nu_{1t} \tag{3.10}
\]

To determine the number of unique cointegrating vectors, two likelihood ratio (LR) test statistics are constructed by using the residual vectors \( \nu_{0t} \) and \( \nu_{1t} \). There are two basic test statistics involved in Johansen and Juselius's maximum likelihood test. The first test statistic, known as the trace test is given by:

\[17\] Goodwin and Grennes (1994) have provided a very straightforward description regarding this method. Hence a large part of the discussion in this section is based on the explanation given by Goodwin and Grennes.
\[ \tau_{trace} (r) = -T \sum_{i=r+1}^{p} \ln (1 - \lambda_i) \]  \hspace{1cm} (3.11)

where \( T \) is the number of usable observations, \( \lambda_{r+1} \ldots \lambda_p \) denote the \( p-r \) smallest squared canonical correlations of \( \nu_{ot} \) with respect to \( \nu_{tt} \). The trace test tests the null hypothesis that the number of cointegrating vectors in \( X_t \) is less than or equal to \( r \) (where \( r \leq N-1 \)). The second test statistic which evaluates the null hypothesis that there are exactly \( r \) cointegrating vectors is known as the maximal *eigenvalue test.* The maximum eigenvalue test statistic is given by:

\[ \tau_{max} (r, r+1) = -T \ln (1 - \lambda_{r+1}) \]  \hspace{1cm} (3.12)

The critical values of the \( \tau_{trace} \) and \( \tau_{max} \) statistics are calculated by Johansen and Juselius (1990). If \( r \) (number of cointegrating vectors) is equal to \( N \) (the number of variables in the system), the vector process, \( X_t \) is said to be stationary (that is all the variables in \( X_t \) are integrated of order zero). In other words, the variables in \( X_t \) are not cointegrated.

Another way to show the maximum likelihood method is by considering a VAR model represented by:

\[ X_t = \sum_{i=1}^{k} A_i X_{t-i} + \epsilon_t \]  \hspace{1cm} (3.13)

where \( A_i \) is a \((N \times N)\) matrix of parameters and \( X_t \) is an \((N \times 1)\) vector of variables. A more general way to present this multivariate model is to express as follow:

\[ \Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \epsilon_t \]  \hspace{1cm} (3.14)

where

\[ \Gamma_i = -I + A_1 + \ldots + A_i (I \text{ is a unit matrix}) \]
\Pi = -(I - A_1 - \ldots - A_k)

The rank of the matrix \Pi is equal to the number of independent cointegrating vectors which can be defined as

\Pi = \alpha \beta^r \tag{3.15}

where the matrix \beta is the matrix of cointegrating parameters and the matrix \alpha is the matrix of weights with which each cointegrating vector enters the N equations of the VAR. In this sense \alpha can be viewed as the matrix of the speed of adjustment parameters.

By using maximum likelihood estimation, \alpha and \beta can be estimated by firstly estimating the error correction model and then determining the rank of \Pi, using the \( r \) most significant cointegrating vectors to form \beta and lastly selecting \alpha such that \Pi = \alpha \beta^r.

In practice we can obtain only estimates of \Pi and its characteristics roots. The \( \tau_{\text{trace}} \) and \( \tau_{\text{max}} \) statistics used in this version are the same as in equation 3.11 and 3.12 respectively except that \( \lambda \) in this case are the estimated values of the characteristics roots.

3.6 Vector Error Correction Model

Cointegrated variables are always thought of as being generated by error-correction equations. The vector error-correction model (VECM) allows a long run component of variables to obey equilibrium constraints while short run components have flexible dynamic specifications. In fact, cointegration implies that there is some adjustment process which guides the variables to the long run relationship. VECM are applied to capture the short run dynamic adjustment of cointegrated variables. It relates the changes
in one variable \( y_t \) to the changes in another variable(s) \( x_t \) and the past periods disequilibrium, \( \epsilon_t \)^18

Consider a VAR system with \( N \) components: the vector time series can be expressed as
\[
Y_t = (y_{1t}, y_{2t} \ldots y_{nt}), \text{ while the ECM is of the form:}
\]
\[
\Delta y_1 = \delta_1 - \alpha_1 \epsilon_{t-1} + \text{lagged (} \Delta y_1, \Delta y_2 \ldots \Delta y_N) + d(B)\mu_{1t}
\]
\[
\Delta y_2 = \delta_2 - \alpha_2 \epsilon_{t-1} + \text{lagged (} \Delta y_1, \Delta y_2 \ldots \Delta y_N) + d(B)\mu_{2t}
\]
\[
\Delta y_N = \delta_N - \alpha_N \epsilon_{t-1} + \text{lagged (} \Delta y_1, \Delta y_2 \ldots \Delta y_N) + d(B)\mu_{Nt}
\]
\[\text{(3.16)}\]
where \( d(B) \) is a finite polynomial in the lag operator \( B \) so that \( B^k y_t = y_{t-k}, \mu \) is a stationary disturbance, \( \epsilon_t = B^* y_t \) an \( Nx1 \) vector of stationary random variables and \( \delta_t \) is the constant.

A more general error correction representation for a multivariate system as given by
Engle and Granger (1987) is as follows:
\[
A(B)(1-B)Y_t = -\alpha \epsilon_{t-1} + d(B) \mu_t
\]
\[\text{(3.17)}\]
where \( \mu_t \) is a stationary multivariate disturbance with \( A(0) = I, A(1) \) has all elements and \( \alpha \neq 0. \)

Equation 3.17 indicates that the amount and direction of \( \Delta y_t \) take into account the size as well as the sign of the previous equilibrium error, \( \epsilon_{t-1}, \epsilon_t \) in a cointegration regression is a stationary series and thus inclined to move towards its mean. The idea behind this equation is simply that a proportion of the disequilibrium from one period is corrected in the next period. If the coefficient on the error correction term (\( \epsilon_t \)) is statistically insignificant, it implies that this variable does not adjust to deviations from equilibrium.

---
^18 \( \epsilon_t \) is the residual equilibrium error. It is a measure of the extent to which the system is out of equilibrium.
If the constant in each system is statistically insignificant, it means that the process is not generated by a linear trend. The error correction terms give an additional channel of Granger-causality so far ignored by the standard causality test (Masih and Masih, 1996).

3.7 Causality

As we have already mentioned (in section 3.5) cointegration means causality in at least one direction amongst the variables in the model. A time series \( y_{2t} \) is said to cause another time series, \( y_{1t} \), if present \( y_{1t} \) can be predicted by using past values of \( y_{2t} \) rather than by not doing so. Granger’s (1969) definitions of causality and feedback are:

(a) Causality
If \( \sigma^2 (Y_t \mid A^t) < \sigma^2 (Y_t \mid A^{t-1}X^t) \), i. e. prediction of \( Y \) using past \( X \) is more accurate than without using past \( X \), in the mean square error sense we say that \( X \) causes \( Y \), denoted by \( X \rightarrow Y \).

(b) Feedback
If \( \sigma^2 (Y_t \mid A^t) < \sigma^2 (Y_t \mid A^{t-1}X^t) \) and \( \sigma^2 (X_t \mid A^t) < \sigma^2 (X_t \mid A^{t-1}Y^t) \), we say that feedback occurs, denoted by \( X \leftrightarrow Y \).

(c) Instantaneous causality
If \( \sigma^2 (Y_t \mid A^t, X^t) < \sigma^2 (Y_t \mid A^t) \), we say that instantaneous causality (of \( X \) to \( Y \)) occurs.

To demonstrate the idea of causality in the Granger sense, consider a VAR system with \( Y_t = (y_1, y_2, \ldots, y_N) \) which is generated by a stationary, normally distributed VAR (k) process.
\[
\begin{bmatrix}
Y_{1t} \\
Y_{2t}  \\
\vdots \\
Y_{Nt}  \\
\end{bmatrix}
= \begin{bmatrix}
\delta_1 \\
\delta_2 \\
\vdots \\
\delta_N  \\
\end{bmatrix}
\begin{bmatrix}
\theta_{11,k} \\
\theta_{21,k}  \\
\vdots \\
\theta_{N1,k}  \\
\end{bmatrix}
\begin{bmatrix}
Y_{1,t-k} \\
Y_{2,t-k}  \\
\vdots \\
Y_{N,t-k}  \\
\end{bmatrix}
+ \ldots +
\begin{bmatrix}
\varepsilon_{1t} \\
\varepsilon_{2t}  \\
\vdots \\
\varepsilon_{Nt}  \\
\end{bmatrix}
(3.18)
\]

Testing for the lack of Granger causality is simply testing the zero constraint on coefficient of the VAR (k). For example, \(y_2\) does not cause \(y_1\) if and only if
\[
\theta_{12,1} = \theta_{12,2} = \theta_{12,3} \ldots \ldots = \theta_{12,k} = 0
\]
(3.19)

Null hypothesis of no Granger causality from \(y_2\) to \(y_1\) can be tested by using the F-test with test-statistic

\[
\frac{\text{SSE}_r - \text{SSE}_u}{k\sigma^2_{11}} \sim F_{k-k^2-1}
\]

where \(\text{SSE}_r\) and \(\text{SSE}_u\) are the sum of squared errors obtained by least squares estimation of the equation in (3.18) with and without imposing restrictions (3.19) respectively. The quantity of \(\sigma^2_{11}\) is the least square estimator of the variance \(\delta_1\). T is the number of observations (or the sample size).

Alternatively, the Lagrange Multiplier (LM) test also provides a powerful test for testing the restrictions (3.19). To use the LM test, first regress \(y_{1t}\) on its own lags \(y_{1t-1} \ldots y_{1t-k}\), then
compute the residuals of the above regression which is denoted by $\mu_{1t}^*$. Regress $\mu_{1t}^*$ on the entire set of explanatory variables (which is $y_{1t-1} \ldots y_{1t-k}, y_{2t-2} \ldots y_{2t-k}, \ldots, y_{Nt-1} \ldots y_{Nt-k}$). Get the coefficient of determination $R^2$ and test the hypothesis by either LM statistics or LMF statistics. In practice it is normally preferable to use the LMF rather than LM statistics.

\[
LM = T \cdot R^2 - \chi^2(k) \quad (3.20)
\]

\[
LMF = (T-N/k) \cdot (R^2/1-R^2) - F_{(k,N-T)} \quad (3.21)
\]

An alternative technique of testing causality has been developed by Sims (1972). Instead of considering equation (3.16) which takes into account only current and past $y_i$ ($i = 1, 2, \ldots, N$) for the projection of $y_{1t}$, a second projection is done for $y_{1t}$ based on future, current as well as past $y_i$. Sims (1972) showed that when $y_{1t}$ does not cause $y_{2t}$ (or in other words, causality runs from $y_{2t}$ to $y_{1t}$ only), the leading terms of $y_{2t}$ should have coefficients insignificantly different from zero, since the future cannot cause the present. The technique for computing the LM test is analogous to that for the Granger test.

Both the Granger-causality test and the Sims causality test stress the importance of stationarity. For non-stationary variables, these tests are valid only approximately, or may not be valid at all (Lutkephol, 1991). However, Geweke (1984) pointed out that these causality tests may still be valid if the form of non-stationarity of the variables can be captured by the inclusion of deterministic trends and/or logarithmic transformations. On
the other hand, Granger (1988) pointed out that the causality tests incorporating differenced (stationary) variables will be misspecified unless the lagged error-correction term is included. For the VAR model, it has been shown that the Granger is superior to the Sims test as the latter consumes more degrees of freedom (Charemza and Deadman, 1992).

3.8 Impulse Response Functions

The dynamic characteristics of a VAR model can be determined by analysing the impulse response functions (IRF) of the model. The IRF is a process tracing through the effect of a shock (or change in residuals, $\epsilon_1, \epsilon_2, \ldots$) to each endogenous variable in the system. The IRF can be simply thought of as a type of dynamic multiplier that shows the response of each variable in the system to a shock\(^{19}\) in one of the variables in the system. The rationale behind this idea lies in the fact that the VAR generates residuals or innovations which can be thought of as unexpected shocks to the variables in the model. Therefore, by introducing a one period standard deviation shock to one endogenous variable, the observable responses of the system to the innovations can be determined by using the IRF. The size of the effects will be indicated by the IRF. To actually calculate the impulse response, the model should be in a stable equilibrium.

Impulse response functions often express a VAR in the form of Vector Moving Average (VMA) where the vector of variables, $x_t = (x_1, x_2, \ldots, x_N)$ is regressed upon the current and past values of the shocks ($\epsilon_{it}$).

\(^{19}\) The shock is maintained for only one period, therefore, is an “impulse”.
\[ x_t = \mu_t + \sum_{i=0}^{\alpha} \Phi_i \epsilon_{t-1} \]  \hspace{1cm} (3.22)

where \(\mu_t\) is a constant term which can be thought of as the mean values of \(x_t\). \(\Phi_i\) is an \((N \times N)\) matrix with elements \(\Phi_{ij}(i)\) which measures the impact of one unit change in the error terms on the endogenous variables in the system and \(\epsilon_{t-i}\) is \((\epsilon_{1t-i}, \epsilon_{2t-i}, \ldots, \epsilon_{Nt-i})\).

Therefore, the coefficient of \(\Phi_{11}(1)\), for example, is the one period responses of unit changes in \(\epsilon_{t-1}\) on \(x_{1t}\).

One major shortcoming of dealing with the IRF is when the errors are contemporaneously correlated. It will then be impossible to determine whether the innovations to a particular variable are an endogenous response to other economic forces or a response to the variables' own exogenous forces as the residuals will have common components that affect more than one variable. When this is the case (as it often is), the usual procedure is to arbitrarily attribute all the effects of such common components to the variable that appears first in the system. Hence, the ordering of the equations in the system will be of particular importance in IRF.

### 3.9 Variance Decomposition

Dynamic behaviour can also be characterized through variance decomposition. Variance decomposition breaks down the variance of the forecast error for each variable into components that can be attributed to each of the endogenous variables. By the Wold decomposition theorem, a covariance stationary vector time-series process has a vector moving average representation, that is, each variable can be expressed as a linear
combination of its own current innovations and the lagged innovations of all the variables in the system.

If there is no contemporaneous correlation between the innovations, it is possible to unambiguously decompose the variance of each variable into components accounted by each innovation. However, the errors across equations are usually contemporaneously correlated and thus a unique decomposition is not likely to exist. The problem can be resolved by triangularizing the system’s estimated variance-covariance matrix to obtain a vector of orthogonal innovations which are contemporaneously uncorrelated. Thus, the forecast errors of each time series variable can be decomposed into the sum of contributions from each of the innovations in the system. Like the impulse response function, ordering is important in variance decomposition. This is because the orthogonalizing process requires a particular causal ordering of variables as a different ordering will yield a different decomposition. To overcome the problem, Doan, Litterman and Sims (1984) proposed a procedure in which the variables that are expected to have less predictive value for other variables are put last. Gordon and King (1982) also suggest that variables that respond most of the current events should be placed last in the order so that their values reflect contemporaneous realization of variables of a higher order. Hence, the order of the variables depends very much on the part of researcher’s attitude and the objectives of the proposed research project and how he or she recognizes the relevant exogeneity amongst variables.
3.10 Conclusion

This chapter extensively discussed several time series econometric tools which will be used in this study. Although our main focus is on cointegration and error correction modelling techniques, other relevant econometric issues were also discussed to give an overall picture of linkages between the time series techniques. The empirical studies in Chapters Five, Six and Seven do not necessarily employ all the techniques outlined in this chapter.
Chapter Four

Theoretical Background

In a standard small open economy, stochastic uncertainty may arise on the demand and supply sides of the economy. Uncertainty enters in the form of disturbances to both aggregate demand and supply. In this chapter, we show stepwise derivation of a standard model that establish open economy relationships among output, the price level, money, the exchange rate and a foreign interest rate. Within this framework, any fluctuation of the exchange rate affects aggregate demand through changing goods market and money market equilibrium positions. Exchange rate fluctuations also affect aggregate supply through price level changes. The subsequent chapters (Five, Six and Seven) apply this theoretical framework as a basis for the empirical models for the exchange rate, price level, money and output in the context of three ASEAN countries namely Malaysia, Indonesia and Thailand.

4. 1 THEORETICAL FRAMEWORK

The demand side of the economy is specified by using IS-LM equations with a modification for a small open economy. The demand side of the economy combines equilibrium conditions for Goods and Money markets.
4.1.1 Goods Markets: The IS Equation

Equation (4.1) divides the small open economy GDP, $Y$, into domestic demand (DD) and net exports (NX).

$$Y = DD + NX$$ \hspace{1cm} (4.1)

And we assume that domestic demand depends on domestic income $Y$ and the domestic rate of interest $R$.\(^{20}\) This relationship is expressed in equation (4.2).

$$DD = f_1( Y, R )$$ \hspace{1cm} (4.2)

Equation (4.3) outlines the relationship between net exports and foreign income $Y^*$, domestic income $Y$ and the real exchange rate RER.

$$NX = f_2( Y^*, Y, RER )$$ \hspace{1cm} (4.3)

where

$Y =$ aggregate output / income (GDP)

DD = domestic demand.

$NX =$ net exports.

$R =$ a domestic interest rate.

$Y^*$ = overseas economic activity (foreign income).

RER = the real exchange rate defined as $(ER \times P^*/P)$.

ER = the nominal exchange rate defined as number of units of domestic currency per unit of foreign (US $) currency.

$P$ and $P^*$ = domestic and foreign price level respectively.

Equations (4.1), (4.2) and (4.3) may be solved for $Y$

\(^{20}\) Although there are many factors such as domestic credit, fiscal deficit and the inflation rate that could influence domestic demand, based on existing literature, we assume that income and interest rates are two important variables for developing countries.
\[ Y = f_3( R, Y^*, RER ) \]  

(4.4)

For a given \( Y^* \) and RER (i.e \( \text{given ER, P and P^*} \)) equation (4.4) defines the standard IS equation for an open economy.

Equation (4.5) represents the log-linear approximation of equation (4.4)

\[ \ln Y = -a_1 \ln R + a_2 \ln Y^* + a_3 \ln RER \]  

(4.5)

Using lower case letters for logs, we re-write equation (4.5) as

\[ y = -a_1 r + a_2 y^* + a_3 \text{rer} \]  

(4.6)

The above specifications are based on the assumption of an absence of government expenditure (G) or some other fiscal measure\(^{21}\).

### 4.1.2 Money Market Equilibrium: The LM Equation

In the previous section we derived the equilibrium condition in the goods market for a small open economy. This will allow us to derive the IS curve in a later section, 4.7. In this section the equilibrium condition in the money market is derived. This will allow us to derive the LM curve,

\[ \frac{M^D}{P} = L( Y, R) = \frac{M}{P} \]  

(4.7)

Equation (4.7) states that in equilibrium demand for real cash balances should equal to the real money supply.

where

\[ \frac{M^D}{P} = \text{real money balances} \]

---

\(^{21}\) This does not necessarily mean that government expenditure is unimportant in determining output. Since the focus of this study is to examine the relationships among the exchange rate, money, price level, output and foreign interest rate, we are not explicitly modelling the government expenditure variable in our theoretical framework.
M = nominal money stock

Equation (4.7) may be solved for R as

\[ R = f_4 \left( Y, \frac{M}{P} \right) \]  

(4.8)

For given M and P, equation (4.8) defines a standard LM equation which is positively sloped, reflecting that an increase in domestic income by increasing the demand for real money balances, will increase the domestic interest rate.

Equation (4.9) is the log-linear approximation of equation (4.8)

\[ \ln R = b_1 \ln Y - b_2 \ln M + b_2 \ln P \]  

(4.9)

which may be written in lower case as below

\[ r = b_1 y - b_2 m + b_2 p \]  

(4.10)

Equation (4.9) or (4.10) denotes the positive relationship between domestic income and the domestic interest rate. The equation also denotes a negative relationship between money stock and the domestic interest rate and a positive relationship between the domestic price level and the domestic interest rate.

### 4.1.3 Aggregate Demand Equation: IS/LM Equilibrium

Now we are in a position to derive the aggregate demand function. This can be found by solving equation (4.6) for r and substituting it in equation (4.10). Solving the resulting equation for y yields

\[ y = - a_1 b_1 y + a_1 b_2 m - a_1 b_2 p + a_2 y^* + a_3 r \]  

(4.11)

For simplicity and to reduce the number of endogenous variables (\( r^* \) will appear in uncovered interest parity, UIP, exchange rate equation), we assume that foreign income \( y^* \) is a decreasing function of the foreign interest rate \( r^* \). Thus
\[ \ln Y^* = - C_1 \ln R^* \quad \text{or} \quad y^* = - c_1 r^* \] 

where lower case letters denote natural log of respective variables.

Moreover by definition we can write rer as

\[ \text{rer} = er + p^* - p \] 

Substituting (4.12) and (4.13) into (4.11) and solving for \( y \) yields the following aggregate demand equation

\[ y = \frac{a_1 b_2}{1 + a_2 b_1} m - \frac{a_1 b_3 + a_3}{1 + a_2 b_1} p - \frac{a_1 c_1}{1 + a_1 b_1} r^* + \frac{a_3}{1 + a_1 b_1} er + \frac{a_3}{1 + a_1 b_1} p^* \] 

Equation (4.14) defines a standard downward sloping aggregate demand curve for given \( m, r^*, er \) and \( p^* \). An increase in \( m, er \) (depreciation) and \( p^* \) raises aggregate demand and shifts the aggregate demand curve to the right. While an increase in \( r^* \) leads to a decrease in \( y^* \) which shifts the aggregate demand curve to the left.

For simplicity we can write the equation (4.14) as

\[ y = \alpha_1 m + \alpha_2 p + \alpha_3 r^* + \alpha_4 er + \alpha_5 p^* \] 

where

\[ \alpha_1 = \frac{a_1 b_2}{1 + a_2 b_1}, \quad \alpha_2 = - \frac{a_1 b_3 + a_3}{1 + a_2 b_1}, \quad \alpha_3 = - \frac{a_1 c_1}{1 + a_1 b_1} \]

\[ \alpha_4 = - \frac{a_3}{1 + a_1 b_1}, \quad \alpha_5 = \frac{a_3}{1 + a_1 b_1} \]

4.1.4 Foreign Exchange Market: PPP in the long run and UIP in the short-run

We start with the assumption that UIP holds in the short-run. Uncovered interest parity is the condition for an absence of interest arbitrage profit in the foreign exchange market.
When UIP holds, investors in each country are indifferent between holding home assets and foreign assets. A typical macroeconomic textbook model of the UIP (Burda and Wyplosz, 1993) has the following form: Let us denote the domestic interest rate as \( R \), the foreign interest rate as \( R^* \) and the nominal exchange rate as \( ER \). At time \( t \) we can write the UIP as

\[
(1+R) = (1+R^*) \frac{E(ER_{t+1})}{ER}
\]

where \( E \) is expectation operator \( (4.16) \)

Taking natural logs and reorganizing

\[
\ln (1+R) - \ln (1+R^*) = \ln E (ER_{t+1}) - \ln ER
\]

\( (4.17) \)

We approximate LHS by \( \ln R - \ln R^* \). Using lower case letters for natural logs, we rewrite equation (4.17) as

\[
r - r^* = E(e_{r,t+1}) - e_r \quad \text{or,}
\]

\[
e_r = E(e_{r,t+1}) - r + r^*
\]

\( (4.18) \)

We also assume that Purchasing Power Parity (PPP) holds in the long-run and this determines the expected exchange rate. Purchasing power parity (PPP) is a theory which states that exchange rates between currencies are in equilibrium when their purchasing power is the same in each of the two countries. This means that the exchange rate between two countries should equal the ratio of the two countries' price index of a fixed basket of goods and services. When a country's domestic price level is increasing (i.e., a country experiences inflation), that country's exchange rate must be depreciated in order to return to PPP. Hence

\[
E(e_{r,t+1}) = E(p_{t+1}) - E(p^*_{t+1})
\]

\( (4.19) \)
We assume further that prices are sticky caused by adaptive expectations in \( p \) and \( p^* \).

Hence we may write

\[
E(e_{t+1}) = \sum_{i=0}^{\infty} \lambda_i p_{t-i} - \sum_{i=0}^{m} \delta_i p^*_{t-i} \tag{4.20}
\]

Where \( \sum_{i=0}^{\infty} \lambda_i = \sum_{i=0}^{m} \delta_i = 1 \)

Hence our exchange rate equation becomes

\[
er = \sum_{i=0}^{\infty} \lambda_i p_{t-i} - \sum_{i=0}^{m} \delta_i p^*_{t-i} - r + r^* \tag{4.21}
\]

Given values for \( p \) (and lagged values), \( p^* \) (and lagged values) and \( r^* \), UIP specified in equation (4.21) provides a negative relationship between \( er \) and \( r \).

Now substituting the value of \( r \) from the LM equation (4.10) into equation (4.21) we get:

\[
er = \sum_{i=0}^{\infty} \lambda_i p_{t-i} - \sum_{i=0}^{m} \delta_i p^*_{t-i} - b_1 y + b_2 m + (\lambda_0 - b_2) p + r^*
\]

or

\[
er = \sum_{i=1}^{\infty} \lambda_i p_{t-i} - \sum_{i=1}^{m} \delta_i p^*_{t-i} + \beta_1 y + \beta_2 m + \beta_3 p + \beta_4 r^* \tag{4.22}
\]

where the coefficients

\( \beta_3 = (\lambda_0 - b_2) \), \( \beta_2, \beta_4 > 0 \), \( \beta_1 \) and \( \beta_3 \) can be positive or negative.

Equation (4.22) provides a standard relationship between the exchange rate \( er \) and other macro variables in our model, \( y \), \( m \), \( p \) and \( r^* \). Given \( m \), \( p \) and \( r^* \), the above equation specifies a positive relationship between income, \( y \), and the exchange rate, indicating exchange exchange rate depreciates when income increases. This happens as income increases, imports increases and Balance of Payments decreases.
4.1.5 Aggregate Supply: Price Equation

A small open-economy assumption plus perfect arbitrage implies PPP in the long-run. However, we allow the domestic price level to move away from PPP in the short-run due to domestic excess demand and supply and lags in the response of \( p \) to changes in \( \varepsilon r \) and \( p^* \). Thus

\[
p = \sum_{i=0}^{\hat{v}} \theta_i p^{* t-i} + \sum_{i=0}^{\hat{v}} \phi_i \varepsilon r^{t-i} + \gamma (y-y_{\text{nat}}) \quad \text{where } \gamma > 0
\]

(4.23)

Equation (4.23) does not describe how the economy returns to \( y_{\text{nat}} \) but it is assumed that in the long-run, when actual prices are fully adapted to expected prices, the real wage returns to its labour market clearing level.

So far we have established the fundamental equations of the model. These are:

\[
y = -a_1 r + a_2 y^* + a_3 \varepsilon r \quad \text{IS Equation}
\]

(4.6)

\[
r = b_1 y - b_2 m + b_2 p \quad \text{LM Equation}
\]

(4.10)

\[
y^* = -c_1 r^* \quad \text{Foreign income equation}
\]

(4.12)

By combining (4.6) (4.10) and (4.12) we get

\[
y = \alpha m + \alpha p + \alpha^* + \alpha \varepsilon r + \alpha p^* \quad \text{Aggregate Demand}
\]

(4.15)

\[
\varepsilon r = \sum_{i=1}^{\hat{v}} \lambda_i p^{* t-i} - \sum_{i=1}^{\hat{v}} \delta_i p^{* t-i} + \beta_1 y + \beta_2 m + \beta_3 p + \beta_4 r^* \quad \text{Foreign exchange}
\]

(4.22)

\[
p = \sum_{i=0}^{\hat{v}} \theta_i p^{* t-i} + \sum_{i=0}^{\hat{v}} \phi_i \varepsilon r^{t-i} + \gamma (y-y_{\text{nat}}) \quad \text{Aggregate Supply}
\]

(4.23)
Equations (4.15), (4.22) and (4.23) are the three equations with three unknowns \( y, er, p \). The other variables \( m, p^*, r^* \) and lagged values of \( p \) and \( p^* \) are exogenous. The natural rate of output is taken as given.

### 4.1.6 Long-run Relationships

The model developed in the previous section is essentially a short-run model. It is important to see the nature of the long-run relationships. The long-run has five fundamental properties outlined below:

\[
\begin{align*}
y &= y_{nat} & \text{(Output returns to natural rate)} \\
er &= p - p^* & \text{(Purchasing Power Parity holds)} \\
E(\text{er}) &= er = p - p^* & \text{(Expectations are fulfilled)} \\
r &= r^* & \text{(UIP hence } E(\text{er}) = er) \\
\end{align*}
\]

Given \( y_{nat}, r^*, r, p^* \) and \( m \) the goods market clearing conditions \( y_{nat} = y \), aggregate demand as depicted by (4.11), (4.14) or (4.15) may be solved for \( p \). Since the \( rer \) is unity in the long-run, the IS component of the aggregate demand relationships is independent of the general price level. Hence, solving \( y = y_{nat} \) for \( p \) is equivalent to solving the LM relationship for \( p \). Given \( r = r^* \) and \( y = y_{nat} \), the LM relationship (4.10) may be solved for \( p \). By re-writing equation (4.10), we get:

\[
r^* = b_1 y_{nat} - b_2 m + b_2 P \text{ and after solving for } p, \text{ relationship (4.10) becomes:}
\]

\[
p = m + 1/ b_2 r^* - b_1/ b_2 y_{nat} \quad \text{(Long-run monetary neutrality)}
\]

The equation above established the relationship between domestic price level and money supply when \( r^* \) and \( y_{nat} \) are given. The domestic price level is determined by the domestic money supply alone given values of \( r^* \) and \( y_{nat} \). Doubling the domestic money supply
doubles the general price level and given $p^*$ it doubles the nominal exchange rate i.e a depreciation of 50%. This is known as long-run monetary neutrality.\(^ {22}\) This suggests a long-run relationship between $m$, $p$, or conditioned on $y_{nat}$, $p^*$ and $r^*$ in which strict neutrality obtains.

Monetary neutrality may be explained through figure 1 in section 4.1.7. In the theoretical framework, it is assumed that long-run aggregate supply (LRAS) is perfectly inelastic with respect to price and increase (decrease) in money supply can not lead to a substantial increase (decrease) in equilibrium output in the long-run. In the long run, since the economy always returns to the natural level of output, any use of expansionary monetary policy stimulates aggregate demand which ultimately raises only the price level. If workers have rational expectations nominal wages rise with the price level and real wages remain constant at the long run natural rate of output. However, in the context of developing countries the vertical LRAS does not have to result from rational expectations.

There are two alternative explanations for vertical LRAS in developing countries. In a much noted paper Rao (1952)\(^ {23}\) argued that the Keynesian fiscal multiplier works only in nominal terms in developing countries. That is, expansionary fiscal policy generates inflation and no increase in output or employment. His analysis is based on price inelasticity of supply due to various bottlenecks, so that any increase in demand will only

\(^{22}\) This is a specific, hypothetical experiment normally not observed directly in actual economies. The experiment is a one-time, permanent, unexpected change in the level of money stock and how this affects domestic price level. For example, if the money stock was $10 million one day and had been $10 million for a long time, then what would the effect be of suddenly changing it to $12 million and keeping it there for long-time? According to Quantity theory of money, prices should rise eventually in proportion to the increase in the money stocks leaving all real variables at their original level and staying there until some further disturbance comes along.

generate inflation –as if the economy is operating at full-employment. On the other hand, Dasgupta\textsuperscript{24} believed that the problem of neutrality was not due to supply rigidity caused by various structural problems in the economy but due to the subsistence real wage. Dasgupta argued that the real wage in developing countries is already too low, and there is no room for further downward adjustment. In other words, every time prices goes up (due to either expansionary monetary or fiscal policy), nominal wages need to be raised so that the real wage does not fall below the subsistence level. So his LRAS is not a result of rational expectations or market clearing assumptions.

Now if $y_{nat}$ is determined by the long-run trend value of $y$, then the long-run relationship would be $F (m, p, r, y, p^*, r^*) = 0$ \hspace{1cm} (4.24)

The neutrality in the above form (4.24) implies that if we condition on $m$, the coefficients on the first three variables should be 1, -1, -1 respectively.

\textbf{4.1.7 Graphical Representation of the Model}

The models developed in sub-sections 4.1.1 to 4.1.6 are variations on a fairly standard small open-economy AD- AS model and can readily be graphed. This is done in the following Figure 1.

The left panel A depicts the open-economy IS-LM model. The IS curve graphs equation (4.6) given $r^*$ (substituting for $y^*$) and rer (given er, p, $p^*$), the LM curve depicts equation (4.10) given m and p. The top-right panel B represents Uncovered Interest Parity (UIP). It graphs equation (4.18) given $r^*$ and E(er).

\textsuperscript{24} Dasgupta, A.K., (1985), \textit{The Economic and Political Weekly}, Bombay, India.
Figure 1: Domestic Monetary Expansion in the Short-run and Long-run

Panel A

Panel B

Panel C

\[ p_1 = p^* + er_1 \]

\[ p_3 = p^* + er_3 \]
The bottom panel C shows the aggregate demand curve obtained from equation (4.15) by allowing \( p \) to vary, given IS-LM equilibrium. It also shows the LRAS at \( y = y_{\text{nat}} \) and SRAS obtained by graphing (4.23) given \( \varepsilon_r \) and \( p^* \) (current and lagged values). Initial long-run equilibrium occurs at \( r = r^* \), \( \varepsilon_{r1} = E(\varepsilon_r) \) i.e \( p_1 = p^* + \varepsilon_{r1} \) and \( y_{\text{nat}} \). This is at the intersection of IS1 and LM1 of \( r (= r^*) \) of UIP1 and of AD1 and LRAS1.

We depict the effects (SR and LR) of an increase in the domestic money supply given (\( r^* \) and \( p^* \)). The increase in \( M \) is represented by a rightward shift of the LM curve to LM2. This initially lowers domestic interest rates from \( r \) to \( r_2 \) (below \( r^* \)). Given an initial \( E(\varepsilon_r) \) based on \( p \) and \( p^* \), the fall in \( r \) leads through UIP to an increase in \( \varepsilon_r \) (i.e a depreciation). The depreciation increases NX and aggregate demand, shifting the IS curve to the right to IS2. Very short-run equilibrium (at an unchanged domestic price level \( p_1 \)) occurs at the intersection of IS2 and LM2 at \( r_2 \) with nominal exchange rate at \( \varepsilon_{r2} \) (with \( p \) still at \( p_1 \) and \( p^* \) and \( r^* \) given the exchange rate has depreciated to \( \varepsilon_{r2} \) along the UIP1 curve). This very short-run equilibrium is depicted in panel C by a rightward shift in the AD curve to AD2 (through \( y_2, p_1 \)).

In the short-run the price level will rise to \( p_2 \) along SRAS1 because of the excess demand \((y_2 - y_{\text{nat}})\). However, even at \( p_2 \) there is still excess demand \((y_1 - y_{\text{nat}})\) which in the LR will drive the price level up further to \( p_3 \). Here the price level will have increased in the same proportion as \( m \). This will return real money balances to the initial level shifting the LM curve back to LM1. As the nominal and expected rates depreciate to \( \varepsilon_{r3} \), \( r \) returns to \( r^* \) on new UIP curve UIP2. Since in the process \( \varepsilon_r \) has depreciated in exactly the same
proportion as \( p \) (and \( m \) have increased, the real exchange rate returns to its starting value, net exports (NX) decline and IS curve moves back to \( IS_1 \). With the rise in \( p \) to \( p_3 \) (and \( er \) to \( er_3 \)) there exists a new SRAS at \( SRAS_2 \).

In brief, we would expect (where a model is a reasonable approximation to reality) a long- run relationship like (24) linking \( m, p, er, y, p^* \) and \( r^* \). We should also expect short-run Keynesian dynamics to be reflected in dynamic versions of (4.15) for \( y \), (4.22) for \( er \) and (4.23) for \( p \) with potential error correction terms.

### 4.1.8 The Monetary Policy Reaction Function

In developing the above model, we assumed that the domestic money supply is exogenous which may be inappropriate in some cases. The money supply is likely to be endogenous in two different cases:

1. The first is where the country’s exchange rate floats freely or is lightly managed and where that country pursues an active monetary policy.
2. And the second is where the country has a completely fixed exchange rate or very heavily managed exchange rate and where consequently, the monetary base varies directly with Central Bank holdings of gold and foreign exchange.

By taking the above two cases separately:

1. Monetary Policy under flexible regimes: When Central Bank targets \( y \) perhaps to influence unemployment, \( p \) to eliminate inflation and \( er \) to reduce volatility and indirectly to avoid inflation, we may conceive a policy reaction function such as:
\[ m = f_c(y, y_{hit}, p, er, p^*, r^*) \]  \hspace{1cm} (4.25)

Under flexible exchange rates, equation (4.25) specified the functional relationship between money stock \( m \), income \( y \), price level \( p \), exchange rate \( er \), foreign price level \( p^* \) and foreign interest rate \( r^* \). Functional relationships among the variables in (4.25) are negative except with respect to the foreign interest rate which is ambiguous. An increase in \( r^* \) may increase or decrease money stock.

(2) Fixed Exchange Rate: In this case the monetary base is directly related to Central Bank holdings of foreign exchange reserves. The latter is directly related to balance of payments disequilibrium under a fixed exchange rate. Hence a balance of payment surplus leads to an inflow of foreign exchange and increases in the monetary base and money supply. A balance of payment deficit leads to reductions in the money supply. Hence we may write

\[ m = f_c(y, p, er - \bar{er}, r^*) \]  \hspace{1cm} (4.26)

Under a fixed exchange rate, equation (4.26) provides the functional relationship between money stocks and income \( y \), price level \( p \) and foreign interest rate \( r^* \). The postulated impact of each argument on the money supply is negative except foreign exchange. An increase in \( y \), \( p \) and \( r^* \) may bring balance of payment disequilibrium and to overcome this the authority should use contractionary policy.

In either case, we might expect the short-run monetary dynamics to be represented by dynamic versions of (4.25) and (4.26). And a hybrid monetary policy reaction function
can be formulated as: \[ m = f(y, \pi, \pi^*, \tau) \] (4.27)

4.2 Conclusion

In this chapter a theoretical framework has been developed using standard open economy relationships and we show its derivation step by step. This theoretical framework is the basis for the empirical models used in Chapters Five, Six and Seven. We started with a model (section 4.1) in which we systematically developed open-economy aggregate demand, aggregate supply and exchange rate functions from basic open economy IS-LM equations. These are the short-run models. Later in section 4.1.6 we outlined the long-run properties of the variables such as \( y, \pi, r \) and \( p \). The monetary policy reaction function is discussed in section 4.1.8 under alternative exchange rate regimes.

Limitations: In this model, we assume that (i) equilibrium conditions hold for goods, money and foreign exchange markets; (ii) In the long-run actual prices equal expected prices; (iii) PPP holds; (iv) money supply is exogenous; and (v) LRAS curve is perfectly inelastic with respect to price and represents constant real wages at the LRAS. But in many cases, especially developing countries, the labour market may not be in equilibrium. In that case, the vertical AS curve could be a result of structural rigidities or subsistence real wage and not of rational expectations or market clearing assumptions. Although money supply is regarded as exogenous, the monetary authority assumed to possess a reaction function. That is money supply responds to changes in economic conditions.
Chapter Five

Empirical Study for Malaysia

5.1 Introduction

The linkages among the exchange rate, money, output and the price level have been the focus of debate and analysis. Much of the debate has centered around the effectiveness of changing exchange rate and monetary policies on money supply and demand. There have been a good number of empirical and theoretical studies carried out over the past several decades on the issue as outlined in Chapter Two. But most of the studies are for developed economies. The interest on emerging economies has heightened in recent years particularly after the Asian crisis in 1997, triggered basically by concerns about the impact of exchange rate policies on major macro variables. Most of the studies emphasized (i) appropriate variable selection and (ii) an appropriate framework to analyze. Inappropriate choice, in many previous studies, of variables in the model and different frameworks produced different conclusions.

Most of the earlier studies on Malaysia concentrated on the money demand function and did not examine the impact of the exchange rate on money supply (see for example, Ibrahim (2001), Dekle and Pradhan (1997) and Sriram (1999)). Sriram (1999) has a comprehensive study on money, the exchange rate, output and the price level but
emphasized the money demand function under both an open and closed economy model where the open economy model includes annualized exchange rate depreciation as a proxy for the exchange rate variable. Studies by Hasim et al. (1994), Tan and Cheng (1995) and Tan and Baharumshah (1999) examined the bivariate causal relationship between important macroeconomic variables such as money, output, the price level and interest rate for Malaysia. Using mostly a closed economy macro model, these studies employed the standard Granger-causality tests without examining the time-series properties of the variables, namely the presence of unit root and cointegration which might lead to misspecification and invalid inferences.

The main problem with many of the previous studies is that they relied on traditional regression methods to analyze the relationship among money and other major macro variables ignoring the role of the exchange rate. Because most of the macro variables are non-stationary, traditional regression estimates of most studies may have been spurious. Manning and Andrianacos (1993) addressed the problem by using a residual-based, single-equation cointegration method. They employed the Engle-Granger (1987) cointegration method with ADF and PP unit root tests on the OLS residuals of the cointegrating equations and found evidence that the series were not cointegrated. This approach is not free from criticism. Studies by DeJong (1992), Dejong et al. (1992) and Diebold and Rudebusch (1991) documented the low power of the ADF test. Campbell and Perron (1991) also warned against the OLS method of estimating and testing cointegration relations and recommended use of full information maximum likelihood
methods such as those of Johansen (1988, 1992a, 1992b, 1992c) or Ahn and Reinsel (1990).

The main purpose of this chapter is to examine the relationship among the exchange rate, price level, money and output for Malaysia in the period of 1973-1999, as discussed in Chapter Three, Cointegration VAR analysis with a vector error correction mechanism (VECM) provides an appropriate framework for analyzing macroeconomic time-series data. VECM is an up-to-date and powerful methodology that remedies the shortcoming of previous studies. The main strength of the cointegration method is its ability to incorporate short-run dynamics with long-run equilibrium relations among variables. We employ the Johansen (1988) model which was expanded by Johansen and Juselius (1990, 1992, 1994). One Monte Carlo study by Gonzalo (1994) finds that out of five alternative cointegration methods, Johansen's procedure performed best in estimating and testing cointegration relationships.

The central issue to be investigated in this chapter is whether there exist(s) a stable and predictable long-run relationship among the exchange rate, price level, money and output. Moreover, specific issues under investigation are: (i) Interpreting the long-run relationship as a policy reaction function for Malaysia (ii) testing for long-run monetary neutrality (iii) examining the nature of the "short-run" dynamic specifications for each endogenous variable (iv) examining the forecasting performance and dynamic adjustment process of a VECM model of exchange rate, price level, output and money.
The remainder of the chapter is organized as follows. Section 5.2 briefly reviews the Malaysian economy. Section 5.3 develops an empirical VAR model on the basis of the theoretical model developed and discussed in chapter Four. It also discusses a number of analytical and empirical issues. Section 5.4 provides a detailed analysis of the empirical results including all time series properties. Section 5.5 is an analysis of short-run dynamic specifications with ECM results and section 5.6 contains the concluding observations of this chapter.

Section 5.2: The Malaysian Economy

Since Independence in 1957, the Malaysian economy has undergone structural changes that significantly shifted the country from a trade-oriented economy based on agriculture commodities to a more diversified export-oriented economy. As a result of structural changes, the share of the agricultural sector in gross domestic product (GDP) has declined over the years from 30.8 per cent in 1970 to 12.8 per cent in 1996 (just before the Asian crisis). The share of the manufacturing sector in GDP increased rapidly from 14.5 per cent to 34.3 per cent between 1970 and 1996. Today, the Malaysian economy is considered one of the most open economies in the world and openness has increased over the years. The ratio of exports to GDP has risen from 48.2 per cent in 1965 to 100.3 per cent in 1996. The Government plays an active role in development planning to promote open economy policies targeting higher economic growth. The growth of the Malaysian economy may be attributed largely to its enterprising population and private

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26 Various Malaysia Plans.
investment including foreign investment, which have contributed both capital and
technology towards the country's development. Economic openness, however, has
rendered the Malaysian economy susceptible to external fluctuations, although the
vulnerability of the domestic economy to external influences has also been influenced to
some extent by domestic economic policies. In this context, it is worth mentioning that
Malaysia has been adopting fairly sound macroeconomic policies since the mid-1980s
with budgetary discipline and monetary prudence. 27 These macroeconomic policy
packages are set out in Table 5.2.

5.2.1 Macro Economic Indicators

As shown in Table 5.1, during the period 1970-2000 the yearly average growth rate of
GDP was quite impressive, at about 7%. As a result of the first oil shock in December
1973, the growth rate of GDP in 1974 declined to 8.31%, compared to 11.71% in 1973
and more severely in 1975 when growth fell to 0.80%. The oil shock had two major
impacts on the economy. First: since Malaysia is a trade-oriented economy, it would be
natural to expect the growth rate to decline as the global recession meant a drop in export
demands. Second: increases in the general price level due to higher imported prices was
reflected by high shipping costs 28. Furthermore, as Malaysia was at the time at the
beginning stage of its industrialization programme where import of investment goods was
essential for the manufacturing sector, cost-push inflation may have been one of the
contributors to high inflation (17.4%) in 1974 (See BNM, 1991 Annual Report).

28 See, Mohamed (2000)
Table 5.1: Basic Economic Data for Malaysia

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP growth (annual %)</th>
<th>GDP per capita growth (annual %)</th>
<th>Consumer price (annual %)</th>
<th>Exchange rate (Ringgit/USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>5.99</td>
<td>3.32</td>
<td>1.84</td>
<td>3.06</td>
</tr>
<tr>
<td>1971</td>
<td>5.75</td>
<td>3.14</td>
<td>1.61</td>
<td>3.05</td>
</tr>
<tr>
<td>1972</td>
<td>9.38</td>
<td>6.70</td>
<td>3.23</td>
<td>2.82</td>
</tr>
<tr>
<td>1973</td>
<td>11.71</td>
<td>9.02</td>
<td>10.56</td>
<td>2.44</td>
</tr>
<tr>
<td>1974</td>
<td>8.31</td>
<td>5.74</td>
<td>17.33</td>
<td>2.41</td>
</tr>
<tr>
<td>1975</td>
<td>0.80</td>
<td>-1.54</td>
<td>4.49</td>
<td>2.39</td>
</tr>
<tr>
<td>1976</td>
<td>11.56</td>
<td>9.01</td>
<td>2.63</td>
<td>2.54</td>
</tr>
<tr>
<td>1977</td>
<td>7.76</td>
<td>5.31</td>
<td>4.79</td>
<td>2.46</td>
</tr>
<tr>
<td>1978</td>
<td>6.65</td>
<td>4.23</td>
<td>4.86</td>
<td>2.32</td>
</tr>
<tr>
<td>1979</td>
<td>9.35</td>
<td>6.85</td>
<td>3.65</td>
<td>2.19</td>
</tr>
<tr>
<td>1980</td>
<td>7.44</td>
<td>4.95</td>
<td>6.67</td>
<td>2.18</td>
</tr>
<tr>
<td>1981</td>
<td>6.94</td>
<td>4.35</td>
<td>9.70</td>
<td>2.30</td>
</tr>
<tr>
<td>1982</td>
<td>5.94</td>
<td>3.30</td>
<td>5.82</td>
<td>2.34</td>
</tr>
<tr>
<td>1983</td>
<td>6.25</td>
<td>3.52</td>
<td>3.70</td>
<td>2.32</td>
</tr>
<tr>
<td>1984</td>
<td>7.76</td>
<td>4.91</td>
<td>3.90</td>
<td>2.34</td>
</tr>
<tr>
<td>1985</td>
<td>-1.12</td>
<td>-3.81</td>
<td>0.35</td>
<td>2.48</td>
</tr>
<tr>
<td>1986</td>
<td>1.15</td>
<td>-1.77</td>
<td>0.74</td>
<td>2.58</td>
</tr>
<tr>
<td>1987</td>
<td>5.39</td>
<td>2.28</td>
<td>0.29</td>
<td>2.52</td>
</tr>
<tr>
<td>1988</td>
<td>9.94</td>
<td>6.66</td>
<td>2.56</td>
<td>2.62</td>
</tr>
<tr>
<td>1989</td>
<td>9.06</td>
<td>5.82</td>
<td>2.81</td>
<td>2.71</td>
</tr>
<tr>
<td>1990</td>
<td>9.01</td>
<td>5.82</td>
<td>2.62</td>
<td>2.70</td>
</tr>
<tr>
<td>1991</td>
<td>9.55</td>
<td>6.87</td>
<td>4.36</td>
<td>2.75</td>
</tr>
<tr>
<td>1992</td>
<td>8.89</td>
<td>6.21</td>
<td>4.77</td>
<td>2.55</td>
</tr>
<tr>
<td>1993</td>
<td>9.89</td>
<td>7.19</td>
<td>3.54</td>
<td>2.57</td>
</tr>
<tr>
<td>1994</td>
<td>9.21</td>
<td>6.53</td>
<td>3.72</td>
<td>2.62</td>
</tr>
<tr>
<td>1995</td>
<td>9.83</td>
<td>7.13</td>
<td>3.45</td>
<td>2.50</td>
</tr>
<tr>
<td>1996</td>
<td>10.00</td>
<td>7.30</td>
<td>3.49</td>
<td>2.52</td>
</tr>
<tr>
<td>1997</td>
<td>7.32</td>
<td>4.66</td>
<td>2.66</td>
<td>2.81</td>
</tr>
<tr>
<td>1998</td>
<td>-7.36</td>
<td>-9.50</td>
<td>5.27</td>
<td>3.92</td>
</tr>
<tr>
<td>1999</td>
<td>6.08</td>
<td>3.60</td>
<td>2.74</td>
<td>3.80</td>
</tr>
<tr>
<td>2000</td>
<td>8.30</td>
<td>5.69</td>
<td>1.53</td>
<td>3.80</td>
</tr>
</tbody>
</table>

During the second oil price shock, however, Malaysia was not badly affected rather it gained from this event when its export value of crude oil increased almost twofold, from RM 2.247 billion in 1979 to RM 4.2135 billion in 1980.\(^{29}\) However, the prolonged world economic recession, which began in 1979 and continued into the early 1980s slowed down the Malaysian economy considerably during the mid 1980s. For example, growth rate of GDP fell to -1.12% in 1985 from 7.76% in 1984 and with a mild improvement (about 2.20 per cent) in GDP growth registered in 1986. In 1979, the inflation rate was recorded at a low of 3.65% and GDP growth was 9.35%. Overall, the yearly average inflation rate over 1974-1978 was recorded around 6.7% and this was much higher than for the period 1970-2000 which was 4.2%. The main inflationary pressures were caused by excess demand, monetary expansion and pressures on the wage rates incompatible with labour productivity.\(^{30}\)

During our study period 1973-2000, major macro variables performed well with few exceptions. Malaysian macroeconomic management was highly regarded by the World Bank and the IMF. But the Asian crisis which resulted in the depreciation of the Malaysian currency by 40% between July 1997 and October 1998 has created some doubts about the continuity of the impressive economic growth. In 1998, Malaysia experienced negative economic growth (almost 8% contraction compared with 1997) and inflation of 5.27 percent.

\(^{29}\) Quarterly Economic Bulletin, BNM, December 1994, p. 88, Table VII.3  
\(^{30}\) The Malaysian Institute of Economic Research (MIER, 1990) estimated inflation model for Malaysia which showed the percentage change in M2 as being the only cause of Inflation. Relatively insignificant variables were lagged one period inflation, percentage change of import deflator, percentage change of wage index and real GDP gap. Tang (2001) found that the major cause of inflation in Malaysia were import price and real income and that the relationship was elastic.
5.2.2 Malaysia Economic Policies since 1970

Table 5.2 below presents the major economic policies, their development and implications during pre and post liberalization periods in Malaysia. The pre-liberalization period is defined from the year when Malaysia gained independence from Britain in 1957 until the end of 1978 when domestic interest rates were deregulated. The post-liberalization period is from post-1978 to 1996, just before the financial crisis. In the event of the Asian crisis, the government of Malaysia undertook several policies to control exchange rates and capital outflows. The main policy changes and reforms are outlined in Table 5.2 in two different sections, section A and section B.

The general policy package in section A of Table 5.2 outlines the pre and post liberalization policy packages. In the pre-liberalization period, the government initiated market led development policies introducing open economy policies. The post-liberalization period broadly covered government policies for industrialization by implementing privatization policies and adopting structural reforms. This pushed Malaysia towards heavy industrialization.

In section B of Table 5.2, the various reforms of monetary, financial system and exchange rate policies from the pre-liberalization period are outlined. Section B presents the major policy steps that the Malaysian government took to make the economy more open and to achieve higher economic growth. We can group the policy issues in Table 5.2

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31 Although much of the pre-liberalisation period is out of our study period, inclusion of the pre-liberalisation period policy packages will give broader picture of policy reforms and therefore help us to compare pre and post liberalisation policy reforms.
into two main categories, monetary and exchange rate policies and financial system policies.

(i) Monetary Policy: Since 1957, Malaysia has pursued a rather conservative monetary policy. The usual practice has been to use restrictive monetary policy to counterbalance expansionary fiscal policy so as to reduce inflationary pressure arising from the latter. So during our study period, 1973-2000, especially after 1980 when fiscal policy was expansionary, monetary policy remained restrictive not only to contain deterioration in the current account balance but also to reduce the inflationary pressures. This contractionary monetary policy did not produce high interest rate in many years. Until 1982 and between 1987 and 1992, Bank Negara Malaysia (BNM) kept interest low on loans and deposits to encourage higher investment but this policy was negated by its interventions in the foreign exchange market in support of the Rinnggit. Thus, there was a conflict between interest rate and exchange rate policies of BNM. It has been argued that this policy mix was partly responsible for the recession in the mid 1980s.

Contractionary monetary policy (in terms of money growth) in the first half of 1980s had many effects on the economy. This reduced gross lending to the public and private sectors, reducing foreign exchange reserves and ultimately affected GDP. GDP growth fell from 7.44 percent in 1980 to -1.12 percent in 1985 (Table 5.1). The monetary

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34 See Gan, W.B (1989)
35 Contractionary monetary policy caused the nominal base lending rate to rise from 8.5 percent in 1982 to 12.3 percent in 1984 (see Ariff (1991)). The export sector was thus hurt by the sharp increase in the real cost of credit since most export firms relied heavily on bank credit for working capital. This high interest rate forced export firms to squeeze their funds from export sector and transfer substantial amount of funds to the non-tradable sector where returns are much higher i.e real estate sector.
restraint had effectively reduced inflation from 9.70 percent in 1981 to 0.35 percent in 1985 (see Table 5.1). From 1986, BNM started to ease the monetary policy by injecting M $ 4.4 billion of liquidity into the financial system.\(^{36}\) BNM also lowered the statutory reserve requirement from 4 percent to 3.5 percent and the liquidity ratio from 18.5 to 17.7 percent.\(^{37}\) The expansionary monetary policy, coupled with a pragmatic exchange rate policy, seems to have had positive effects on exports and GDP growth. As evident from Table 5.1, GDP growth increased from -1.12 percent in 1985 to 9.94 percent in 1989.

**Monetary Policies: 1990-96**

In the last decade, there have been two episodes of relatively high inflation in Malaysia. The first one in 1991-92 and the second in 1998 (Table 5.1). The inflation in 1991-92 was caused by a number of factors, namely the increase in aggregate demand; high monetary growth; supply-side constraints and external developments.\(^{38}\) In order to reduce inflation to an acceptable level, the government of Malaysia implemented a comprehensive package of anti-inflationary policies. These included monetary tightening and continued fiscal consolidation. These demand management policies were reinforced by other policy initiatives to deal with supply shortages and inefficiencies. To curb rising inflation in the first episode, BNM also increased interest rates.


\(^{37}\) Ibid.

### Table 5.2: Main Economic Policy Changes and Reforms in Malaysia

#### Section A: General Policy Package

<table>
<thead>
<tr>
<th>Pre-liberalization</th>
<th>Post-liberalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957-70: launched market-led development policy</td>
<td>1980-90: Heavy industrialization push</td>
</tr>
<tr>
<td>1968-85: promotion of export oriented policy</td>
<td>1983: Beginning of privatization policy</td>
</tr>
<tr>
<td>1965-70: launched First Five-year Malaysia Plan</td>
<td>1986-90: adjustment and liberalisation</td>
</tr>
<tr>
<td>1971-75: Second Five-Year Malaysia Plan</td>
<td>1986-95: Industrial Master Plan</td>
</tr>
<tr>
<td>1970: Establishment of Free Trade Zone</td>
<td>1986-90: Fifth Five-year Malaysia Plan</td>
</tr>
<tr>
<td>1991-95: Sixth Five-year Malaysia Plan</td>
<td>1991-95: Sixth Five-year Malaysia Plan</td>
</tr>
</tbody>
</table>

#### Section B: Financial Liberalization and Monetary Policy Reform

<table>
<thead>
<tr>
<th>Monetary Policy Reforms</th>
<th>Exchange Rate and Capital Flows</th>
<th>Financial System Reforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975: Quantitative control on credit was abolished but maintained credit to selected sectors.</td>
<td>1973: conversion from fixed to a flexible exchange rate regime.</td>
<td>1960: Establishment of Malayan Stock Exchange market (equity market) and birth of Malaysian Government Securities</td>
</tr>
<tr>
<td>Since 1978, sales &amp; Purchases of Government and central Bank securities have become increasingly important.</td>
<td>Since 1978 there has been no restriction on capital inflows</td>
<td>1963: Establishment of discount houses</td>
</tr>
<tr>
<td>1991: removal of base lending rate that was introduced in 1983</td>
<td>1997-98: After the crisis, measures were taken to prevent non-resident ownership of Ringgit balances held abroad, making it impossible to settle Ringgit contracts except through Malaysian Banks in Malaysia.</td>
<td>1973: Malaysia and Singapore agreed to terminate their common currencies and at the same time stock market was disjointed</td>
</tr>
<tr>
<td></td>
<td>1998: Introduction of Fixed exchange Rate (at 3.8 Ringgit to the US dollar)</td>
<td>1978: the birth of Banks NCD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1980: the development of private debt securities market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1990: actual splitting of the Kuala Lumpur Stock Exchange and Singapore Stock exchange</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1990: establishment of the international off shore financial centre</td>
</tr>
</tbody>
</table>

Ministry of Finance, Malaysia, Economic Reports, Various issues.
Bank Negara, Malaysia, Annual Report, Various issues.
These higher interest rates caused a surge in short-term capital inflows in 1992-93, inundating the banking system with liquidity which ultimately reduced interest rates sharply. The 1998 inflation was basically from the excessive depreciation of the Ringgit exchange rate which we will discuss in the following section.

Monetary Policies: 1997-2000

Studies on the Malaysian economy by Ariff et al. (1997) and Athukorala (1998) identified several key weaknesses of the Malaysian economy before the financial crisis. These was (i) the high growth from 1991, which was deemed to be beyond the economy's potential, generating wage increases above productivity gains, (ii) the loss of efficiency indicated by declining growth of total factor productivity, (iii) the rapid bank credit expansion, and persistent current account deficits, (iv) the appreciation of the Ringgit despite the current account deficits indicating overvaluation of the currency. The monetary policy in this period was aimed at addressing the current account deficits, curbing inflationary pressures from exchange rate depreciation and preventing large outflows of short-term capital. The BNM implemented a strategy of high interest rates to reduce inflation and prevent capital outflows.

(ii) Exchange Rate Policies

Malaysia adopted a flexible exchange rate (basically managed floating) in June 1973 which continued until the Asian crisis in 1997. In the early 1980s, the exchange rate of
the Ringgit was determined on the basis of a composite basket of currencies of countries that were significant trading partners with Malaysia. But it was never rigidly pegged to the basket. Moreover, the BNM allowed limited fluctuations of the exchange rate relative to the basket and intervened in the foreign exchange market at the time of unusual fluctuations coming from sudden rises in short-run capital inflows. By the late 1980s, the Ringgit was allowed to depreciate in both nominal and real terms targeting export competitiveness. But the Ringgit appreciated in the early 1990s due to persistent rise in capital inflows. During the 1997-98 financial crisis, the Ringgit depreciated against the US dollar. It appreciated in 1999, when Malaysia converted to a fixed exchange rate regime. Since then the nominal exchange rate has been fixed at 3.8 Ringgit / US dollar.

(iii) Fiscal Policies

In the early 1970s, Malaysia pursued a prudent fiscal policy which helped insulate the economy to a certain extent from external shocks. But this scenario changed when the government undertook an expansionary development programme in the wake of export growth after 1977. During the period 1979-83, fiscal policy was highly expansionary. Development expenditure as a percentage of GNP nearly doubled from 14.3 percent in 1976-80 to more than 27 percent in both 1981 and 1982. The sharp increase in public sector spending was a major factor boosting the economy in the face of a global recession. However in the late 1980s, the government of Malaysia tried for a balanced fiscal

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40 The rate of depreciation peaked in 1986, when the ringgit was allowed to depreciate by about 14 percent against its composite basket.
41 Ariff (1991), pp 30
position although the fiscal deficit increased to 9.8 percent of GNP in 1986. The fiscal
deficit-GNP ratio fell remarkably to 4.9 percent in 1987 and 2.0 percent in 1988 but
increased again to 2.9 percent in 1989.43 So Malaysia tried to reduce fiscal deficit in the
late 1980s which may have had deflationary effects on the economy. As the economy was
growing more than expected in the 1990s, aggregate demand also increased. In 1992, the
government adopted a tighter fiscal approach to slow down rising aggregate demand and
prevent an overheating economy arising from a surge in capital inflows. This eased
demand pressures in 1996. Again in 1997, the government tightened the fiscal policy due
to higher demand pressure. During 1997-98, in order to re-establish macroeconomic
stability at the pre-crisis level, the government budget for 1998 showed fiscal restraint
targeting slower growth rather than recession.44 The fiscal restraint came from reducing
consumption expenditure, deferring non-critical projects and privatizing government
activities. This fiscal restraint produced a surplus of 0.5 percent of GNP by the end of
1998.

Finally, the Malaysian economy started to recover from the crisis in 1999 due to active
monetary, fiscal and exchange rate policies. Table 5.1 shows that GDP growth in 1999
and 2000 was 6.08 percent and 8.30 percent respectively. The most important issue is that
macro economic stability was reestablished, partly as a result of the government’s fixed
exchange rate and the capital control policies of late 1997.

43 Ariff (1991), pp 32
44 Colin, B., (edited, 2001), pp 50
Section 5.3: Empirical Model and Data

Malaysia is a small open economy and we would like to examine how exchange rate affect output, money and the price level. Initially, we develop a structural VAR (SVAR) model consisting of five critical macroeconomic series for a vector of endogenous variables given by $X_t = [\text{LIP}, \text{LER}, \text{LCPI}, \text{LM}, \text{USTB}]$, where LIP is the log of industrial production proxy for GDP, LER is the log of the nominal exchange rate. The nominal exchange rate is defined as the number of units of the Malaysian Ringgit per US dollar, so in this case an increase in LER means depreciation. LCPI is the log of the Malaysia domestic consumer price index. LM is the log of domestic aggregate money. USTB is the United States Treasury Bill rate, used as proxy for the foreign interest rate and therefore we treat it as an exogenous variable. Using standard notation, the joint dynamics of $X_t$ are modelled by the following structural VAR.

$$AX_t = A(L)X_{t-1} + BZ_t + u_t$$  \hspace{1cm} (5.1)

The square $A$ is a $5 \times 5$ matrix of structural (contemporaneous) coefficients, $A(L)$ is a polynomial of order $p$ in the lag operator $L$ and $Z$ is a vector of deterministic terms.

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45 In the theoretical analysis in Chapter Four we have actually six variables to be included in the SVAR model. But due to high correlation among domestic price level LCPI and foreign price level $P^*$ (LUSCPI), we drop the foreign price level from our SVAR model. Cointegration results with LUSCPI included produced estimates which were not credible. In contrast, the cointegrating vector excluding LUSCPI made a lot of economic sense.

46 Because quarterly GDP data are not available and we have used Industrial Production data as the best alternative available data for our study period. For Indonesia and Thailand, Industrial production data are not available and therefore we derive quarterly GDP data from annual GDP data using Lisman and Sandee's techniques (1964). Aggregate money is defined according to IMF definition (IMF 1994, pp. xv).

47 We chose USTB as foreign interest rate as because US is the major partner of Malaysian (as well as Thailand and Indonesian) foreign trade. For example, Malaysia's 21% export goes to USA which is highest among exporting countries (for example, to Japan 13%, EU 14%, Singapore 18% and others 26%) and 17% of its imports coming from USA which second highest among the list of importing countries such as Japan 21%, EU 12%, Singapore 14% and others 26%. (MIER, 2001. http://www.mier.org.my)

48 The lag operator ($L$) works as follows: $LX_t = X_{t-1}$, $L^2X_{t-1} = X_{t-2}$, ..., $L^pX_t = X_{t-p}$. The matrix polynomial $A(L)X_t = A_0X_{t-1} + A_1LX_{t-1} + A_2L^2X_{t-1} + \ldots + A_pL^pX_{t-p}$ where all matrices $A_i$ are square.
with associated coefficients matrix B. The vector of structural shocks \( \mathbf{u}_t = [u_{lfp}, u_{ler}, u_{lcp}, u_{lm}, u_{ustb}]' \) contains the contemporaneous response of the variables to disturbances or innovations. More specifically, \( u_{lfp} \) represents a domestic output shock, \( u_{ler} \) represents an exchange rate shock, \( u_{lcp} \) a domestic price level shock, \( u_{lm} \) is a domestic money supply shock and \( u_{ustb} \) is a foreign interest shock.

Since the structural shocks are assumed to be white noise with zero covariance terms, this implies that each disturbance arises from independent sources so that their variance-covariance matrix \( \mathbb{E}(uu') = \mathbf{D} \) is diagonal.

The problem with representation (5.1) is that because the coefficients in the matrices are unknown and the variables have contemporaneous effects on each other it is not possible to uniquely determine the values of the parameters in the model. The model in this form is not fully identified. However, it is possible to transform (5.1) into a reduced-form model to derive the standard VAR representation, as shown in (5.2) which facilitates estimation of the model parameters.

The reduced form VAR is derived from equation (5.1)

\[
\mathbf{X}_t = \mathbf{A}^{-1} \mathbf{A} (L) \mathbf{X}_{t-1} + \mathbf{A}^{-1} \mathbf{B} \mathbf{Z}_t + \mathbf{A}^{-1} \mathbf{u}_t
\]

(5.2)

Or we can write (5.2) as:

\[
\mathbf{X}_t = \mathbf{F}(L) \mathbf{X}_{t-1} + \mathbf{G} \mathbf{Z}_t + \mathbf{x}_t
\]

Clearly, \( \mathbf{F}(L) = \mathbf{A}^{-1} \mathbf{A} (L) \) is order \( p \) and \( \mathbf{G} = \mathbf{A}^{-1} \mathbf{B} \). \( \mathbf{x}_t \) is now the vector of reduced form innovations \([\text{LIP, LER, LCPI, LM USTB}]'\), with variance – covariance matrix
$$E(x_t x_t') = \Sigma$$ If we compare (5.1) and (5.2), it is apparent that

$$x_t = A^{-1}u_t \quad \text{or}$$

$$u_t = A x_t \quad \quad (5.3)$$

$$E(uu') = D = AS \quad \quad (5.4)$$

Equations (5.3) and (5.4) show that the structural shocks \( u_t \) and their variances in \( D \) are related to the reduced form innovations and covariances respectively through the contemporaneous coefficient matrix \( A \). Given estimation of \( x_t \) and \( \Sigma \), identification of the SVAR shows that the recovery of the structural shocks and variances through the imposition of a sufficient number of restrictions on the \( A \) matrix is possible. In other words, restrictions are the better way to organize the instantaneous correlations among the endogenous variables.

On the basis of our theoretical model developed in Chapter Four\(^{49}\), it is possible to develop four potential core equilibrium relationships, along with the equation for exogenous variable USTB, which are described below:

\[
\begin{align*}
\text{LIP} &= a_{10} + a_{12}\text{LER} + a_{13} \text{LCPI} + a_{14}\text{LM} + a_{15} \text{USTB} + u_p \\
\text{LER} &= a_{20} + a_{21}\text{LIP} + a_{23} \text{LCPI} + a_{24}\text{LM} + a_{25} \text{USTB} + u_{er} \\
\text{LCPI} &= a_{30} + a_{31}\text{LER} + a_{32} \text{LIP} + a_{34}\text{LM} + a_{35} \text{USTB} + u_{cpi} \\
\text{LM} &= a_{40} + a_{41}\text{LER} + a_{42} \text{LCPI} + a_{43}\text{LIP} + a_{45} \text{USTB} + u_{lm} \\
\text{USTB} &= a_{50} + u_{ustb}
\end{align*}
\]

\(^{49}\) In chapter four, we derive the relationship among variables \( m, p, er, y, p^* \) and \( r^* \) (equation 4.24). The VAR model (see Chapter Three discussion) allows us to derive four core equilibrium relationships. The reason for dropping \( p^* \) is mentioned in footnote 45.
So in terms of our five-variable Malaysian Model, the relationship outlined in (5.3) between the structural shocks and the reduced form innovations is outlined below in matrix notations:

MODEL: SVAR for Malaysia

\[
\begin{bmatrix}
1 & a_{12} & a_{13} & a_{14} & a_{15} \\
a_{21} & 1 & a_{23} & a_{24} & a_{25} \\
a_{31} & a_{32} & 1 & a_{34} & a_{35} \\
a_{41} & a_{42} & a_{43} & 1 & a_{45} \\
0 & 0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
LIP \\
LER \\
LCPI \\
LM \\
USTB
\end{bmatrix}
+ \begin{bmatrix}
a_{10} \\
a_{20} \\
a_{30} \\
a_{40} \\
a_{50}
\end{bmatrix}
= \begin{bmatrix}
U_{lpp} \\
U_{ler} \\
U_{lip} \\
U_{lm} \\
U_{ustb}
\end{bmatrix}
\]

In a compact form \( u_t = A x_t + a_0 \) where \( a_0 = (a_{10}, a_{20}, a_{30}, a_{40}, a_{50})' \). Which means \( a_0 \) matrix consisting of intercept terms is one part of the \( Z \) matrix.

In the above SVAR model, normalizing the diagonal entries of \( A \) to unity leaves a total of 16 free parameters in the matrix. Add to this five unknown variances in the \( D \) matrix and there is altogether a total of 21 elements that need to be determined plus we have four restrictions in the model. This indicates that the number of unknown parameters in the structural model is therefore equal to the number of estimated parameters in the reduced form - showing our SVAR meets the order condition for identification. On the basis of SVAR above, we now derive the error-correction model\(^{50}\)

\[
\Delta X_t = \alpha + \sum_{i=1}^{8} \beta_i \Delta X_{t-i} + \sum_{i=1}^{8} \theta_i USTB + \gamma_i \xi_{t-1} + DZ_t + U_t
\]  
(5.10)

\(^{50}\) In general, the ECM model will have the I(0) representation of variables both on the left-hand side and on the right hand side(RHS) of the equation. Since the variables are I(0), the RHS will contain variables expressed in terms of first differences (except for EC term which will be in level). As one lag of a difference term equals second lag of the level, the number of lags in the ECM is usually one less than what applied in the cointegration tests. In the case of Malaysian data, we used 9 lags for cointegration and therefore, 8 lags for ECM.
where $X_t = [LIP, LER, LCPI, LM]'$, $u_t$ is an 4x1 vector of serially uncorrelated shocks, $\gamma$ is 4 x 4 matrix of error correction coefficients. $\xi_{t-1} = AX_{t-1}$ are the error correction terms. $\beta_i (i = 1, 2, 3, n)$ are the short run coefficients. $\theta_i$ are the coefficients of USTB. In the $DZ_i$ matrix three dummies D84, D94, D97 are used. Among them D97 is the dummy for the Asian financial crisis. The period covers by D97 is from September 97 to August 98. D94 is added because the government introduced temporary control measures beginning from this period to sap excess liquidity from the banking system caused by the heavy capital inflows (Sriram, 1999). In January 1984, the government of Malaysia incorporated two amendments into the Banking Act, 1973 which may have had some impact on the credit facilities available to the community. D84 is for these two amendments and covers only the first quarter of 1984 while D94 covers the first and second quarter of 1994. Because graphs of the data do not exhibit seasonality, at this stage we ignore the seasonal dummy variables. All data are from International Monetary Fund International Financial Statistics, 2001 CD-ROM.

By construction, the above specification embodies the economic theory's predictions which is better than the usual approach where the starting point is an unrestricted VAR model, with some vague priors about the nature of the long-run relations.

---

5.4 Time Series Properties

A number of tests were conducted in this section to establish the time series properties of the Malaysian data.

5.4.1 Unit Root Tests

Before we estimate the SVAR model, it is necessary to examine whether the order of integration of the series is I(0) or I(1) or higher. This can be carried out by applying DF and ADF tests which are discussed in Chapter Three. The series in the present model tested are Industrial Production (LIP), the Nominal Exchange Rate (LER), the Consumer Price Index (LCPI), the Domestic Money Supply (LM) and the United States Treasury Bill Rate (USTB) as proxy for foreign interest rate. All series are in logs except USTB. The graphs of the original series are shown in Appendix 5. 1. The null of the DF and ADF tests is that each of the individual variables under examination has a unit root against the alternative hypothesis that the root is less than one. Rejection of the null means the series in question is generated by a stationary process.

The results of the DF and ADF are presented in Table 5.3. The tests are applied to both ‘levels’ and the ‘first differences’ of all the series for the sample period 1973Q1 to 1999Q4. The results show that in the case of ‘levels’ all the series are characterised by unit root non-stationary processes i.e they are all approximately I(1). In the case of
Table 5.3: DF and ADF tests Results

**Series in Levels**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test Statistic with intercept</th>
<th>Lag Length</th>
<th>Test Statistic with intercept + Trend</th>
<th>Lag Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIP</td>
<td>-0.41</td>
<td>8</td>
<td>-2.14</td>
<td>8</td>
</tr>
<tr>
<td>LER</td>
<td>0.14</td>
<td>0</td>
<td>-1.89</td>
<td>0</td>
</tr>
<tr>
<td>LCPI</td>
<td>-1.26</td>
<td>0</td>
<td>-1.63</td>
<td>0</td>
</tr>
<tr>
<td>LM</td>
<td>-0.32</td>
<td>2</td>
<td>-2.86</td>
<td>6</td>
</tr>
<tr>
<td>USTB</td>
<td>-1.91</td>
<td>3</td>
<td>-2.86</td>
<td>6</td>
</tr>
</tbody>
</table>

**Series in first Differences**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test Statistic with intercept</th>
<th>Lag Length</th>
<th>Test Statistic with intercept + Trend</th>
<th>Lag Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLIP</td>
<td>-3.38</td>
<td>7</td>
<td>-3.35</td>
<td>7</td>
</tr>
<tr>
<td>DLER</td>
<td>-9.05</td>
<td>0</td>
<td>-9.22</td>
<td>0</td>
</tr>
<tr>
<td>DLCPI</td>
<td>-10.78</td>
<td>0</td>
<td>-10.88</td>
<td>0</td>
</tr>
<tr>
<td>DLM</td>
<td>-4.59</td>
<td>5</td>
<td>-4.54</td>
<td>5</td>
</tr>
<tr>
<td>DUSTB</td>
<td>-3.59</td>
<td>5</td>
<td>-4.05</td>
<td>6</td>
</tr>
</tbody>
</table>

95% critical value for the ADF statistic is -2.8915 for regression includes an intercept but not trend. But when regression includes intercept and a trend then the value is -3.4519.

‘First difference’ all the series reject the null hypothesis of a unit root (non-stationarity) at the 5 percent significance level. Hence we conclude that the series are I(1).
Since all series are integrated of the same order, the series will be tested for the existence of one or more long-term relationships among them, i.e., cointegration. Before cointegration tests it is necessary to determine the optimal lag lengths of the VAR.

5.4.2 Lag Determination

The lag length chosen should be sufficiently large to make serial correlation of the residuals unlikely. However, the longer the lag length, the greater the number of parameters to be estimated and the fewer the degrees of freedom. As mentioned in Chapter Three, there are two approaches to choose optimum lag lengths in estimating a VAR. (1) To set appropriate lag lengths based on some statistical criterion and (2) to specify a few arbitrary alternative lag lengths as recommended by Sims (1980). This study will use statistical criterion such as the AIC, SBC and Likelihood Ratio tests (extensively discussed in Chapter Three) to determine optimal lag lengths.

We determine the optimal number of lags from the Table 5.4. The highest value of AIC occurs with lag 9 while the LR tests also suggest lag 9. SBC criteria suggests lag 3 which is small for a fast emerging economy like Malaysia where adjustment needs some time to return to normal once disturbed. So we choose VAR of lag order 9.
Table 5.4

Test statistic and choice criteria for selecting the order of the VAR model

| List of the variables included in the unrestricted VAR is: LER, LIP, LCPI, LM |
| List of the deterministic and/or exogenous variables: USTB, D84, D94 D97 |

<table>
<thead>
<tr>
<th>A: Likelihood ratio statistics:</th>
<th>B: Akaike Information Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag</td>
<td>LR ( \chi^2 ) (16)</td>
</tr>
<tr>
<td>10:9</td>
<td>13.54 [0.633]</td>
</tr>
<tr>
<td>9:8</td>
<td>62.59 [0.001]</td>
</tr>
<tr>
<td>8:7</td>
<td>99.27 [0.000]</td>
</tr>
</tbody>
</table>

Notes: LR statistics are calculated Sims' (1980) modified likelihood ratio test statistics for the null hypothesis that lower lag VAR is an acceptable restriction on a higher order system (e.g. \( H_0 \): the 8-lag VAR is as good as 9-lag VAR system). The figures in the square brackets are the \( p \)-values which indicate the probability of finding a \( \chi^2 \) value greater than or equal to a calculated \( \chi^2 \) statistic under the null hypothesis. A \( p \)-value > 0.05 does not reject the null hypothesis at 5% level of significance. AIC selects the lag which has highest value. All the estimations in this table were conducted using MICROFIT 4.0 program of Pesaran and Pesaran (1997).

5.4.3 Cointegration: The Long-run Relationship

As unit root tests show that the variables are I(1), cointegration techniques are appropriate to test for the existence of long run relationships among macro variables of the model. These tests are carried out using the maximum likelihood approach developed by Johansen (1988) and Johansen and Juselius (1990). This approach has been shown to be superior to Engle and Granger’s (1987) residual-based approach. Among other things, the Johansen approach is capable of detecting multiple cointegration relationships. Variables tested for cointegration are LIP, LER, LCPI, LM and USTB and all in levels. Three dummies such as D84, D94 and one Asian crisis dummy D97 are introduced.
The cointegration test results are provided in Table 5.5. They report that both maximal eigenvalue and Trace tests reject zero cointegrating vectors in favour of at least one vector. The results are significant at the 5% level for both the maximal eigenvalue and the Trace test. Model selection criterion AIC and SBC also support the finding of one cointegrating vector. The eigenvalue associated with the first vector is certainly dominant over those corresponding to other vectors, thereby confirming that there exists a unique cointegrating vector in the model. In order to find out whether it represents the money equation, matrix $\beta'$ (panel C of Table 5.5) containing the parameters of the cointegration vectors is examined. The rows of the $\beta'$ matrix correspond to the standardized coefficients of the variables entering into the respective cointegrating vector.

The coefficients are normalized with a value of one along the principal diagonal of the matrix. For example, the first row corresponds to the significant cointegrating vector identified above in which LM is normalized as one. It can be written in an equilibrium form as follows:

$$\text{LM} - 1.09 \text{LIP} - 1.15 \text{LCPI} + 1.06 \text{LER} + 0.03 \text{USTB} = 0$$  \hspace{1cm} (5.11)

5.4.4 Discussion on the Coefficients of the equation (5.11)

Based on the signs and magnitudes of the estimated coefficients, the unique cointegrating vector as shown in the form of equation (5.11) can be interpreted as the long-run relationship equation (4.24) of Chapter Four. In terms of the monetarist proposition that money supply should grow at the same rate as prices, our estimated results support that
Table 5.5

Johansen Cointegration Tests

1973Q1 to 1999Q4 (Total 99 observations). Cointegration with unrestricted intercepts and no trends in 9 lag VAR. Variables included in the cointegrating VAR are LIP, LER, LCPI, LM, one I(1) exogenous variables are USTB and Three dummies such as D84, D94 and D97.

<table>
<thead>
<tr>
<th>Null</th>
<th>Alternative</th>
<th>Statistic</th>
<th>95% Critical value</th>
<th>90% Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = 0</td>
<td>r = 1</td>
<td>69.87</td>
<td>30.71</td>
<td>28.27</td>
</tr>
<tr>
<td>r &lt;= 1</td>
<td>r = 2</td>
<td>23.61</td>
<td>24.59</td>
<td>22.15</td>
</tr>
<tr>
<td>r &lt;= 2</td>
<td>r = 3</td>
<td>9.81</td>
<td>21.07</td>
<td>15.98</td>
</tr>
<tr>
<td>r &lt;= 3</td>
<td>r = 4</td>
<td>0.22</td>
<td>11.47</td>
<td>9.53</td>
</tr>
</tbody>
</table>

A. Maximum Eigenvalue Test

B. Trace Tests

C. Standardized Eigenvectors β′

<table>
<thead>
<tr>
<th>LM</th>
<th>LIP</th>
<th>LER</th>
<th>LCPI</th>
<th>USTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>-1.09</td>
<td>1.06</td>
<td>-1.15</td>
<td>0.03</td>
</tr>
<tr>
<td>(0.15)</td>
<td>(0.17)</td>
<td>(0.31)</td>
<td>(0.007)</td>
<td></td>
</tr>
</tbody>
</table>

Note: (i) r represents the number of cointegrating vectors. The estimated cointegrated vectors reported above have been normalized by first setting the estimated coefficients on LM equal to 1 and then dividing each of the cointegrating vectors by the value of the reported LM coefficients. Standard errors are in brackets. All the above estimation is done by Microfit 4.0.

(ii) There are two reasons for choosing unrestricted intercepts and no trends. First: although the underlying variables are trended, they move together, and it seems unlikely that there will be trend in the cointegrating relationships among the variables (see Pesaran and Pesaran, p. 293). Second: Allowing an intercept term in VAR model implies that we allow variables in levels to grow (i.e non-stationary). The VAR intercept may be linked to a) a linear deterministic trend in the levels, or b) a unit root in the levels variables. Because we tested our variables for unit roots and found all the variables in 'levels' are I(1), we don't want a linear trend in cointegration equation.
proposition. A one percentage increase in the price level accompanies an increase in money of close to one percent. The price level coefficient close to unity indicates that money demand is a demand for real money balances and is consistent with monetary neutrality. This finding is inconsistent with Sriram (1999) and Marashdeh (1997) for Malaysia. The price elasticity in Marashdeh’s (1997) study is -2.46 and in Sriram’s (1999) is - 4.89. In the case of the Marashdeh (1997) model, the use of the domestic interest rate and the trade weighted nominal exchange rate with a smaller sample size could have contributed to this result. Sriram (1997) found a price elasticity of -4.74 for a closed economy and – 4.89 for an open economy using M2. Sriram’s results indicated that an increase in price level reduces money demand indicating financial systems are well-developed. But the findings could be due to variables used in the model. The study used three versions of interest rates (two domestic and one foreign), annualized inflation and depreciation rates, M2 and industrial production of Malaysia for a large number of observations (269). But our finding is consistent with a few studies such as Chowdhury (1997) who found a price elasticity of 0.89 for Thailand. Regarding income elasticity, the long-run income elasticity of money demand is very close to one (1.09). This means an increase in income by 1% will increase money demand by almost 1.09 percent. In the case of Malaysia, as the financial system is fairly well-developed and institutions are relatively well in place, the results seem to suggest that the income elasticity of money is close to one. This finding is consistent with most empirical studies such as Marashdeh (1997), Ibrahim (2001), Sriram (1999) but inconsistent with Chowdhury (1997) for
Thailand data. Moreover, the finding of a large income elasticity is not uncommon in developing countries context.\(^\text{52}\)

The negative coefficient (-1.06) for the exchange rate in equation (5.11) is at odds with monetary neutrality but may indicate that depreciation leads to a contractionary monetary policy for given output and price level.\(^\text{53}\) This finding is inconsistent with Sriram (1999) in terms of coefficient value (-0.58) but consistent with the finding of Ibrahim (2001) in terms of coefficient sign not value (value is -0.38). These inconsistencies may be because of different variables used in their respective open economy models. For example, Sriram (1999), along with other variables, used an average nominal exchange rate variable without a foreign interest rate variable in the model and the estimated results could be partially the effect of the missing foreign interest rate variable. This finding is also inconsistent with the finding of Chowdhury (1997) for Thailand. He found the coefficient for exchange rate 0.21 for M2 and 0.19 for M1.

Malaysia as we mentioned before was pursuing open economy policies to encourage foreign investment. So we assume the foreign interest rate plays a vital role in this small open economy. In our model we use the US Treasury Bill Rate (USTB) as the foreign interest rate. Although the USTB coefficient in equation (5.11) is small it is negative implying that an increase in the foreign interest rate will depreciate the domestic currency hence leading people prefer to hold more foreign currency and less domestic currency. Sriram (1999) failed to obtain a meaningful long-run relationship by including foreign

\(^{52}\) See Blejer et al., (1991)

\(^{53}\) See Yurtsever (2003).
interest in the model. Therefore, we are unable to compare his results with the result of this study. However, the findings of Chowdhury (1997) could be comparable although his results are for Thailand. His results for foreign interest rate are 0.10 for M1 and 0.38 for M2. The difference could be due to a different data set and different definition of foreign interest rates (This study used USTB while Chowdhury (1997) used Eurodollar rate).

Finally, we formulate two hypotheses on the estimated cointegrating vector (equation 5.11) which are economically meaningful for an emerging country like Malaysia. The first one is to test whether money is neutral in the long-run and the other is to find the long-run relationship between the nominal exchange rate and money. Restrictions on equation (4.24) in Chapter Four represent the theoretical side of monetary neutrality. These can be formulated in the following way:

(i) \[ a_1 = - a_3 \]

(ii) \[ a_1 = - a_4 \]

where \( a_1, a_3 \) and \( a_4 \) are the coefficients of LM, LCPI and LER. These restrictions are designed to test long-run monetary neutrality. The results are in Table 5.6 and the log-likelihood ratio test does not reject the first restriction implying the presence of long-run monetary neutrality with regard to the price level in our study period. But the LR test rejects our second restriction, and hence rejects monetary neutrality in general. Our finding is inconsistent with Marashdeh (1993) for Malaysia. He used anticipated and unanticipated money to test the long-run neutrality proposition for the period 1970 to 1990 and found unanticipated money has a real effect in the long-run. Our finding is

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54 A core belief of “Classical Economics” was first put forward in the 18th century by David Hume. He set up the classical dichotomy that economic variables come in two varieties, nominal and real, and that the things that influence nominal variables do not necessarily affect the real economy.
largely consistent with Boschen and Mills (1995) for the USA data, Olekalns (1996) for the Australian data for the period 1900-01 to 1993-94 and for narrowly defined money. Our finding is further supported by Gregorio (2004)\textsuperscript{55} who argued that, in the long-run, there is no relationship between money growth and output growth and if anything, it is inflation that affects growth and welfare.

Table 5.6

Restrictions on cointegrating Vector

<table>
<thead>
<tr>
<th>When $a_1 = -a_3$</th>
<th>Imposed restrictions on cointegrating vectors (in normalized value)</th>
<th>When $a_1 = -a_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM</td>
<td>-1.00</td>
<td>-.100</td>
</tr>
<tr>
<td>LIP</td>
<td>-1.17</td>
<td>-0.17</td>
</tr>
<tr>
<td>LCPI</td>
<td>1.00</td>
<td>3.24</td>
</tr>
<tr>
<td>LER</td>
<td>1.10</td>
<td>1.00</td>
</tr>
<tr>
<td>USTB</td>
<td>0.04</td>
<td>-0.08</td>
</tr>
<tr>
<td>LR : $\chi^2(1)$</td>
<td>0.26[.61]</td>
<td>43.69[.00]</td>
</tr>
</tbody>
</table>

LR is log-likelihood ratio tests. $P$ values are in the brackets.

Our result could indicate the possibility of "bottlenecks" in the Malaysian economy during our study period. This type of "bottlenecks" Rao (1952) defined as full employment and any policy change at this full employment level only increases price

\textsuperscript{55} (a) Gregorio examined money and inflation relationship using both M1 and M2 definition of money for all the countries with populations more than 1 million and per capital income more than one thousand dollars. This study provides empirical evidence based on simple regression using inflation, change in current inflation and change in future inflation as dependent variables of three separate equations. (b) Also studies by Fisher and Seater (1993) and King and Watson (1995) found similar results.
level. Studies by Tan and Cheng (1995) and Tan and Baharumshah (1999) also recognized the ongoing problems of "bottlenecks" in the Malaysian economy.\(^{56}\)

5.4.5 Weak-exogeneity tests

The weak-exogeneity tests permit one to draw inferences from cointegration relationships obtained earlier to examine whether the short-run dynamic specifications could be

Table 5.7

Weak-exogeneity test

<table>
<thead>
<tr>
<th>Variables</th>
<th>LIP</th>
<th>LCPI</th>
<th>LM</th>
<th>LER</th>
<th>USTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha_1 = 0)</td>
<td>(\chi^2(1) = 22.73 [.000])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\alpha_2 = 0)</td>
<td>(\chi^2(1) = 21.63[0.00])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\alpha_3 = 0)</td>
<td>(\chi^2(1) = 43.61 [.000])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\alpha_4 = 0)</td>
<td>(\chi^2(1) = 28.21 [.000])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\alpha_5 = 0)</td>
<td>(\chi^2(1) = 27.93 [.000])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The log-likelihood ratio statistic is used for testing each restriction separately. \(\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5\) are the representatives of LIP, LCPI, LM, LER, USTB respectively. All the restrictions are statistically significant. All the estimations were done by Microfit 4.0 by Pesaran and Pesaran (1997).

\(^{56}\) Tan and Cheng (1993) argued that after several years of sustained economic growth, Malaysian economy experienced rising inflationary expectations, growing labour shortages and worsening bottlenecks in infrastructures. Tan and Baharumshah (1995) also expressed their concern on the problems of infrastructures and labor shortages and effects of this two factors on the price level.
modeled in a simpler setting. Since we found one cointegration relationship, the weak-
exogeneity test is carried out under the assumption of rank $r = 1$.

The test statistics will be asymptotically distributed as $\chi^2(1)$ if weak exogeneity of a
given variable for the cointegrating vector is valid. The null hypothesis is the existence of
weak exogeneity. It is usually examined by restricting the particular coefficient $\alpha$ equal
to zero. In general terms, weak-exogeneity tests examine the hypothesis whether or not
the corresponding row of $\alpha$ equal to zero (Johansen, 1992). If the null hypothesis is not
rejected, disequilibrium in the cointegration relationship does not feed back on to that
variable but any disequilibrium of a given variable will have impact on the cointegrating
relationships. Weak-exogeneity results in Table 5.7 show that the null hypothesis is
rejected for all variables at 1 percent level. Therefore, a short-run model can be designed
with systems of error-correction equations starting with the LIP equation. The error-
correction model is designed to bring out the short-run dynamics.

5.5 Short-run dynamic specification

Our short-run dynamic specifications are based on four equations derived from the SVAR
model discussed in section 5.2. That is, the predictions of the output, price level,
exchange rate and money supply equations will be used to predict the short-run dynamics
of the EC equations.
Output Equation

In the theoretical model developed in Chapter Four, we systematically derived an aggregate demand equation i.e. equation (4.14) from the basic IS-LM equilibrium condition for a small open economy. Equation (4.14) in Chapter Four specifies that aggregate demand depends on money supply M, domestic and foreign price level p and p*, nominal exchange rate er and foreign interest rate r*. Our output equation (5.5) is a representation of that equation where we keep all the variables except foreign price level as the correlation between domestic price level and foreign price level is very high.

The model developed is an open economy IS-LM, AS-AD model. Output in such a model is determined in the short-run by the interaction of aggregate demand and aggregate supply. Thus an increase in nominal exchange rate (i.e. depreciation) should increase net exports which increase aggregate demand and income (output). Similarly, an increase in the domestic money supply should lead to a decrease in domestic interest rates which should increase investment and consumption and increase aggregate demand. Also an increase in the money supply should lower domestic interest rate which will increase the nominal exchange rate (i.e. depreciation), increase net exports and aggregate demand and hence output Y. Finally, an increase in the domestic price level (upward shift in the AS curve) implies real appreciation which decreases net exports and hence decreases output. It also implies a reduction in the real money supply with additional contractionary effects on output.
Exchange rate equation

In Chapter Four we developed equation (4.22) assuming PPP holds in the long-run and UIP holds in the short-run. So the exchange rate is determined by the interaction of UIP with other macro variables in the model. Moreover, PPP may also affect exchange rate expectations. Thus we can say from equation (5.6) that an increase in income (in this case industrial production, IP) should increase the domestic interest rate and hence decrease the exchange rate (appreciation). Also an increase in income should increase imports which leads to an expected depreciation and finally depreciates the exchange rate. But an increase in the money supply should decrease the domestic interest rate and through UIP this increases exchange rate expectation (depreciation). Following the similar UIP logic, we could argue that an increase in the foreign interest rate (i.e. USTB) should increase exchange rate (depreciation). Finally, an increase in the price level should increase the exchange rate (depreciation) as we are assuming PPP holds in the long-run.

Price Level Equation

The EC equation for the price level (5.7) is derived from the interaction of aggregate demand and aggregate supply. Thus we can say that an increase in income (i.e industrial production (IP) for Malaysia but GDP for Thailand and Indonesia) will increase the price level through the Phillips curve. Similarly, an increase in the exchange rate (depreciation) should increase net exports and aggregate demand and finally increase the price level. It will also raise costs and increase prices directly as the AS curve shifts up. An increase in
the money supply lowers domestic interest rate, increases aggregate demand and finally increases the price level. In the case of the foreign interest rate (i.e. USTB), the price level increase can come in three ways: (i) an increase in foreign interest rate increases exchange rate (depreciation) and hence increases the price level. This is known as the direct price effect. (ii) an increase in the foreign interest rate increases exchange rate (depreciation) which should increase aggregate demand via net exports and hence increase the price level. (iii) another possibility is that an increase in foreign interest rate reduces foreign income and therefore negative effects on net exports and aggregate demand. This may reduce the domestic price level. So the overall effect of the foreign interest rate on the price level is ambiguous.

Monetary policy reaction function

The monetary policy reaction function (5.8) specifies the manner in which the monetary authority has responded to its policy informing variables. In the theoretical Chapter Four, equation (4.27) specifies the monetary policy reaction function. 57 Based on the theoretical literature 58 on the money supply and the assumption of a small open economy, the monetary policy reaction function outlines the relationship between changes in money supply and changes in other macro variables. Thus, governments normally use tighter monetary policy at a time of higher income if targeting inflation. Also at the time of

57 There is controversy about about the specification of monetary reaction function. Most of the literature identifies three plausible component of dependent variable such as interest rate, monetary aggregates and the exchange rate. But Jaffee and Russell (1976), Keeton (1979) and Stiglitz and Weiss (1981) have postulated domestic credit as the main dependent variable. In our case, we use monetary aggregates as dependent variable based on our theoretical model developed in Chapter Four.  
58 Such as Sanchez-Fung (2002) and Affandi (2004). Sanchez-Fung provided an insight in the context of an IS-LM aggregate framework. He demonstrates that the choice of policy instrument depends heavily on the type of shocks authority thinks relevant.
higher price level government uses tighter monetary policy. An increase in the exchange rate (depreciation) should increase the general price level (direct price effect) and hence government tightens monetary policy by reducing money supply. Tighter monetary policy can also be in use when aggregate demand increases due to an increase in net exports (as a result of depreciation). So an increase in the exchange rate leads to a tighter monetary policy. Finally, an increase in foreign interest rate should increase exchange rate (depreciation) and the price level. Hence government uses tighter monetary policy in order to prevent imported inflation.

Foreign interest rate equation

This equation (5.9) essentially represents the foreign interest rate as proxied by the United States Treasury Bills Rate and is assumed exogenous in this case and therefore affected only by its own shock. Our short-run dynamic specifications do not include this as an EC equation.

5.5.1 Short-run Error-correction Models

When variables are cointegrated then a dynamic error-correction representation of the data also exists. The short run model provides information concerning how adjustments are taking place among variables to restore equilibrium to the long-run level in response to short-term disturbances. Essentially it is ECM which contains an error-correction term to ensure that the long-run relationship is satisfied. The specification of ECM will be
based on the unit-root characteristics of the variables and the lag length applied in the cointegration analysis. In general, the short-run model will have I (0) representation of variables both on the LHS and RHS of the equation. Since the variables are I(1), the RHS will contain variables expressed in terms of first differences (except for the EC term(s) which will be in level). As one lag of a difference term equals the second lag of the level, the number of lags in the short-run model is usually one less than that applied in the cointegration tests. Since the original model includes dummy variables D84, D94 and D97, we also included these dummies in our short-run dynamics.

We begin by estimating the unrestricted model in MICROFIT 4.0. The model will then be reduced to a parsimonious form following the general-to specific approach developed by Hendry (1993)\textsuperscript{59}. The reduction process is carefully monitored to make sure that the model finally obtained is not worse off than any previously specified model. Both unrestricted and parsimonious models will be examined for their characteristics and behaviour.

### 5.5.2 Unrestricted models

The short-run unrestricted models are outlined in matrix form in equation (5.10) above. A single equation unrestricted reduced form is formulated to analyze the short-run dynamics for each of $\Delta$LIP, $\Delta$LCP, $\Delta$LER, $\Delta$LM. The unrestricted ECM model for $\Delta$LIP

\textsuperscript{59} Hendry also mentioned about the potential problems in the general to specific methodology (see page 257). These are: (i) With the general to specific methodology, the intention may not be realized – the chosen model could actually comprise a very special case of the data generation process, so that diagnostic testing remains important; (ii) there could be data limitations – sample size or the information content of the data may be inadequate; (iii) most importantly, there is no uniquely 'best' sequence for simplifying the model – different approximations which have similar sample likelihoods may forecast very differently.
is written as $\Delta LIP$ on the LHS and first differences in LIP, LER, LCPI, LM and USTB with each variable having eight lags to match the lag lengths of nine in the cointegration test. The RHS also include the ECM term. The coefficient of the ECM term is the speed of convergence to equilibrium. The larger the error correction coefficient (in absolute value) the faster the economy's return to its equilibrium once shocked.\(^6\) DZ represent the three dummies such as D84, D94 and D97. We follow the same procedure to write unrestricted ECM models for $\Delta LCPI$, $\Delta LER$, $\Delta LM$. ECM results for all unrestricted models are presented in Table 5.8.

- Results for the output equation indicate that the constant, $\Delta LIP_{t-2}$, $\Delta LIP_{t-3}$, $\Delta LIP_{t-5}$, $\Delta LIP_{t-7}$, $\Delta LIP_{t-8}$, $\Delta LER_{t-6}$, $\Delta LER_{t-7}$, $\Delta LER_{t-8}$, $\Delta LCPI_{t-4}$, $\Delta LM_{t-8}$, $\Delta LM_{t-6}$, D84 are significant at the 10% level or better. All the other variables including the Asian crisis dummy (D97) are found to be insignificant. The error correction term is positive but insignificant at the conventional significance level.

- Unrestricted ECM results for the price level equation, $\Delta LCPI$, indicate that the constant, $\Delta LIP_{t-5}$, $\Delta LIP_{t-7}$, $\Delta LER_{t-8}$, $\Delta LCPI_{t-8}$, $\Delta LM_{t-6}$, ECM\(_{t-1}\) are found significant at up to 10% or better. All the other variables including dummies are found to be insignificant.

- Unrestricted ECM results for the exchange rate equation, $\Delta LER$, indicate that the constant, $\Delta LIP_{t-1}$, $\Delta LIP_{t-2}$, $\Delta LIP_{t-3}$, $\Delta LIP_{t-4}$, $\Delta LIP_{t-5}$, $\Delta LIP_{t-6}$, $\Delta LIP_{t-7}$, $\Delta LER_{t-4}$, $\Delta LER_{t-5}$, $\Delta LCPI_{t-5}$, $\Delta LM_{t-5}$, $\Delta USTB_{t-1}$, $\Delta USTB_{t-3}$, $\Delta USTB_{t-5}$, $\Delta USTB_{t-7}$, ECM\(_{t-1}\)

---

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>ΔLIP</th>
<th>ΔLCPI</th>
<th>ΔLER</th>
<th>ΔLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.16 [.50]</td>
<td>-.10 [-.43]***</td>
<td>.70 [5.07]***</td>
<td>.33 [2.82]***</td>
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<tr>
<td>ΔLIP_{t-1}</td>
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<td>.05 [1.90]</td>
<td>-.44 [-2.92]***</td>
<td>-.30 [-2.33]**</td>
</tr>
<tr>
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<td>.02 [1.09]</td>
<td>-.34 [-2.55]***</td>
<td>-.10 [-.88]</td>
</tr>
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<td>ΔLIP_{t-3}</td>
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<td>.04 [1.40]</td>
<td>-.52 [-3.59]***</td>
<td>-.48 [-3.86]***</td>
</tr>
<tr>
<td>ΔLIP_{t-4}</td>
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<td>.01 [.38]</td>
<td>-.37 [-2.53]***</td>
<td>-.27 [-2.18]**</td>
</tr>
<tr>
<td>ΔLIP_{t-5}</td>
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<td>.08 [3.17]***</td>
<td>-.44 [-3.15]***</td>
<td>-.22 [-1.84]*</td>
</tr>
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<td>.02 [7.8]</td>
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<td>-.36 [-2.67]*</td>
</tr>
<tr>
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<td>.04 [1.77]*</td>
<td>-.31 [-2.50]***</td>
<td>-.18 [-1.7]*</td>
</tr>
<tr>
<td>ΔLIP_{t-8}</td>
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<td>.007 [.31]</td>
<td>-.18 [-1.46]</td>
<td>-.33 [-3.06]***</td>
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<td>ΔLCPI_{t-2}</td>
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<td>.07 [.79]</td>
<td>-.52 [-1.06]</td>
<td>-.36 [-.86]</td>
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<td>-.33 [-3.10]***</td>
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<td>.009 [.40]</td>
<td>-.25 [-1.92]*</td>
<td>-.03 [-.31]</td>
</tr>
<tr>
<td>ΔLER_{t-5}</td>
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<td>-.013 [.57]</td>
<td>-.25 [-1.92]*</td>
<td>-.09 [-.82]</td>
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<tr>
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<td>-.01 [-.84]</td>
<td>.01 [.09]</td>
<td>.20 [1.94]***</td>
</tr>
<tr>
<td>ΔLER_{t-7}</td>
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<td>.16 [1.30]</td>
<td>-.04 [-.41]</td>
</tr>
<tr>
<td>ΔLER_{t-8}</td>
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<td>-.05 [-1.67]*</td>
<td>-.05 [-.38]</td>
<td>.42 [3.16]***</td>
</tr>
<tr>
<td>ΔLM_{t-1}</td>
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<td>.03 [.03]</td>
<td>.18 [1.18]</td>
<td>-.09 [-.76]</td>
</tr>
<tr>
<td>ΔLM_{t-2}</td>
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<td>.015 [.63]</td>
<td>.20 [.148]</td>
<td>.31 [.26]*</td>
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<td>ΔLM_{t-3}</td>
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<td>-.03 [-.108]</td>
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<tr>
<td>ΔLM_{t-4}</td>
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<td>.002 [.90]</td>
<td>.016 [.11]</td>
<td>.10 [.85]</td>
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<td>ΔLM_{t-5}</td>
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<td>.001 [.05]</td>
<td>.33 [2.36]***</td>
<td>.21 [.74]*</td>
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<td>-.05 [-1.67]</td>
<td>-.06 [-.35]</td>
<td>.21 [.40]</td>
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<td>ΔLM_{t-7}</td>
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<td>.14 [.12] [2.23]</td>
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<td>.28 [1.54]</td>
<td>.44 [2.83]***</td>
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<td>ΔUSTB_{t-1}</td>
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<td>-.001 [-1.12]</td>
<td>.014 [2.54]***</td>
<td>-.001 [-.32]</td>
</tr>
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<td>ΔUSTB_{t-2}</td>
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<td>-.001 [-1.37]</td>
<td>.000 [.04]</td>
<td>.01 [.21]**</td>
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<td>.012 [.19] [2.89]**</td>
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<td>ΔUSTB_{t-4}</td>
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<td>-.001 [-1.17]</td>
<td>.002 [.38]</td>
<td>.014 [2.11]**</td>
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<tr>
<td>Variable</td>
<td>Value</td>
<td>Value</td>
<td>Value</td>
<td>Value</td>
</tr>
<tr>
<td>------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>( \Delta \text{USTB}_{t-5} )</td>
<td>.007[-.18]</td>
<td>.00[-.02]</td>
<td>.014[2.09]**</td>
<td>-.008[-1.39]</td>
</tr>
<tr>
<td>( \Delta \text{USTB}_{t-6} )</td>
<td>-.000[-.11]</td>
<td>-.001[-1.10]</td>
<td>.007[.96]</td>
<td>.01[1.97]**</td>
</tr>
<tr>
<td>( \Delta \text{USTB}_{t-7} )</td>
<td>.006[1.46]</td>
<td>.000[-.87]</td>
<td>.01[1.9]**</td>
<td>-.008[-1.64]**</td>
</tr>
<tr>
<td>( \Delta \text{USTB}_{t-8} )</td>
<td>-.004-.93[.35]</td>
<td>.000[-.622]</td>
<td>.01[1.75]</td>
<td>.01[2.88]** ***</td>
</tr>
<tr>
<td>ECM(_{t-1})</td>
<td>.03[1.22]</td>
<td>-.028[4.70]** ***</td>
<td>.16[4.73]** ***</td>
<td>.06[2.26]**</td>
</tr>
<tr>
<td>D84</td>
<td>.24[7.43]** ***</td>
<td>.01[1.49]</td>
<td>.01[.27]</td>
<td>-.05[-1.47]</td>
</tr>
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<td>D94</td>
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<td>.05[9.51]</td>
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<td>D97</td>
<td>.000[.008]</td>
<td>-.006[-1.38]</td>
<td>.17[6.83]** ***</td>
<td>-.007[-.34]</td>
</tr>
<tr>
<td>R(^2)</td>
<td>.84</td>
<td>.82</td>
<td>.66</td>
<td>.76</td>
</tr>
<tr>
<td>D-W</td>
<td>2.39</td>
<td>1.77</td>
<td>2.10</td>
<td>2.15</td>
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<tr>
<td>Serial corr.: ( \chi^2 )(4)</td>
<td>15.96 (.003)</td>
<td>5.06(2.8)</td>
<td>7.37(11)</td>
<td>6.34 (.17)</td>
</tr>
<tr>
<td>Functional Form: ( \chi^2 )(1)</td>
<td>.25 (.618)</td>
<td>4.63(0.31)</td>
<td>16.02 (.00)</td>
<td>6.29 (.012)</td>
</tr>
<tr>
<td>Normality: ( \chi^2 )(2)</td>
<td>1.90(.387)</td>
<td>.56 (.753)</td>
<td>8.22(.016)</td>
<td>4.94 (.084)</td>
</tr>
<tr>
<td>Heteroscedasticity: ( \chi^2 )(1)</td>
<td>3.86 (.049)</td>
<td>.19(.660)</td>
<td>2.24(.134)</td>
<td>4.7 (.03)</td>
</tr>
</tbody>
</table>

Notes:
1. t-values are in square brackets.
2. *** significant at the 1% level.
3. ** significant at 5% level.
4. * significant at 10% level.
5. The \( p \)-values are in rounded brackets.

and D97 are found significant at 10% or better. All the other variables including dummies are found to be insignificant.

- Unrestricted ECM results for the policy reaction function, \( \Delta \text{LM} \), indicate that the constant, \( \Delta \text{LIP}_{t-1}, \Delta \text{LIP}_{t-3}, \Delta \text{LIP}_{t-4}, \Delta \text{LIP}_{t-5}, \Delta \text{LIP}_{t-6}, \Delta \text{LIP}_{t-7}, \Delta \text{LIP}_{t-8}, \Delta \text{LER}_{t-1}, \Delta \text{LER}_{t-2}, \Delta \text{LER}_{t-3}, \Delta \text{LER}_{t-4}, \Delta \text{LER}_{t-5}, \Delta \text{LCPI}_{t-2}, \Delta \text{LCPI}_{t-3}, \Delta \text{LM}_{t-2}, \Delta \text{LM}_{t-3}, \Delta \text{LM}_{t-5}, \Delta \text{LM}_{t-8}, \Delta \text{USTB}_{t-2}, \Delta \text{USTB}_{t-6}, \Delta \text{USTB}_{t-7}, \Delta \text{USTB}_{t-7}, \text{ECM}_{t-1} \) are found to be significant at the 10% or better. All the other variables including dummies found insignificant.

The absolute value of the error correction term for equations \( \Delta \text{LCPI}, \Delta \text{LER} \) and \( \Delta \text{LM} \) is found significant indicating the existing disequilibrium is reduced over time. This also indicates that the cointegration relationship established previously is valid as per

5.5.3 The Parsimonious model

The unrestricted model is reduced to a parsimonious one by following the general-to-specific principles and by applying the OLS technique. All the significant variables in the unrestricted version (Table 5.8 above) are found likewise in the parsimonious model as well.

The results for the parsimonious models are shown in Table 5.9.

(i) Malaysian output movements depend on changes in output itself, in the exchange rate, in the domestic price level and in the money supply. The interesting findings are: (1) A depreciation has substantial positive impacts on output in the short-run; (2) Monetary expansion increases output in the short-run. (3) The effects of an increase in the general price level are ambiguous i.e. an increase in the general price level decreases output (LIP) after four quarters but increases output after eight quarters. (4) Another interesting finding is that in the short-run, the foreign interest plays no role in the movement of Malaysian output level. The coefficient on the lagged error-correction term is .026 which is statistically significant at the 2% level of significance. This shows that the speed of adjustment towards long-run equilibrium is 2.6% per quarter i.e. about 2.6% of the previous disequilibrium is corrected every quarter. One possible implication of the slow
### Table 5.9

Parsimonious representations of Error correction Models

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>$\Delta$ LIP</th>
<th>$\Delta$ LCPI</th>
<th>$\Delta$ LER$^H$</th>
<th>$\Delta$ LM$^H$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.12 [2.69]</td>
<td>-.05 [-5.28]</td>
<td>.26 [4.31]</td>
<td>.05 [8.72]</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
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<td>$\Delta$ LCPI$t_{-2}$</td>
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<td>.04 [3.06]</td>
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<td></td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
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</tr>
<tr>
<td>$\Delta$ LCPI$t_{-6}$</td>
<td></td>
<td></td>
<td>.27 [1.32]$^N$</td>
<td></td>
</tr>
<tr>
<td>$\Delta$ LCPI$t_{-8}$</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta$ LER$t_{-1}$</td>
<td></td>
<td></td>
<td>-.25 [-2.28]</td>
<td></td>
</tr>
<tr>
<td>$\Delta$ LER$t_{-2}$</td>
<td></td>
<td>.04 [2.85]</td>
<td></td>
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</tr>
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<td></td>
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</tr>
<tr>
<td>$\Delta$ USTB$t_{-7}$</td>
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<td></td>
<td>.007 [1.89]</td>
<td></td>
</tr>
<tr>
<td>ECM$t_{-1}$</td>
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<td>-.014 [-6.28]</td>
<td>.06 [3.86]</td>
<td>.014 [1.02]*</td>
</tr>
<tr>
<td>D84</td>
<td>.21 [8.11]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D94</td>
<td></td>
<td></td>
<td>.05 [12.51]</td>
<td></td>
</tr>
<tr>
<td>D97</td>
<td></td>
<td></td>
<td>.10 [2.24]</td>
<td>-.02 [-1.39]</td>
</tr>
<tr>
<td>R$^2$</td>
<td>.70</td>
<td>.75</td>
<td>.30</td>
<td>.54</td>
</tr>
<tr>
<td>D-W</td>
<td>2.24</td>
<td>1.78</td>
<td>2.13</td>
<td>2.06</td>
</tr>
<tr>
<td>Serial corr: $\chi^2 (4)$</td>
<td>9.05 (.08)</td>
<td>7.44 (.11)</td>
<td>2.17 (.70)</td>
<td>5.25 (.26)</td>
</tr>
<tr>
<td>Functional form: $\chi^2 (1)$</td>
<td>3.6 (.15)</td>
<td>2.85 (.09)</td>
<td>26.39 (.00)</td>
<td>9.55 (.002)</td>
</tr>
<tr>
<td>Normality: $\chi^2 (2)$</td>
<td>.38 (.82)</td>
<td>4.72 (.09)</td>
<td>54.75 (.00)</td>
<td>8.68 (.013)</td>
</tr>
<tr>
<td>Heteroscedasticity: $\chi^2 (1)$</td>
<td>.04 (.82)</td>
<td>.03 (.842)</td>
<td>44.01 (.00)</td>
<td>7.09 (.008)</td>
</tr>
</tbody>
</table>
adjustment speed is that the goods market remains in disequilibrium for a number of years.

So in the parsimonious ECM results for LIP, all the coefficients have expected signs and are significant. The diagnostic tests show no econometric problem exists in the parsimonious model. This is unlike the results reported in Upadhyaya and Upadhyaya (1999) for six Asian countries. In a first difference form of estimation, the results indicate that devaluation has both positive and negative effects on output over any length of time. Any effect on output identified comes from the relative price change (the ratio of foreign to domestic). A rise in domestic prices relative to the foreign price level has a positive contemporaneous effect for India, Pakistan and Philippines but not for Malaysia. Unanticipated money growth is found to have a positive and significant effect on output for Malaysia. Our findings are partially consistent with findings of Marashdeh (1993), Tan and Cheng (1995), Tan and Baharumshah (1999) and Masih and Masih (1996) for Malaysia. These studies examined output-monetary policy linkages for Malaysia and concluded that money does have a real effect in the short-run. However, the focus of these studies is only on the causal effects of monetary policy on real aggregate fluctuations.
(ii) The short-run movement of the Malaysian exchange rate is positively related with output, the price level and money supply. Hence short-run increases in output, the price level and the money supply all lead to depreciation. The foreign interest rate again plays a minimum role (almost zero). The significant dummy variable D97 implies that the Asian crisis had a major role in Malaysian exchange rate movements leading to a depreciation of about 10%. The coefficient of the lagged error-correction term is .06 which is statistically significant at the 1% level. This shows the speed of adjustment of the foreign exchange market towards long-run equilibrium is about 6% per quarter. This also shows that about 6% previous disequilibrium in the foreign exchange market is corrected every quarter. All the results here are White's heteroscedasticity adjusted. So the parsimonious ECM results for variable LER indicate that all the coefficients including error-correction term and D97 dummy are found expected and statistically significant. As the t-values are White's heteroscedasticity adjusted, there is no econometric problem in this ECM. This finding is partially consistent with Rittenberg (1993) for Turkey and inconsistent with the findings of Alba and Papell (1998) for three ASEAN countries including Malaysia. Rittenberg found that domestic inflation substantially contributed to the movement of Turkey's exchange rate. But the findings of Alba and Papell show that exchange rate expectations are mainly affected by current exchange rate. Findings of the study by Deravi et al. (1995) for USA are consistent with our finding showing significant relationship among exchange rate, money and price level.

(iii) The short-run movement of the Malaysian price level depends upon output, exchange rate and the money supply. The results clearly show that (1) rapid output growth
increases inflation (as measured by the consumer price level), a result predicted by the Phillips curve; (2) depreciation increases inflation in the initial quarters but is partly reversed after eight quarters; (3) increases in the money supply increases inflation in the short-run. Moreover the foreign interest rates play no role in the movement of the Malaysian price level. The dummy variable D94 is significant indicating that policy changes (discussed before) may have had some effect on the price level. The coefficient of the lagged error-correction term is -0.014 which is statistically significant at the 1% level. This shows that about 1.4% of the previous disequilibrium in the price level is corrected every quarter suggesting that the price level may remain in disequilibrium for a number of years. So the parsimonious ECM results for the variable LCPI indicate that all the signs of all coefficients are as expected (except ΔLERt-1) and significant. A negative and significant error-correction term validates the previously established cointegration relationship. It also establishes that the existing disequilibrium is reduced over time.

Another interesting aspect is that the policy measures introduced in 1994, as explained before, prove to be important for LCPI in the short-run but the D84, D94 are found insignificant. The diagnostic tests reveal no problem with serial correlation, functional form and heteroscedasticity. Our finding of price level and exchange rate relationship is consistent with the findings of Alba and Papell (1998) for Malaysia and inconsistent with Rana and Dowling (1985) for Malaysia, Rittenberg (1993) for Turkey. Alba and Papell found positive relation between inflation and effective exchange rate in Malaysia. Rana and Dowling found negative relationship between inflation and effective exchange rate for Malaysia, although estimates are marginally significant. Papell’s (1994) finding for G-7 countries is consistent with our findings. Using the maximum likelihood estimation
technique, the result of Papell’s paper shows that exchange rates have relatively small effects on national price levels for G-7 countries.

(iv) Finally, the short-run ECM model for the policy reaction function (LM) suggests a negative relationship between LIP and LM which is expected and significant. One of the possible explanations is that, in Malaysia, our study period is a period of economic boom. So the authority was conscious of controlling money supply when they had feelings of inflationary pressure coming from higher aggregate demand (output). This is inconsistent with the findings of Marashdeh (1993) that anticipated movements of output affects money growth positively. Tan and Cheng’s (1995) findings also support our findings. Their study shows the existence of a bidirectional relationship between money supply and nominal output. The short-run impact of inflation on money supply growth is negative and expected suggesting authorities reduce money supply growth when inflation goes up. The most obvious explanation that can be provided is that inflation targeting has been the main focus of Bank Negara Malaysia\(^{61}\) (BNM) monetary policy during our study period. The positive relationship between the exchange rate and the money supply suggests that at the time of depreciation the monetary authority intervened in the foreign exchange market by buying foreign exchange (selling Ringgit) to encourage further depreciation, perhaps to enhance competitiveness. This is a common practice in a developing country where managed exchange rate prevails. In that process it increases money supply in the economy. The relationship between foreign interest rate and money supply is found significant in most cases in the unrestricted ECM model (Table 5.8) but not in the parsimonious ECM model (Table 5.9). This indicates that Malaysia in the short-run,

\(^{61}\) BNM is the Central Bank of Malaysia.
during our study period, used sterilization policy$^{62}$ as evidenced by Dean (1996), and Islam and Chowdhury (2000)$^{63}$. The insignificant error-correction term means that the policy reaction function is not responsible for returning the system to long-run equilibrium.

5.5.4 Stability Tests

We examine the stability of the coefficients by applying the CUSUM and CUSUMSQ proposed by Brown et al. (1975). The tests are applied to the residuals of all four EC models in Table 5.8. Figures 5.1, 5.2, 5.3 and 5.4 are graphical representations of the CUSUM and CUSUMSQ plots applied to the error-correction models. Except one, all CUSUM and CUSUMSQ plots are within critical bounds of 5% significant level implying no evidence of structural instability. The CUSUM plots of exchange rate equation crosses the critical bound while CUSUMSQ does not, implying that stability test result is inconclusive. However, Bahmani-Oskooee and Shin (2002) shows that as long as CUSUMSQ are within critical bound the function is stable.

$^{62}$ Sterilization is a policy used by many developing countries which experience large capital inflows. Through this policy intervention, capital-receiving countries under floating or managed floating exchange rate system have tried to prevent nominal appreciation of their currencies and avoid monetary expansion associated with an accumulation of foreign reserves.

Figure 5.1  CUSUM and CUSUMSQ test for Coefficient Stability: Output Equation

**Plot of Cumulative Sum of Recursive Residuals (DLIP)**

The straight lines represent critical bounds at 5% significance level

**Plot of Cumulative Sum of Squares of Recursive Residuals (DLIP)**

The straight lines represent critical bounds at 5% significance level
Figure 5.2 CUSUM and CUSUMSQ test for Coefficient Stability: Price level Equation

Plot of Cumulative Sum of Squares of Recursive Residuals (DLCPI)

The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Recursive Residuals (DLCPI)

The straight lines represent critical bounds at 5% significance level
Figure 5.3 CUSUM and CUSUMSQ test for Coefficient Stability: Exchange Rate Equation

Plot of Cumulative Sum of Recursive Residuals (DLER)

The straight lines represent critical bounds at 5% significance level.

Plot of Cumulative Sum of Squares of Recursive Residuals (DLER)

The straight lines represent critical bounds at 5% significance level.
Figure 5.4 CUSUM and CUSUMSQ test for Coefficient Stability: Monetary Policy Reaction Function

Plot of Cumulative Sum of Recursive Residuals (DLM)

The straight lines represent critical bounds at 5% significance level.

Plot of Cumulative Sum of Squares of Recursive Residuals (DLM)

The straight lines represent critical bounds at 5% significance level.
5.6 Conclusion

The analysis of this chapter follows a systematic approach to modeling the exchange rate, output, price level and money in Malaysia. We developed a structural cointegrating VAR model on the basis of the theoretical framework discussed in Chapter Four. All the relevant macro issues have been taken into consideration while selecting appropriate variables in the model. The unit root tests indicate that the variables in the model are I(1) and therefore the cointegration technique of Johansen (1988) and Johansen and Juselius (1990) can be applied to evaluate the long run relationship. On the basis of cointegration and weak-exogeneity tests appropriate ECMs are set up to evaluate the short-run properties of the model. The major results of this chapter may be summarised as follows.

The cointegration test results suggest that aggregate money is cointegrated with output (industrial production), price level, exchange rate and foreign interest rate. This implies that there are stable long-run relationships among aggregate money and other mentioned variables. Of particular importance is the minimal role of foreign interest rate in the long-run. Moreover, we have tested important hypotheses of long-run monetary neutrality and found that monetary-neutrality exists in the long-run with respect to the price level but not the exchange rate. This monetary neutrality could indicate the possibility of ‘bottlenecks’ in the Malaysian economy during our study period.

The short-run formulation of ECMs shows that Malaysian output movements depend on output itself, the exchange rate, the domestic price level and the money supply. The
foreign interest rate (as proxied by USTB) plays almost no role in the movement of Malaysian output in the short-run. In the case of the nominal exchange rate, the ECM results show that the nominal exchange rate is positively related with output, the price level and the money supply i.e increases in each of these leads to depreciation. The foreign interest rate plays a minimal role in the movements of the Malaysian nominal exchange rate. In this ECM, the Asian crisis dummy is significant. The ECM results for LCPI show that, in the short-run, the Malaysian price level is highly correlated with output, the exchange rate and the money supply but not significantly with the foreign interest rate. Finally, the ECM for monetary policy reaction function suggests a negative relationship between money and output and a positive relationship between exchange rate and money. A negative relationship between the price level and money is also found in this ECM. The significant relationship between foreign interest rate and money indicates that Malaysia used sterilization policy in the short-run. The insignificant error-correction term means that the policy reaction function is not responsible for returning the system to long-run equilibrium.

Our empirical work presented above points to the conclusion that in Malaysia, depreciations have been associated with higher output in the short-run. But a higher price level should be seen as partly detrimental to output in the short-run. The results also point out that the domestic price level is highly sensitive to lagged values of itself, output, money supply and depreciation. The Malaysian exchange rate is positively related with the price level and money supply. Even though Malaysia is a small open economy, the foreign interest plays almost no role in the movements of Malaysian output, the price
level and the exchange rate in the short run which is contradictory to most theoretical and empirical findings (i.e. Mundell- Fleming Model, Chowdhury 1997).

The findings of stable long-run relationships among the exchange rate, price level, output and money as well as short run results have potentially important implications for authorities in Malaysia. The most important implications are: (i) Expansionary monetary policy has a positive effect on output, inflation and exchange rate (depreciation) in the short-run. However, in the long-run, money could be neutral indicating no real effects on the economy. As this thesis argued, 'bottlenecks' may have caused this neutrality. Tan and Cheng (1995) and Tan and Bahrumshah (1999) also raised the issue of 'bottlenecks' in the context of the Malaysian economy and in the context of policy effectiveness. (ii) Malaysia authority could use sterilization policy in the short-run to prevent nominal appreciation of their currency. (iii) Exchange rate policies should be designed to have a positive effect on output but they needed attention to price level effects as depreciation increases price level in the short-run.
Appendix 5.1

Malaysian data Series

Nominal Exchange Rate (in log)

Industrial Production (in log)
**Consumer Price Index (in log)**

**Money Supply (in log)**
US Treasury Bill Rate

Value

Year

Chapter Six

Empirical Study for Indonesia

6.1 Introduction

The relationships among output, money, the exchange rate and price level are important for any small open economy. We systematically outlined a theoretical framework in Chapter Four to identify these relationships in a macro-economic framework. One of the most important parts of this type of study, among other things, is to test for monetary neutrality and PPP relationships in a ‘natural rate’ model of aggregate supply both in the short-run and in the long-run. Indonesia is a small open economy with frequent government interventions and modelling macro-economic relationships is somewhat complicated. As the review in chapter Two reveal, the related empirical literature on this issue is quite voluminous, only a few are specific to Indonesia. Most studies undertaken have extensively emphasized money demand issues for developed countries with less government intervention in the economy (see for example, Elyasiani and Zadeh (1995), Miller (1991), Ericsson (1998), Saunders (2002), and Gali (1992). There are few studies on developing ASEAN countries i.e. Chowdhury (1997) for Thailand, Sriram (1999) for Malaysia, Marashdeh (1993, 1997) for Malaysia and Tan and Cheng (1995) for Malaysia and studies on Indonesia are Affandi (2004), Siregar (1999), Siregar and Rajan (2004) but none of them specific to the relationships among the exchange rate, price level, output
and money. In this chapter, we hope to fill the gap that exists in the literature and most importantly analyze the issue within a theoretical framework as outlined in Chapter Four.

The remainder of the chapter is set out as follows. Section 6.2 provides a brief review of the Indonesian economy since 1970. Section 6.3 develops the empirical model for estimation using theoretical model discussed in Chapter Four and Chapter Five. Section 6.4 is the time series properties of the Indonesian data including cointegration. Section 6.5 is the analysis of Short-run dynamics with stability tests and Section 6.6 is the conclusion.

6.2 The Indonesian Economy

In the last two decades, except during, and in the immediate aftermath of the Asian financial crisis period of 1997-98, Indonesia experienced remarkable economic growth leading the World Bank to classify it as one of the world's high-performing economies. Since the 1970s, prudent economic policies and continuing structural reforms have kept Indonesia as a high performing economy as can be seen from Table 6.1. With an average 7 percent per annum growth, the economic structure has become diversified from oil dependency to export-oriented manufacturing led by a dynamic private sector and fueled by high domestic savings and large inflows of foreign direct investment. Rising per capita income reduced the incidence of poverty during this period. Since the beginning

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64 See the World Bank (1993). But Indonesia is still classified as a low income country, but with sustained development, it is now within striking distance of joining the ranks of middle income countries.
of the 1970s, Indonesia placed emphasis on consistent macro-economic policies targeting economic growth and stability. During the period of the oil boom in the 1970s, it used oil revenue to develop other sectors of the economy such as agriculture, physical and social infrastructure which lead to economic growth at nearly 8% p.a.

At the same time, it followed cautious macroeconomic policies including a conservative external borrowing strategy and maintained fiscal balance although inflation did increase due to higher spending from oil revenue. The government of Indonesia announced restrictive trade and investment policies and future plans for an expanded state enterprise sector. Moreover, a large depreciation took place in November 1978 to restore competitiveness in the non-oil trading sectors. These cautious policies, according to the World Bank, led to current account surpluses and a debt ratio below 13% which was considered one-quarter of Mexico's level at that time.

During the 1980s, Indonesia faced a series of severe external shocks including the collapse of oil prices, dropping of World GDP growth from 3 percent to 2 percent in 1980, the rise in international interest rates and the depreciation of the US dollar. These external shocks had negative impacts on the economy, sharply reduced exports and fiscal revenues, increased external and internal finance pressures and raised external debt.

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65 Largely because of its bitter experience of hyper-inflation in the mid 1960s.
66 Inflation was as high as 41 percent. In this context, one interesting observation made by H.W. Arndt in BIES (1974) survey is "Indonesia in 1974 is like a man who has just won first prize in a lottery. The opportunities are immense, almost unimaginable. But so are the pressures and temptations to spend too much too fast, and the differences in making wise and effective use of the windfall".
### Table 6.1

Basic Economic Indicators for Indonesia

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP growth (annual %)</th>
<th>GDP per capita growth (annual %)</th>
<th>Consumer price change (annual %)</th>
<th>Exchange Rate: Rupiah / US $</th>
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<td>1970</td>
<td>8.15</td>
<td>5.61</td>
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<tr>
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<td>6.99</td>
<td>4.46</td>
<td>4.35</td>
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<td>6.51</td>
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<tr>
<td>1974</td>
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<td>5.67</td>
<td>40.60</td>
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<td>1975</td>
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<td>3.71</td>
<td>19.05</td>
<td>415.00</td>
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<tr>
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<td>8.10</td>
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<tr>
<td>1979</td>
<td>7.09</td>
<td>4.84</td>
<td>16.26</td>
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<td>18.01</td>
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<td>8.39</td>
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<td>9.43</td>
<td>2248.61</td>
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<tr>
<td>1996</td>
<td>7.64</td>
<td>5.91</td>
<td>7.96</td>
<td>2342.30</td>
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<tr>
<td>1997</td>
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<td>3.01</td>
<td>6.73</td>
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<tr>
<td>1998</td>
<td>-13.12</td>
<td>-14.53</td>
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<tr>
<td>1999</td>
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<td>7855.15</td>
</tr>
<tr>
<td>2000</td>
<td>4.77</td>
<td>3.08</td>
<td>3.72</td>
<td>8421.78</td>
</tr>
</tbody>
</table>

The economy was growing less than expected at a rate of 4 per cent and gross domestic income grew at an even slower pace. Hill\(^8\) explained this situation as:

"Indonesian Economy in mid-1984 is something of a puzzle. The macro indicators are encouraging.... Yet investment is sluggish, the deep-seated problems of protection and regulation and of indifferent performance of the large state enterprise sector remain, and some of the governments recent industrial policy initiatives to be very costly.... The paradox is resolved partly when it is remembered that rice and oil are still crucial. A good performance in these two sectors can gloss over problems elsewhere."

The policy responses to these shocks were targeted to recovery from the shocks and to economic growth. In the initial phase, the government introduced an austere budget in January 1983; increasing government expenditure only by 6 per cent above the level of the previous year and targeting the inflation rate at less than 10 per cent. Monetary policy tightened by controlling the money supply (M1 not M2). Credit ceilings were removed and regulations governing the financial and credit system relaxed. Tax, custom and banking reforms were introduced and the Rupiah\(^9\) was devalued by 38 percent in 1983 to bring the real exchange rate back to the level set by the 1978 devaluation.\(^7\)

The policy reforms introduced in the 1980s were successful in stabilizing the economy maintaining growth on average at 7 per cent. Better macroeconomic management substantially reduced the current account and fiscal deficits and inflation fell below 10 percent.\(^7\) Prudence in external borrowing allowed Indonesia to service its debt without

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\(^9\) Indonesian domestic currency.

\(^7\) Woo, W. T., Glassburner, B., and Nasution, A., (1994). The Rupiah was further devalued by 45 per cent in 1986 to recover from sharp fall in price of oil as well as US dollar depreciation.

\(^7\) In Indonesia government was very much concerned about inflation. Inflation became a political agenda of the government. So it uses every possible way to control inflation for political gain. Hall (2000) mentioned that inflation was under control largely because of direct/indirect interventions by the government. As a direct intervention, Bank Indonesia used interest rate policy to control inflation. In case
rescheduling in that period. Despite its huge debts in the 1980s, Indonesia retained access to voluntary market finance throughout the adjustment period.

In the 1990s, Indonesia experienced a sudden increase in domestic demand with an accommodating monetary policy which eventually increased inflation, increased the current account deficit and reduced international reserves. As the government of Indonesia was always concerned about inflation, efforts to restrain demand started in 1990 and intensified in 1991 when the government announced several monetary and credit policies. Among these policies, a more restrictive CAMEL\textsuperscript{72} system to regulate and supervise bank loan operations was introduced, limits were imposed on state enterprise’s external borrowing and guidelines for private external borrowing were prominent. To influence domestic credit, Bank Indonesia (BI) also increased interest rates on its certificates to control the money supply. It was evident by the end of 1992 that the above stabilization policies were working leading to a GDP growth of 7.4%. Until 1996, the economy was doing well and Indonesia became an industrial exporter country. Another feature of this period was the growing commercial strength and independence of the private sector although there were considerable subsidies and protection for state-owned enterprises.

The value of the exchange rate is determined by BI under a managed float. It maintains the Rupiah's competitiveness against a basket of currencies, mainly by depreciating the Rupiah to compensate for the differential between Indonesian and US inflation and

---

\textsuperscript{72} CAMEL introduced in February 1991 and stands for Capital adequacy, asset quality, management, earning and liquidity.
adjusting for fluctuations in the US dollar cross-exchange with other currencies. During the whole of the 1990s, whenever there were inflationary pressures, the government used a policy of slowing the rate of depreciation of the exchange rate and keeping tradable goods price inflation low which can help reduce inflationary expectations.

Finally, when we talk about the economic development of a developing country like Indonesia, we examine certain "Sequences" proposed in the literature. For example, one school of thought proposed that in the process of liberalization of the capital account should be opened last, after restoration of financial stability and the opening of the current account (i.e., trade liberalization). Indonesia is sometimes cited as an exception to this proposition because its international capital account was opened in 1970 while trade reform was pursued more than a decade later. The economic performance of Indonesia, however, does not invalidate the main principles of the sequencing literature. By the end of 1996, moderate economic growth had been achieved, inflation was broadly under control and fiscal deficits were modest. But macroeconomic indicators started showing unusual signs at the beginning of the 1997 financial crisis and Indonesia was hit hardest by this crisis. Table 6.1 shows that in 1998 GDP declined by about 14% and consumer prices went up by almost 58% and the external value of the Rupiah has depreciated by over 300 percent since 1997. The exchange rate and interest rates oscillated widely during 1997-1998. The Jakarta stock exchange plunged by more than 50 percent during this period. A new set of policies was introduced by the Bank of Indonesia to overcome

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73 World Bank (1994)
the crisis. Among them, a relatively free floating exchange rate system, bank-sector restructuring and controlling private sector external debt and fiscal distress.

6.3 Empirical Model and Data

Indonesia's economic problems in the 1960s were at least as serious as those of today's least developing countries in Asia and Africa. But by the mid 1980s, Indonesia was being classified as a member of a group of highly select countries destined to become the newly industrialized economies largely because of its outward-looking policies. Although Indonesia started its structural reforms in the early 1970s, the real reforms started with the massive depreciation in November 1978. Our empirical model is, therefore, designed to examine the relationship among the exchange rate, price level and output from that point of time. We use a similar empirical model that we developed in Chapter Five\(^75\) to examine this relationship. Our structural VAR consists of five macroeconomic series: Gross domestic product (GDP), the nominal exchange rate (ER), money supply (M), consumer price index (CPI) and United States Treasury Bond rate (USTB) as a foreign interest rate. All the variables are in log form except USTB. Quarterly data from October 1978 to December 2001 are used for estimation purposes. The quarterly GDP data is unavailable for Indonesia and we, therefore, derived this from annual data using the method popularized by Lisman and Sandee (1964).\(^76\) Our data are sourced from IFS CD-ROM, September, 2002.

\(^75\) Which, in fact, is developed on the basis of our theoretical framework in Chapter Four.

\(^76\) Lisman, J. H. C., and Sandee, J., (1964), "Derivation of Quarterly Figures from Annual Data", Applied Statistics, 13, pp 87-90. This is a purely mathematical method in which coefficients used in increasing the frequency are constant.
The issue to be investigated in this chapter is whether there exist(s) a stable and predictable long-run relationship(s) among the exchange rate, price level, money and output. Moreover, specific issues under investigation are: (i) the money and PPP relationships for Indonesia within 'natural rate' aggregate supply model developed in Chapter Four (ii) long-run monetary neutrality (iii) the nature of "short-run" dynamics for all the endogenous variables in the model and (iv) forecasting performance of the VECM model of exchange rate, price level, output and money.

The appropriate specification of the relationship between long-run theory and the short-run dynamics has dominated much of time series research in recent years and represents the principal response to the collapse of many of the aggregate macro-economic relationships in the 1970s (Davidson et al. 1978). Thus, the econometrics of dynamic specification led to important revisions to the modeling of macro-economic relationships including money demand functions (Engle and Granger, 1987; Johansen and Juselius, 1990). However, in most cases this macro relationship establishes the link between money demand and exchange rate (see, for example, Saunders (2002), Arango and Naidiri (1981), Olekalns (1996), Marashdeh (1993, 1997) and Boschen and Mills (1995), Bahmani-Oskooee and Malixi (1991), and Sanchez-Fung (2002) but not within a model of aggregate demand and supply. Except Olekalns (1996), Marashdeh (1993) and Boschen and Mills (1995), none of the above mentioned studies addresses the money and monetary neutrality from an open economy point of view like Indonesia.
We develop four potential equilibrium relationships for Indonesia similar to Chapter Five equations (5.5) to (5.9), along with one equation for the exogenous variable USTB.

\[
\begin{align*}
\text{LGDP} &= a_{10} + a_{12}\text{LER} + a_{13}\text{LCPI} + a_{14}\text{LM} + a_{15}\text{USTB} + u_{\text{gdp}} \\
\text{LER} &= a_{20} + a_{21}\text{LGDP} + a_{23}\text{LCPI} + a_{24}\text{LM} + a_{25}\text{USTB} + u_{\text{er}} \\
\text{LCPI} &= a_{30} + a_{31}\text{LER} + a_{32}\text{LGDP} + a_{34}\text{LM} + a_{35}\text{USTB} + u_{\text{cpi}} \\
\text{LM} &= a_{40} + a_{41}\text{LER} + a_{42}\text{LCPI} + a_{43}\text{LGDP} + a_{45}\text{USTB} + u_{\text{lm}} \\
\text{USTB} &= a_{50} + u_{\text{ustb}}
\end{align*}
\]

The above relationships can be written in matrix notations (similar to the matrix developed for Malaysia in Chapter Five) as \( X_t = A x_t + a_0 + u_t \) where \( x_t = [\text{LGDP, LER, LCPI, LM, USTB}] \), \( A \) is a matrix of coefficients, \( a_0 = [a_{10}, a_{20}, a_{30}, a_{40}, a_{50}] \) and consists of intercept terms. The vector of structural shocks \( u_t = [u_{\text{gdp}}, u_{\text{er}}, u_{\text{cpi}}, u_{\text{lm}}, u_{\text{ustb}}] \) contains the contemporaneous response of the variables to disturbances or innovations. Specifically, \( u_{\text{gdp}} \) represents a domestic output shock, \( u_{\text{er}} \) represents an exchange rate shock, \( u_{\text{cpi}} \) domestic price level shock, \( u_{\text{lm}} \) is domestic money supply shock and \( u_{\text{ustb}} \) is a foreign interest shock.

In our SVAR, identified above and in Chapter Five, we are seeking to construct an open economy macro model for Indonesia, formulated equations (6.1) to (6.5) that integrate long-run properties with short-run dynamics based on the theories of cointegration and error-correction. Our error correction specification is similar to equation (5.10) in Chapter
Five except that we include LGDP instead of LIP for the output equation and the $DZ_i$ includes three seasonal dummies such as SC1, SC2 and SC3 to overcome seasonality effects and three dummy variables D83, D86, D97. D83 dummy stands for the massive devaluation (38%) in 1983 and D86 dummy is also for devaluation (45%) but comes after new policies to recover from the oil price drop. D97 is the dummy for the Asian financial crisis.

6. 4 Time Series Properties

6.4.1 Unit Root Tests

As we are using time-series data, it is important to check the time-series properties of the data. The first step is testing for unit roots in the data for which we use the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests which are discussed in the Methodology Chapter (Chapter Three). All the variables (except USTB) are in logarithmic form. The graphs of all the original series are shown in the Appendix 6.1. The unit root tests results are reported in Table 6.2. The tests are applied to both ‘levels’ and the ‘first differences’ of all the series. The results show that in the ‘levels’ all of the series are non-stationary i.e I (1). But series are stationary after ‘first differences’ and are significant at 5 per cent level. Since the ADF tests are sensitive to the lag length on the augmentation term, we choose a lag based on information criteria such as AIC, SBC etc.
Table 6.2: DF and ADF tests Results

**Series in Levels**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test Statistic with intercept</th>
<th>Lag Length</th>
<th>Test Statistic with intercept + Trend</th>
<th>Lag Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGDP</td>
<td>-2.21</td>
<td>6</td>
<td>-1.37</td>
<td>8</td>
</tr>
<tr>
<td>LER</td>
<td>-0.61</td>
<td>6</td>
<td>-2.36</td>
<td>2</td>
</tr>
<tr>
<td>LCPI</td>
<td>0.05</td>
<td>3</td>
<td>-1.74</td>
<td>5</td>
</tr>
<tr>
<td>LM</td>
<td>-0.95</td>
<td>0</td>
<td>-2.49</td>
<td>0</td>
</tr>
<tr>
<td>USTB</td>
<td>-1.46</td>
<td>4</td>
<td>-2.59</td>
<td>1</td>
</tr>
</tbody>
</table>

**Series in first Differences**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test Statistic with intercept</th>
<th>Lag Length</th>
<th>Test Statistic with intercept + Trend</th>
<th>Lag Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLGDP</td>
<td>-6.75</td>
<td>1</td>
<td>-7.33</td>
<td>1</td>
</tr>
<tr>
<td>DLER</td>
<td>-6.96</td>
<td>2</td>
<td>-5.57</td>
<td>5</td>
</tr>
<tr>
<td>DLCPI</td>
<td>-4.90</td>
<td>4</td>
<td>-4.88</td>
<td>4</td>
</tr>
<tr>
<td>DLM</td>
<td>-10.58</td>
<td>0</td>
<td>-10.56</td>
<td>0</td>
</tr>
<tr>
<td>DUSTB</td>
<td>-8.48</td>
<td>0</td>
<td>-8.53</td>
<td>0</td>
</tr>
</tbody>
</table>

95% critical value for the ADF statistic is −2.8967 for a regression including an intercept but not a trend. When the regression includes an intercept and a trend then the value is −3.4645.

### 6.4.2 Lag determination

The second step in our SVAR for Indonesia is to choose an appropriate lag to be used in the model. We use appropriate selection criteria (AIC, SBC etc.) to choose the lag lengths.
But selection criteria may not always be able to choose the optimum lag lengths. In that case, it is important to check the residuals of the individual equations in the VAR for possible serial correlation. Starting with lag length 10, Table 6.3 suggests that LR chooses lag lengths 4, while AIC and SBC choose lag lengths 9 and 2 respectively. Since we have 93 observations which is not a very long time-series and to avoid over-parameterization we choose lag length 6.

Table 6.3

Test statistic and choice criteria for selecting the order of the VAR model

<table>
<thead>
<tr>
<th>Lag</th>
<th>LR</th>
<th>$\chi^2$ (16)</th>
<th>Lag</th>
<th>AIC</th>
<th>SBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:9</td>
<td>12.10</td>
<td>[.733]</td>
<td>10</td>
<td>893.28</td>
<td>650.15</td>
</tr>
<tr>
<td>9:8</td>
<td>32.31</td>
<td>[.451]</td>
<td>9</td>
<td>896.77</td>
<td>673.90</td>
</tr>
<tr>
<td>8:7</td>
<td>57.84</td>
<td>[.156]</td>
<td>8</td>
<td>891.89</td>
<td>689.29</td>
</tr>
<tr>
<td>7:6</td>
<td>79.29</td>
<td>[.094]</td>
<td>7</td>
<td>881.51</td>
<td>699.16</td>
</tr>
<tr>
<td>6:5</td>
<td>90.42</td>
<td>[.200]</td>
<td>6</td>
<td>875.35</td>
<td>713.26</td>
</tr>
<tr>
<td>5:4</td>
<td>113.06</td>
<td>[.113]</td>
<td>5</td>
<td>879.84</td>
<td>738.01</td>
</tr>
<tr>
<td>4:3</td>
<td>142.36</td>
<td>[.028]</td>
<td>4</td>
<td>872.45</td>
<td>750.89</td>
</tr>
<tr>
<td>3:2</td>
<td>184.06</td>
<td>[.001]</td>
<td>3</td>
<td>858.17</td>
<td>756.87</td>
</tr>
<tr>
<td>2:1</td>
<td>250.46</td>
<td>[.000]</td>
<td>2</td>
<td>831.09</td>
<td>750.04</td>
</tr>
</tbody>
</table>

Notes: LR statistics are calculated by Sims' (1980) modified likelihood ratio test statistics for the null hypothesis that a lower lag VAR is an acceptable restriction on a higher order system (e.g. $H_0$: the 8-lag VAR is as good as 9-lag VAR system). The figures in the square brackets are the $p$-values which indicate the probability of finding a $\chi^2$ value greater than or equal to a calculated $\chi^2$ statistic under the null hypothesis. A $p$-value $> 0.05$ does not reject the null hypothesis at 5% level of significance. AIC & SBC select the lag which has highest value. All the estimation in this table was conducted using MICROFIT 4.0 program of Pesaran and Pesaran (1997).

For quarterly data, 6 lags are long enough both to capture the dynamic relationships and to eliminate autocorrelation problem. To confirm that lag length 6 is acceptable in terms
of residual whiteness, serial correlation tests are carried out using lag length 6. The results (not reported here) suggest that lag length 6 is not a problem in the present application.

6.4.3 Cointegration

The ADF tests confirm that there exists no unit roots in the first differences in the series. This implies all variables in the model are I(1). The next step is to test whether the variables are cointegrated as we are interested in long-run relationships among variables. Our defined vector is $X_t = [LM, LER, LGDP, LCPI, USTB]$ where the first four variables are endogenous and USTB is structurally exogenous in the sense that there exists no long-run (short-run as well) feedback of USTB in the equations explaining $X_t$. Models of this type are quite effective in empirical macroeconomic analysis for a small developing open economy like Indonesia where, for any macroeconomic modeling, foreign price, foreign interest and foreign income can often be treated as exogenous I(1) variables. The cointegration tests are carried out using Johansen’s (1988) and Johansen and Juselius’s (1990) Maximum Likelihood procedure. The main benefits of this procedure have been described in Chapters Three and Five.

The results obtained from the cointegration test indicate that there exists a single cointegrating vector (Table 6.4). The results are significant at the 5% for the Eigenvalue and at 10% for the Trace test. Model selection criteria AIC and SBC also support (not reported) the finding of one cointegrating vector.
Table 6.4
Johansen Cointegration Tests

1978Q4 to 2001Q4 (93 observations). Cointegration with unrestricted intercepts and no trends in 6 lag VAR. Variables included in the cointegrating VAR are LM, LGDP, LER, LCPI, one I(1) exogenous variables are USTB and Three dummies such as D83, D86, D97 & three seasonal dummies SC1, SC2 & SC3.

<table>
<thead>
<tr>
<th>Null</th>
<th>Alternative</th>
<th>Statistic</th>
<th>95% Critical value</th>
<th>90% Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A. Maximum Eigenvalue Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r = 0</td>
<td>r = 1</td>
<td>31.57</td>
<td>30.71</td>
<td>28.27</td>
</tr>
<tr>
<td>r &lt;= 1</td>
<td>r = 2</td>
<td>18.57</td>
<td>24.59</td>
<td>22.15</td>
</tr>
<tr>
<td>r &lt;= 2</td>
<td>r = 3</td>
<td>5.80</td>
<td>18.06</td>
<td>15.98</td>
</tr>
<tr>
<td>r &lt;= 3</td>
<td>r = 4</td>
<td>1.37</td>
<td>11.47</td>
<td>9.53</td>
</tr>
<tr>
<td></td>
<td>B. Trace Tests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r = 0</td>
<td>r &gt;= 1</td>
<td>57.33</td>
<td>58.63</td>
<td>54.84</td>
</tr>
<tr>
<td>r &lt;= 0</td>
<td>r &gt;= 2</td>
<td>25.75</td>
<td>38.93.44</td>
<td>35.88</td>
</tr>
<tr>
<td>r &lt;= 2</td>
<td>r &gt;= 3</td>
<td>7.18</td>
<td>23.32</td>
<td>20.75</td>
</tr>
<tr>
<td>r &lt;= 3</td>
<td>r = 4</td>
<td>1.37</td>
<td>11.47</td>
<td>9.53</td>
</tr>
<tr>
<td></td>
<td>C. Standarized Eigenvectors $\beta$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM</td>
<td>LGDP</td>
<td>LER</td>
<td>LCPI</td>
<td>USTB</td>
</tr>
<tr>
<td>1.00</td>
<td>-1.32</td>
<td>-0.19</td>
<td>-0.91</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.09)</td>
<td>(0.18)</td>
<td>(.007)</td>
</tr>
</tbody>
</table>

Note: (i) $r$ represents the number of cointegrating vectors. The one cointegrating vector is normalized on LM. Standard errors are in brackets. All the above estimation was done by Microfit 4.0.

(ii) There are two reasons for choosing unrestricted intercepts and no trends. First: although the underlying variables are trended, they move together, and it seems unlikely that there will be trend in the cointegrating relationships among the variables (see Pesaran and Pesaran, p. 293). Second: Allowing an intercept term in VAR model implies that we allow variables in levels to grow (i.e non-stationary). The VAR intercept may be linked to a) a linear deterministic trend in the levels, or b) a unit root in the levels variables. Because we tested our variables for unit roots and found all the variables in 'levels' are I(0), we don't want a linear trend in cointegration equation.
The eigenvalue associated with the first vector is certainly dominant over those corresponding to other vectors, thereby further confirming that there exists one cointegrating vector in the model. Having confirmed the existence of a single cointegrating vector, we present matrix $\beta'$ in panel c of Table 6.4. The row of matrix $\beta'$ corresponds to the standardized coefficients of the variables entering into the respective cointegrating vector. The coefficients are normalized with a value of one along the principal diagonal of the matrix. For example, the first row corresponds to the money in which LM is normalized as one. It can be written as an equilibrium form as follows:

$$LM -1.32LGD - 0.19LER - 0.91LCPI - 0.03USTB = 0$$

(6.6)

Equation (6.6) represents the long-run relationship among money supply (LM), gross domestic output (LGD), exchange rate (LER), price level (LCPI) and foreign interest rate (USTB). Equation 6.6 can also be interpreted as the long-run relationship of equation (4.24) of Chapter Four. The signs on the variables involved in the cointegrating relationship are extremely important and need to be carefully analyzed.

In the equilibrium relationship above, equation (6.6), signs of the estimated coefficients are in accordance with what intuition would suggest. In the long-run, an upward movement in money supply is generally expected to be associated with an upward movement in output as well as depreciation and an increase in the price level. It is plausible to interpret the coefficient on LGDP as the income elasticity of demand for money. The long-run income elasticity is 1.32 indicating that a 1% increase in income will increase money demand by 1.32 per cent. The findings of long-run income elasticity and price elasticity are consistent with the findings of Chowdhury (1997) for M2
estimation for Thailand. His finding for income elasticity is 1.29 and price elasticity is .89. However, his results derived from an open economy money demand where both versions of money are used. These findings are also supported by the study of Aresties and Demetriades (1991) for Cyprus, Marashdeh (1997), Ibrahim (2001) and Sriram (1999) for Malaysia. As mentioned earlier in Chapter Five, finding a large income elasticity is not uncommon in a developing country context. 77 This certainly reflects Indonesia’s increased coordination of economic activity during our study period. Our findings are inconsistent with Saunders (2002) for the US economy who reported an income elasticity significantly less than unity (0.16) for the US economy. This difference could be, mainly due to the characteristics of the economy i.e. Saunders studied a developed economy. The coefficient on the exchange rate indicates that increases in the money supply are associated with depreciation in Indonesia during our study period. Saunders estimated of exchange rate coefficient is different from the findings of this study for Malaysia (1.06) and Thailand (0.76). This study finding is consistent with the finding of Chowdhury (1997) for Thailand (0.21 for M2 and 0.19 M1). Our results indicate that in the long-run, the monetary policy of Indonesia did not target exchange rate rather focus has been on maintaining domestic price stability, allowing the effect of the exchange rate to flow through the economy. 78 This is contrary to the view of Siregar (1999) whose results suggest that authority played an active role in maintaining stable rupiah value from 1987 to 1995. Like Malaysia, Indonesia also pursued open economy policies during our study period although there were frequent government interventions in the economy. Accordingly, we expected a significant role for the foreign interest rate in the macro

77 See Blejer et al., (1991)
78 See Grenville (2000) for a detailed discussion
economy of Indonesia. But the coefficient of USTB indicates that the role of USTB in the movement of money is very small. This is inconsistent with the finding of Chowdhury (1997) for Thailand. The fundamental difference between Chowdhury’s finding and ours is the definition of foreign interest rate. He used Euro dollar rate and this study uses US treasury bill rate.

Finally, we formulate two hypotheses about long-run monetary neutrality\(^7\) on equation (4.24) in Chapter Four. In our equilibrium relationship (6.6), we use the following two restrictions:

1. \(a_1 = - a_3\)
2. \(a_1 = - a_4\)

where \(a_1, a_3\) and \(a_4\) are the coefficients of LM, LCPI and LER respectively. The restriction results are in Table 6.5. The log-likelihood test does not reject the first restriction but does reject the second restriction implying the presence of monetary neutrality\(^8\) in the long-run only with respect to the price level but not the nominal exchange rate. This test result may be explained, in part, by the fact that we are not controlling the foreign price level. This is consistent with a number of empirical studies on developed economics such as Saunders (2002) and Boschen and Mill (1995) for the US economy, and Olekalns (1996) for the Australian economy. Moreover empirical studies such as King and Watson (1995) and Fisher and Seater (1993) support our finding. Of course these studies are not on Indonesia. Our finding is inconsistent with the finding of Marashdeh (1993) for Malaysia. He used both anticipated and unanticipated money to

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\(^7\) A formal definition of the long-run neutrality of money is that permanent, exogenous changes to the level of money supply will have no effect on the level of real output in the long-run.

\(^8\) Only with respect to the price level but not the nominal exchange rate.
test the long-run monetary neutrality proposition for the period 1970-1990 and found unanticipated money has a real effect in the long-run.

Table 6.5

Restrictions on cointegrating Vector

<table>
<thead>
<tr>
<th>When</th>
<th>Imposed restriction on cointegrating vectors (in normalized value)</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_1 = - a_3$</td>
<td></td>
<td>$a_1 = - a_4$</td>
</tr>
<tr>
<td>LM</td>
<td>-1.00</td>
<td>-1.00</td>
</tr>
<tr>
<td>LGDP</td>
<td>1.23</td>
<td>2.60</td>
</tr>
<tr>
<td>LCPI</td>
<td>1.00</td>
<td>-.62</td>
</tr>
<tr>
<td>LER</td>
<td>.14</td>
<td>1.00</td>
</tr>
<tr>
<td>USTB</td>
<td>.03</td>
<td>.07</td>
</tr>
<tr>
<td>LR: $\chi^2(1)$</td>
<td>.26[.60]</td>
<td>10.23[.00]</td>
</tr>
</tbody>
</table>

$LR$ is log-likelihood ratio tests. $P$ values are in the brackets.

As argued earlier in Chapter Five, the results of monetary neutrality could indicate the possibility of "bottlenecks" in the Indonesian economy during our study period which was also a period of high economic growth. This monetary neutrality may not be the result of subsistence real wage (Dasgupta, 1985) as argued in Chapter Four. Manning's (1997) study on Indonesian wages found that there has been real wage growth in a range of agricultural and non-agricultural sectors.\(^{81}\) World Bank (1993b, p. 263) data also put Indonesia ahead of Malaysia and Singapore in terms of growth of average earnings over

---

\(^{81}\) Although real wages and labour income increased rapidly, there were also slower, uneven and periodic reversals of trends in unskilled wage rates indicating that Indonesia is still a labour surplus economy.
the period 1970-1990. The non-rejection of the second restriction implies that monetary tightening would reduce both inflation and the real exchange rate and hence should have positive real effects through net exports.

6.4.4 Weak-exogeneity Tests

In the previous section, we established the long-run equilibrium relationships among the variables. The next step is to examine the short-run dynamic relationships among the variables. In order to carry this out, it is important for us to perform weak-exogeneity tests. In our case, the weak-exogeneity test is carried out under the assumption of rank $r = 1$ as we have found one cointegration relationship. The testing of weak-exogeneity means testing zero restrictions on the $\alpha$ matrix. Table 6.6 below presents the weak-exogeneity test results.

---

82 This is now widely recognized as a crucial concept for applied economic modeling. The issue of weak exogeneity tests in a linear Vector Error Correction model (VECM) has been previously discussed by Jahanssen (1992), Ericsson et al (1998), Hec et al (2000), Hendry and Mizon (1993) and Rault (2001).
Table 6.6

Weak-exogeneity test

<table>
<thead>
<tr>
<th>Variables</th>
<th>LCPI</th>
<th>LGDP</th>
<th>LM</th>
<th>LER</th>
<th>USTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_1 = 0$</td>
<td>$\chi^2(1) = 7.41 [.006]$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_2 = 0$</td>
<td>$\chi^2(1) = 11.39[0.001]$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_3 = 0$</td>
<td>$\chi^2(1) = 13.00[.000]$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_4 = 0$</td>
<td>$\chi^2(1) = 3.97[.046]$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_5 = 0$</td>
<td>$\chi^2(1) = 12.99[.000]$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The log-likelihood ratio statistic is used for testing each restriction separately. $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ are the representatives of LCPI, LGDP, LM, LER, USTB respectively. All the restrictions are statistically significant. All the estimations were done by Microfit 4.0 by Pesaran and Pesaran (1997).

The null hypothesis of the existence of weak exogeneity is rejected for all variables. Therefore, a short-run model can be designed with a system of equations starting with LGDP equation.

6.5 Short-run Dynamic Specification: The Error-Correction Models

The final stage in the model building process requires the construction of error-correction models. This involves regressing the first difference of each variable in the cointegration equations onto lagged values of the first differences of all of the variables plus the lagged
value of the error-correction terms (that is, the error term) plus dummy variables if any. One of the important issues in the ECM modeling is to choose the lag lengths to be used in the error-correction models.\textsuperscript{83} As one lag of a difference term equals second lag of the level, the number of lags in the short-run models will be one less than that applied in the cointegration tests.

Our ECM equations are based on four equations set out as equation (6.1) to (6.4) for the output, price level, exchange rate and money supply (policy reaction) equations discussed in section 6.3. Theoretical derivation of the above equations is extensively discussed in Chapter Four.

**Short-run Error correction Models**

Our short-run error correction model contains four equations. The first differences of LGDP, LCPI, LER and LM are each functions of distributed lags of first differences of LGDP, LCPI, LER and LM as well as USTB. Each EC equation also includes the once-lagged error-correction term.\textsuperscript{84}

The results of the error-correction model are divided into two subsections; the first subsection analyses the unrestricted error correction model while the second subsection is

\textsuperscript{83} There are many techniques to determine the lag structure of the error-correction models. Among them, FPE criteria (see Akaike, 1973), Hendry's general to specific modeling strategy (see Gilbert, 1986) and the general strategy based on the nature and number of observations (see Pesaran and Pesaran, 1997).

\textsuperscript{84} More than one lag of error-correction term is unnecessary. The effects of additional lagged error-correction terms are already captured in the distributed lags of the first differences of LGDP, LCPI, LER and LM.
on the parsimonious model. As discussed earlier in Chapter Five, the parsimonious form is derived using the *general-to specific* approach developed by Hendry (1993).

### 6.5.1 Unrestricted Models

Table 6.7 below presents the unrestricted ECM estimation results. We are using an error-correction equation similar to equation (5.10) in Chapter Five. We have four equations in our ECM model: ΔLGDP represents the output equation, ΔLCPI represents the price level equation, ΔLER represents the exchange rate equation, ΔLM represents the monetary policy reaction function for Indonesia. Each variable on the right hand side (including USTB) has five lags to match the lag lengths of six in the cointegration analysis discussed earlier. The right hand side also includes an error-correction term which indicates the speed of convergence to equilibrium. Each equation also includes three seasonal dummies as data used here are seasonally unadjusted and the D83, D86 and D97 dummies are for two large devaluations and the Asian financial crisis respectively.
Table 6.7

Empirical Estimates of the ECMs for LGDP, LCPI, LER, LM andUSTB relationships

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>ΔLGDP</th>
<th>ΔLCPI</th>
<th>ΔLER</th>
<th>ΔLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-.02[-2.43]**</td>
<td>-.07[-1.89]*</td>
<td>.81[2.91]***</td>
<td>.10[.934]</td>
</tr>
<tr>
<td>ΔLGDPt_{-1}</td>
<td>1.42[11.11]***</td>
<td>-.99[-1.65]</td>
<td>-8.06[-2.94]***</td>
<td>-15[-.901]</td>
</tr>
<tr>
<td>ΔLGDPt_{-2}</td>
<td>-1.31[-5.81]***</td>
<td>.21[.206]</td>
<td>2.26[.464]</td>
<td>-3.65[-1.24]</td>
</tr>
<tr>
<td>ΔLGDPt_{-3}</td>
<td>.86[3.37]</td>
<td>-.02[-.023]</td>
<td>3.85[.700]</td>
<td>5.84[1.74]*</td>
</tr>
<tr>
<td>ΔLGDPt_{-4}</td>
<td>-.54[-2.46]**</td>
<td>.45[.437]</td>
<td>-1.50[-3.11]</td>
<td>-2.76[-.957]</td>
</tr>
<tr>
<td>ΔLGDPt_{-5}</td>
<td>.11[0.98]</td>
<td>-.27[-.49]</td>
<td>-.23[-.091]</td>
<td>.53[.342]</td>
</tr>
<tr>
<td>ΔLCPI_{t-1}</td>
<td>.08[2.59]**</td>
<td>-.045[-.304]</td>
<td>-1.08[-1.56]</td>
<td>-.46[-1.12]</td>
</tr>
<tr>
<td>ΔLCPI_{t-2}</td>
<td>.02[0.81]</td>
<td>.022[.146]</td>
<td>1.02[1.38]</td>
<td>.15[.351]</td>
</tr>
<tr>
<td>ΔLCPI_{t-3}</td>
<td>.005[.016]</td>
<td>-.13[-.87]</td>
<td>-1.24[1.68]*</td>
<td>.009[.021]</td>
</tr>
<tr>
<td>ΔLCPI_{t-4}</td>
<td>.05[1.65]*</td>
<td>.08[.53]</td>
<td>-.33[-.468]</td>
<td>.16[.386]</td>
</tr>
<tr>
<td>ΔLCPI_{t-5}</td>
<td>.02[0.10]</td>
<td>.01[.076]</td>
<td>-.22[-.385]</td>
<td>.06[.185]</td>
</tr>
<tr>
<td>ΔLER_{t-1}</td>
<td>.003[.49]</td>
<td>.005[.163]</td>
<td>-.32[-2.18]**</td>
<td>.07[.787]</td>
</tr>
<tr>
<td>ΔLER_{t-2}</td>
<td>-.009[1.02]</td>
<td>.072[1.95]*</td>
<td>-.17[-.996]</td>
<td>-.06[-.623]</td>
</tr>
<tr>
<td>ΔLER_{t-3}</td>
<td>.012[1.72]*</td>
<td>.05[.53]</td>
<td>-.09[-.58]</td>
<td>-.07[-.813]</td>
</tr>
<tr>
<td>ΔLER_{t-4}</td>
<td>-.014[-2.05]**</td>
<td>.04[.128]</td>
<td>.289[1.92]</td>
<td>.06[.72]</td>
</tr>
<tr>
<td>ΔLER_{t-5}</td>
<td>-.02[-3.45]***</td>
<td>.020[.756]</td>
<td>.14[1.13]</td>
<td>-.03[-.42]</td>
</tr>
<tr>
<td>ΔLMt_{-1}</td>
<td>-.013[-1.20]</td>
<td>.09[1.80]*</td>
<td>.28[1.05]</td>
<td>-.09[-.65]</td>
</tr>
<tr>
<td>ΔLMt_{-2}</td>
<td>.015[1.39]</td>
<td>.03[.69]</td>
<td>-.40[-1.65]*</td>
<td>.05[.40]</td>
</tr>
<tr>
<td>ΔLMt_{-3}</td>
<td>-.001[-1.58]</td>
<td>.004[.09]</td>
<td>-.19[-.84]</td>
<td>.08[.63]</td>
</tr>
<tr>
<td>ΔLMt_{-4}</td>
<td>-.027[-2.64]***</td>
<td>.07[1.53]</td>
<td>.02[.106]</td>
<td>.19[1.42]</td>
</tr>
<tr>
<td>ΔLMt_{-5}</td>
<td>-.003[-0.34]</td>
<td>.014[.287]</td>
<td>-.13[-.57]</td>
<td>-.16[-1.17]</td>
</tr>
<tr>
<td>ΔUSTB_{t-1}</td>
<td>.001[2.58]**</td>
<td>.001[.479]</td>
<td>.04[.034]***</td>
<td>.005[.694]</td>
</tr>
<tr>
<td>ΔUSTB_{t-2}</td>
<td>.00[.46]</td>
<td>.003[.121]</td>
<td>.02[1.98]**</td>
<td>.01[.144]</td>
</tr>
<tr>
<td>ΔUSTB_{t-3}</td>
<td>.00[.59]</td>
<td>.003[.208]</td>
<td>.03[2.08]**</td>
<td>.008[1.09]</td>
</tr>
<tr>
<td>ΔUSTB_{t-4}</td>
<td>-.00[-.38]</td>
<td>.001[.455]</td>
<td>-.009[-.073]</td>
<td>.01[.147]</td>
</tr>
<tr>
<td>ΔUSTB_{t-5}</td>
<td>.00[1.56]</td>
<td>.000[.31]</td>
<td>.01[.765]</td>
<td>.000[.010]</td>
</tr>
<tr>
<td>ECM_{t-1}</td>
<td>-.009[-2.83]***</td>
<td>-.036[-2.22]**</td>
<td>-.52[-2.57]**</td>
<td>.02[.484]</td>
</tr>
<tr>
<td>D38</td>
<td>-.001[-.54]</td>
<td>.033[2.13]**</td>
<td>.20[2.82]**</td>
<td>.02[.66]</td>
</tr>
<tr>
<td>D86</td>
<td>-.00[-.59]</td>
<td>.03[-.33]</td>
<td>.09[2.13]**</td>
<td>.01[.453]</td>
</tr>
<tr>
<td>D97</td>
<td>-.02[-8.03]***</td>
<td>.017[1.21]</td>
<td>.21[3.35]***</td>
<td>.02[.657]</td>
</tr>
<tr>
<td>SC1</td>
<td>-.00[-.09]</td>
<td>.006[1.77]*</td>
<td>.00[.099]</td>
<td>-.006[-.586]</td>
</tr>
<tr>
<td>SC2</td>
<td>-.001[-1.33]</td>
<td>.000[.16]</td>
<td>.02[1.27]</td>
<td>.007[.755]</td>
</tr>
<tr>
<td>SC3</td>
<td>.00[.76]</td>
<td>-.002[-.68]</td>
<td>-.03[-1.97]**</td>
<td>-.013[-1.31]</td>
</tr>
<tr>
<td>R²</td>
<td>.96</td>
<td>.82</td>
<td>.74</td>
<td>.51</td>
</tr>
<tr>
<td>D-W</td>
<td>2.32</td>
<td>1.99</td>
<td>2.20</td>
<td>2.09</td>
</tr>
<tr>
<td>Serial corr: $\chi^2(4)$</td>
<td>8.90 (.064)</td>
<td>2.91 (.572)</td>
<td>10.54 (.032)</td>
<td>9.79 (.044)</td>
</tr>
<tr>
<td>Functional Form: $\chi^{2}(1)$</td>
<td>13.43(.000)</td>
<td>24.29(.00)</td>
<td>21.58(.000)</td>
<td>.140(.708)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>Normality: $\chi^{2}(2)$</td>
<td>134.73(.000)</td>
<td>.016(.992)</td>
<td>1.52(.467)</td>
<td>.49(.78)</td>
</tr>
<tr>
<td>Heteroscedasticity: $\chi^{2}(1)$</td>
<td>.064 (.800)</td>
<td>4.92 (.027)</td>
<td>13.29(.000)</td>
<td>.12(.72)</td>
</tr>
</tbody>
</table>

Notes
1. t-values are in square brackets.
2. *** significant at the 1% level.
3. ** significant at 5% level.
4. * significant at 10% level.
5. The p-values are in rounded brackets.

- The estimated ECM for output results indicate that the intercept, $\Delta LGDP_{t-1}$, $\Delta LGDP_{t-2}$, $\Delta LGDP_{t-4}$, $\Delta LCPI_{t-1}$, $\Delta LCPI_{t-4}$, $\Delta LER_{t-3}$, $\Delta LER_{t-4}$, $\Delta LER_{t-5}$, $\Delta LM_{t-4}$, $\Delta USTB_{t-1}$ are significant but the signs of some of the coefficients are unexpected. The ECM term is found significant at the 1 per cent level. The coefficient is negative with a value close to zero indicating it will take a long time to converge to equilibrium once the market is disturbed. Among the dummies, D97 is found significant. This ECM equation is not free from econometric problems.

- In the case of the price level equation, the intercept, $\Delta LGDP_{t-4}$, $\Delta LER_{t-2}$, $\Delta LM_{t-1}$, $\Delta USTB_{t-2}$ are found significant with expected signs. The coefficient of the ECM term is negative and significant. Among the dummy variables, D83 and SC1 are found significant. The price level equation is free from serial correlation and normality problems but not free from heteroscedasticity problems.

- The exchange rate equation results in unrestricted ECM show that the intercept and $\Delta LGDP_{t-1}$, $\Delta LCPI_{t-3}$, $\Delta LCPI_{t-4}$, $\Delta LER_{t-1}$, $\Delta LM_{t-2}$, $\Delta USTB_{t-1}$, $\Delta USTB_{t-2}$, $\Delta USTB_{t-3}$ are found significant but many of them have unexpected signs especially $\Delta LGDP_{t-1}$. When income goes up one would expect depreciation
(positive change in exchange rate in this case) but estimated results show that the reverse happens. There could be many explanations for this but in this case we argue that too much government intervention in the economy and particularly in the exchange rate market may have led this to unexpected sign. The ECM term is negative and significant at the 5 percent level indicating adjustment towards long-run equilibrium is possible once it is shocked. Among the dummy variables SC3, D83, D86 and D97 are found significant.

- In the case of the monetary policy reaction function in unrestricted ECM form, the estimated results show that $\Delta LGDP_{t-3}$ is significant and correctly signed. All other variables including the ECM terms and dummies were found insignificant. Surprisingly, this equation is free from all econometric problems.

Since our unrestricted ECM results do not provide us with expected results we examine parsimonious regressions. There are number of ways we can do that: (a) we progressively eliminate the variables from the equations which are least significant in the unrestricted ECM, (b) we eliminates the variables which have incorrect signs in the unrestricted ECM (c) we can use a combination of (a) and (b). Our estimation strategy for the parsimonious ECM will be (c).
6.5.2 Parsimonious Models

Table 6.8 below reports the estimation results based on parsimonious ECM models using the same lag lengths as in the unrestricted model. Several interesting observations emerge from the findings.

Table 6.8

Parsimonious representations of Error correction Models

Empirical Estimates of the ECMs for LGDP, LCPI, LER, LM and USTB relationships

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>ΔLGDP</th>
<th>ΔLCPI^H</th>
<th>ΔLER^H</th>
<th>ΔLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.39[4.73]***</td>
<td>.39[4.73]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLGDP_t-1</td>
<td>1.45[15.33]***</td>
<td>-.83[-3.38]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLGDP_t-2</td>
<td>-.13[-8.50]***</td>
<td>-.29[-3.51]**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLGDP_t-3</td>
<td>.88[5.37]***</td>
<td>4.71[4.51]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLGDP_t-4</td>
<td>.38[4.28]***</td>
<td>.58[2.88]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLCPI_t-1</td>
<td>.06[3.02]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLCPI_t-2</td>
<td>.63[2.36]**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLCPI_t-3</td>
<td>-1.70[-3.11]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLER_t-1</td>
<td>-1.62[-1.62]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLER_t-2</td>
<td>.08[3.36]***</td>
<td>-.20[-3.75]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLER_t-3</td>
<td>.01[3.89]***</td>
<td>.02[1.14]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLER_t-4</td>
<td>.03[2.83]***</td>
<td>.38[3.48]***</td>
<td>.09[1.78]***</td>
<td></td>
</tr>
<tr>
<td>ΔLER_t-5</td>
<td>-.01[-2.77]***</td>
<td>.02[1.68]***</td>
<td>.24[2.29]***</td>
<td></td>
</tr>
<tr>
<td>ΔLM_t-1</td>
<td>.10[2.91]***</td>
<td>.60[2.88]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLM_t-2</td>
<td>.02[2.97]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLM_t-3</td>
<td>.02[3.58]***</td>
<td>.07[2.27]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLM_t-4</td>
<td>-.18[-1.95]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLM_t-5</td>
<td>.00[2.23]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔUSTB_t-1</td>
<td>.01[2.85]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔUSTB_t-2</td>
<td>.01[3.32]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔUSTB_t-3</td>
<td>.00[3.17]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔUSTB_t-4</td>
<td>-.02[-1.92]***</td>
<td>.01[2.22]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM_t-1</td>
<td>-.001[-3.34]***</td>
<td>-.005[-2.67]***</td>
<td>-.03[-1.87]***</td>
<td>-.26[-4.08]***</td>
</tr>
<tr>
<td>D83</td>
<td>.03[3.41]***</td>
<td>.21[3.25]***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D86</td>
<td>.08[1.68]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D97</td>
<td>-.02[8.04]***</td>
<td>.025[2.36]***</td>
<td>.33[6.40]***</td>
<td>.04[1.93]***</td>
</tr>
<tr>
<td>SC1</td>
<td>.007[2.97]***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC3</td>
<td>-.02[-1.79]*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>.94</td>
<td>.79</td>
<td>.52</td>
<td>.516</td>
</tr>
<tr>
<td>D-W</td>
<td>2.19</td>
<td>2.01</td>
<td>2.15</td>
<td>1.74</td>
</tr>
<tr>
<td>Serial corr: $\chi^2(4)$</td>
<td>5.19(.268)</td>
<td>.23(.994)</td>
<td>4.18(.381)</td>
<td>4.15(.386)</td>
</tr>
<tr>
<td>Functional Form: $\chi^2(1)$</td>
<td>10.02(.002)</td>
<td>19.36(.000)</td>
<td>29.41(.000)</td>
<td>5.80(.10)</td>
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<tr>
<td>Normality: $\chi^2(2)$</td>
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<td>.80(.668)</td>
<td>129.633(.000)</td>
<td>.55(.75)</td>
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<td>Heteroscedasticity: $\chi^2(1)$</td>
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<td>H adjusted</td>
<td>H adjusted</td>
<td>1.10(.293)</td>
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</tbody>
</table>

Notes
1. t-values are in square brackets.
2. *** significant at the 1% level.
3. ** significant at 5% level.
4. * significant at 10% level.
5. The p-values are in rounded brackets.
6. H is White's Heteroscedasticity adjusted S.E's

First, for the output equation, the expected sign of the coefficient of the ECM term is negative and significant although the coefficient value is very small (close to zero). This indicates that the Indonesian goods market will take a longer time to return to equilibrium once it is shocked. The Asian financial crisis dummy, D97 is found significant at 1 percent level indicating its negative impact on the output of Indonesia. The coefficients of $\Delta LGDP_{t-1}$, $\Delta LGDP_{t-2}$, $\Delta LGDP_{t-3}$, $\Delta LGDP_{t-4}$, $\Delta LCPI_{t-1}$, $\Delta LER_{t-3}$, $\Delta LER_{t-5}$, $\Delta LM_{t-2}$, $\Delta LM_{t-4}$ are significant and of expected sign except $\Delta LER_{t-5}$, which is negative. But the sum of the exchange rate coefficients is positive indicating depreciation has a positive effect on Indonesian domestic output. This is unlike the results reported in Upadhyaya and Upadhyaya (1999) for six Asian countries. In a first difference form of estimation, the results indicate that devaluation has both positive and negative effects on output over
any length of time. Any effect on output identified comes from the relative price change (the ratio of foreign to domestic prices). The money supply coefficients indicate that an increase in the money supply will have positive effects on output. This is consistent with Upadhyaya and Upadhyaya (1999) for Malaysia. Our findings are partially consistent with the findings of Marashdeh (1993), Tan and Cheng (1995), Tan and Baharumshah (1999) and Masih and Masih (1996) for Malaysia. These studies examined output-monetary policy linkages for Malaysia and concluded that money does have a real effect in the short-run. However, the focus of these studies was only on the causal effects of monetary policy on real aggregate fluctuations. Although Indonesia was pursuing open economic policies during our study period, the foreign interest rate plays almost no role in the movements of domestic output. This model is free from major econometric problems such as serial-correlation, non-normality and heterocedasticity.

Second, for the price level equation, the coefficient of the ECM term is negative and significant at the 1 per cent level. But the coefficient is very small (.005) indicating a long period of time is needed to restore equilibrium in prices once disturbed. The dummy variables D83, D97 are significant implying that the large 1983 devaluation and the Asian financial crisis had inflationary impacts on the price level of Indonesia. The coefficients on $\Delta LGDP_{t-1}$, $\Delta LGDP_{t-4}$, $\Delta LER_{t-2}$, $\Delta LER_{t-4}$, $\Delta LER_{t-5}$, $\Delta LM_{t-1}$, $\Delta LM_{t-4}$, $\Delta USTB_{t-3}$, are significant and have expected signs except that on $\Delta LGDP_{t-1}$, which is negative. The negative sign on $\Delta LGDP$ implies that when income growth goes up inflation goes down initially which is inconsistent with most theoretical and empirical findings. But for

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85 See for example Alamsyah et al.(2001). They argued that during periods of economic upswings, rising aggregate demand is accompanied by both increased foreign borrowing and the liquidation of SBI (central
Indonesia this is not surprising because, as we have already discussed in section 6.2, the government implemented policies to control the price level at times of high economic growth. The signs of other coefficients imply that depreciations, increases in the money supply, increases in the rate of change in GDP (after four lags) all have positive impacts on the price level of Indonesia. This is consistent with the findings of McLeod (1997) for Indonesia. McLeod identified the growth rate of base money above money demand was the main reason for chronic inflation in Indonesia since 1972. Our finding of depreciation and price level relationship is supported by the findings of Siregar (1999) for Indonesia, Alba and Papell (1998) for three ASEAN countries and, Rittenberg (1993) for Turkey. Siregar shows that exchange rate policy which targets a faster rate of depreciation of rupiah contributes to a higher inflation rate. The results also indicate that the foreign interest rate plays almost no role in movements of the Indonesian price level which is consistent with our findings for Malaysia.

Third, for the exchange rate equation, the coefficient of the ECM term is found negative (-.03) and significant at the 10 per cent level. This indicates that the speed of adjustment of the foreign exchange market towards long-run equilibrium is about 3% per quarter. The dummies D83, D86, D97 and one seasonal dummy SC1 are found significant. The coefficient of ΔLGDP in the third period is significant and of the expected sign implying an increase in income in the short run will have positive effects on the exchange rate of Indonesia i.e. depreciation. The coefficient on ΔLCPI is significant but the sign is very much unexpected as it opposes the findings of Alba and Papell (1998) for three ASEAN
countries and Bahmani-Oskooee, Malixi (1992) for Philippines and Rana and Dowling (1985) for Singapore. However, this is consistent with the finding of Rana and Dowling (1985) for Malaysia. Additionally, this is not unusual as Indonesia was under constant government intervention during our study period. After almost all major devaluations, the Indonesian economy was experiencing rising inflation and interest rate. The pressure from the rising inflation rate was suppressed by the government’s policy to run a ‘budget surplus’ or to narrow the ‘budget deficit, its policy to subsidize prices of state-vended products\text{\textsuperscript{86}} and to adopt a more vigorous trade liberalization program.\text{\textsuperscript{87}} The money supply coefficient is significant and the sign is expected. This is inconsistent with the findings of Grenville (2000, p. 49) who noted “From both intuition and experience, it was clear that a very high interest rate would be needed to offset, in a mechanical way, the short-term expectation of a depreciation. If the issue was one of confidence in policy and signalling, then a short sharp shock of higher interest rates might do the job of shifting expectations.” The foreign interest rate coefficient is significant with an unexpected sign indicating that higher foreign interest rates encourage appreciation which is inconsistent with the theoretical open economy model. However, this uncommon finding could be explained in Granville’s (2000, p. 51) terms. His observation on capital outflow during the financial crisis is, “...the rupiah denominated deposit of residents - did they flee the country? The evidence suggests quite strongly that this did not happen to any great extent. While rupiah denominated deposits certainly shifted from private banks to state

\textsuperscript{86} Include staple foods (such as rice, sugar, wheat flour), building materials (such as Portland cement), energy (such as electricity and Petroleum products) and services (such as transportation fares and school tuition fees)

banks (for confidence reasons), they did not fall during the second half of 1997 and rose quite sharply in the first half of 1998.” Moreover he observed that “Curiously, ... foreign currency denominated deposits rose quite sharply in rupiah terms- by around $10 billion between the middle of 1997 and mid 1998.” This ECM model is free from serial correlation and the heteroscedasticity problem is overcome by taking White’s heteroscedasticity adjusted standard errors.

Finally, for the monetary policy reaction function, the coefficient of the ECM term is negative and significant. The coefficient of the EC term indicates that about 2.6% of the previous disequilibrium in the money market is corrected every quarter suggesting that the money market in Indonesia may have remained in disequilibrium for a long period. Among the dummy variables, only the Asian crisis dummy D97 is found significant. An increase in output generally increases money demand which may increase the interest rate. Authority uses expansionary monetary policy to stop rising interest rates. This is consistent with the findings of Affandi (2004) for Indonesia. He found that when BI had a choice between output and inflation, the monetary authority put more weight on inflation, arising from higher interest rates. This is also consistent with our findings for Malaysia, Marashdeh (1993) and Tan and Cheng (1995) for Malaysia. The coefficients for the exchange rate are largely negative indicating strong government intervention at the time of devaluation. As the Indonesian government was very much concerned about inflation, a devaluation (an increase in the exchange rate) was usually followed by an active contractionary monetary policy.88 This finding is consistent with the number of studies.

For example, the IMF (1999, p. 78) noted that “Although no targets were announced for exchange rates, the exchange rate was the central focus of monetary policy, and the interest rates the operating target... the exchange rate was the best available guide to policy, as no other nominal variable was immediately observed.” Implementing contractionary monetary policy (higher interest rate) at the time of depreciation does not necessarily stabilize the domestic currency.89 This is the primary reason for the negative exchange rate coefficients in our policy reaction function. The positive relation between the price level and money is inconsistent with number of studies such as Affandi (2004) and Mcleod (1997). Affandi identified three factors that contribute to the Indonesian price level. These are: (i) the response by monetary authority to expected inflation; (ii) the depreciation rate; and (iii) the long run real interest rate. To reduce inflation, BI should take the above three factors into consideration. On the other hand, Mcleod (1997) argued that price stability depends on controlling base money which is clearly not the case here. This is probably consistent with the view of Goodhart (1994) who thinks that believing Central Bank can control the monetary base ‘is totally mistaken.’ He argued that commercial banks cannot control depositors demand for cash withdrawals, which, in practice are seasonal and unpredictable. Given this scenario in cash flows, Central Banks’ attempt to fix base money on any day are bound to cause residual for the commercial banks’ reserve, either excessive or deficient. All the coefficients of the foreign interest rate except one are significant and the signs are not unexpected. A rise in the US interest rates (which might be expected to have a global contractionary effect) was generally met by domestic monetary expansion. This indicates that the Indonesian monetary authority used sterilization policy in the short-run during our study period. Our findings of


6.5.3 Stability Tests

We examine the stability of the coefficients by applying the CUSUM and CUSUMSQ proposed by Brown et al. (1975). The tests are applied to the residuals of all four EC models in table 6.6. Figures 6.1, 6.2, 6.3 and 6.4 are graphical representations of the CUSUM and CUSUMSQ plots applied to the error-correction models. All the graphs indicate no evidence of any significant structural instability.
Figure 6.1  CUSUM and CUSUMSQ test for Coefficient Stability: Output Equation

Plot of Cumulative Sum of Recursive Residuals (DLGDP)

The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals (DLGDP)

The straight lines represent critical bounds at 5% significance level
Figure 6.2 CUSUM and CUSUMSQ test for Coefficient Stability: Price level Equation

Plot of Cumulative Sum of Recursive Residuals (DLCPI)

The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals (DLCPI)

The straight lines represent critical bounds at 5% significance level
Figure 6.3 CUSUM and CUSUMSQ test for Coefficient Stability: Exchange rate Equation.

Plot of Cumulative Sum of Recursive Residuals (DLER)

The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals (DLER)

The straight lines represent critical bounds at 5% significance level
Figure 6.4 CUSUM and CUSUMSQ test for Coefficient Stability: Monetary Policy Reaction Function

Plot of Cumulative Sum of Recursive Residuals (DLM)

The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals (DLM)

The straight lines represent critical bounds at 5% significance level
6.6 Conclusion

In this chapter we applied the theoretical framework outlined in Chapter Four using Indonesian data. Structural cointegrating VAR with an error-correction approach is used to analyze the relationship among Indonesian macro variables of output, the price level, exchange rate, money supply and a foreign interest rate (USTB) which in this case is assumed an exogenous variable. Cointegration estimates the long-run relationships among the variables for a developing open economy like Indonesia and the error-correction models outline the short-run dynamics of the determinants of the long-run variables.

The cointegration test results indicate the presence of one cointegrating vector which is largely (though not wholly) consistent with equilibrium in a ‘natural rate’ model of aggregate supply with IS/LM underpinning aggregate demand.

Cointegration analysis in equation (6.6) suggests that money has a long-run relationship with GDP, the price level, the nominal exchange rate and the foreign interest rate. All the signs of the coefficients are expected and significant. Moreover, these findings offer some new evidence of “Monetary Neutrality” for Indonesia indicating that, in the long-run money supply increases increase the price level in roughly the same proportion. As argued earlier in Chapter Five, the results of monetary neutrality could indicate the possibility of “bottlenecks” in the Indonesian economy during our study period which was also a period of high economic growth.
The error correction results for the output equation provide evidence that in the goods market, it will take a longer period to return to long-run equilibrium once it is shocked. The signs of most of the coefficients are expected and significant. Depreciation has positive effects on output only in the later periods (after 3 and 4 lags) while money supply growth has positive effects after two and four lags. Price level has positive effects on output only in initial quarter. Asian crisis has strong impacts on output.

In the price level equation, the ECM results provide evidence that like the goods market, this market will also take a long time to reach long-run equilibrium if it is disturbed. The ECM results suggest a negative relationship between output and price level which is inconsistent with most of the findings (see for example Alamsyah et al. (2001)). The relationship between money supply, the exchange rate and price level are positive in the short-run. The Asian crisis has significant impact on the price level.

In the exchange rate equation, the EC term is found negative and significant indicating that the speed of adjustment in the foreign exchange market towards long-run equilibrium is about 3% per quarter. In the short-run, an increase in income will have positive impact on depreciation only after third lag. The unexpected sign of the price level coefficient may be explained by government intervention to control inflation when devaluation occurs. The money supply has positive impact on depreciation of Indonesia. The foreign interest rate has negative impact on exchange rate only after forth quarter which is inconsistent with open-economy models. All the dummy variables are found significant
indicating policy changes in 1983, 1986 and Asian crisis all have positive impact on depreciation.

Finally, estimated results for the policy reaction function suggest that about 2.6% of the previous disequilibrium in the money market is corrected every quarter. The relationship between output and money is positive indicating expansionary monetary policy when there is a growth. The negative exchange rate coefficients indicate the presence of a strong monetary authority intervention at times of devaluation. Also monetary authorities used expansionary monetary policy at the time of high US interest rates (foreign interest rate) indicating short-run use of sterilization policy. The relationship between USTB and money supply suggests that Indonesian monetary policy reaction function should include USTB as one of its determinants.

The important implications of the long-run and short-run findings are as follows: (i) Changes in monetary and exchange rate policies will take time to affect output in the short-run. However, the price level effect of monetary policy is positive both in the short-run and long-run implying the existence of long-run monetary neutrality. As argued in Chapters Four and Five, this neutrality may not be the result of rational expectations but could be the result of ‘bottlenecks’ in the Indonesian economy. In the short-run, output has a positive effect on depreciation but negative effects on price level which indicates that authorities should not worry about price level at a time of high economic growth.
Appendix 6.1

Indonesian Data Series

Nominal Exchange Rate (in log)

Gross Domestic Product
Chapter Seven

Empirical Study for Thailand

7.1 Introduction

The behavior of major macro variables in a small open economy like Thailand has received increasing attention in recent years. Among the various types of studies, two are particularly important. The first strand of studies examines economic growth in an open economy and the second strand of studies focuses on open economy policies and their effects on major macro variables. Thailand, as we discuss in the following section, undertook various monetary, fiscal and exchange policy reforms during the years 1980-2000 to integrate with the world economy. As a result of these policies, the financial sector of the economy experienced liberalization. The government removed most of the controls on the exchange rate, capital flows, interest rate and bond and equity markets. Despite this huge development, it is still similar to many developing countries: it is dominated by a relatively small number of domestic banks, has limited availability of financial instruments for both borrowers and depositors, has a thin capital market and most importantly it suffers from frequent government intervention. Despite the changes, the money market is still small relative to the size of the banking sector.90 All these

90 Reasons for this small money market are: (i) The Thai government stopped treasury bills in 1989 because of central government budget surplus at that time and (ii) transferable commercial bank deposit certificates declined significantly after 1987 due to higher interest rate that commercial banks can offer on fixed deposits.
changes in the domestic economy may have certain effects on major macro variables such as exchange rate, price level, output and money.

In Chapter Four, we outlined a theoretical framework among the mentioned macro variables. But previous empirical studies on this have provided different conclusions concerning the short-run and long run relationships. Most of the studies derived open economy money demand function e.g. Gupta (1990) and Chowdhury (1997). Gupta’s (1990) study which is on eleven Asian countries including Thailand, emphasized the mechanism of nominal versus real adjustment in money demand. Chowdhury (1997) examined the long run money demand function using Johansen and Johansen and Juselius (1990) cointegration method and found stable long run relationships among money and number of macro variables. There are few studies such as De Brouwer (2003), Mcleod (2003) and Tanner (2001) which emphasized monetary policy issues. Tanner examined how monetary policy affects exchange market pressure for six Asian and Latin American countries. Tan and Baharumshah (1999) empirically tested the dynamic causal chain among money, real output, an interest rate and inflation for Malaysia using Johansen multivariate cointegration analysis.

The major problems with the previous studies are that most studies have misspecification problems, specially omitting some important variables such as the exchange rate and the foreign interest rate. Thailand has pursued open economy policies since the 1980s. Therefore it is important to include the exchange rate and foreign interest rate variables that have an influence on major macro variables.
Most of the past studies on money in Thailand implicitly assume the existence of an underlying equilibrium relationship among money and related explanatory variables. So if the implicit assumptions were false then estimates will be incorrect and inconsistent. So the primary aim of this chapter is to determine (i) whether an equilibrium relationship exists between certain combinations of money, output, the price level and foreign sector variables and (ii) then determine the short-run dynamics among the variables. The cointegration test procedures developed by Johansen (1988) and Johansen and Juselius (1990) are used for testing this relationship. The objectives are similar to those of the previous two chapters.

The remainder of the chapter is as follows. Section 7.2 provides a brief discussion of the Thai economy since 1980. Section 7.3 sets up an empirical model for Thailand. Section 7.4 discusses the time-series properties of the data and most importantly the cointegration results. Section 7.5 discusses the error-correction model results both unrestricted and parsimonious. Stability tests are also conducted. Section 7.6 contains the conclusions of this chapter.
7.2 The Thai Economy

Thailand once known as ‘the dark horse’\textsuperscript{91} of ASEAN has increasingly integrated with the regional and world economy since the mid-1980s. Thailand’s average annual growth was in excess of 8 percent throughout the 1960s, more than 7 percent during the 1970s and approximately 5 percent in the first half of the 1980s. In per capita terms, GNP annual growth was 4.5 percent during the period 1960-82 (Mackie, 1985). Such growth has brought fundamental changes to the structure of the Thai economy which may have contributed to a per capita growth rate of GDP of 4.7 percent per annum during 1970-2000. Thailand’s recent economic development can be divided into two distinct phases. The first period is from 1981-1995 and can be described as a period of rapid economic growth and the second phase from 1996-2000, a period of economic slowdown.

7.2.1 First period: 1981-95

In the early 1980s, Thailand experienced a number of economic problems as a result of the 1979-80 oil-price shocks and the subsequent collapse of non-oil commodity prices and, to a certain extent, domestic over spending. Moreover, there was a serious current account deficit which was 7 percent of GDP. However, the economy grew at an impressive rate in the late 1980s and the early 1990s. As is evident from Table 7.1, the Thai economy grew on average 5 per cent per annum during 1981-86. In the 1987-1995

\textsuperscript{91} See Bowring (1982). The term basically indicates that even though Thailand’s potential but tended to be underrated because of its high and sustained rates of economic growth since the early 1960s were overshadowed by the more spectacular growth rates achieved by newly industrialized countries such as Singapore, South Korea, Hong Kong and Taiwan.
period, the economy grew at a rate of 10.5 percent per annum which was very impressive and led Thailand to be classified as one of the fastest growing economies in the world. There were several factors behind this impressive economic growth:

First: In the 1970s, the Thai government took decisions to switch from import-substitution policies to export-oriented policies but the significant effect of this change did not occur till the second half of the 1980s.92

Thailand became one of the main beneficiaries in the initial period after the Plaza Accord as Japanese production plants set up in Thailand to produce for export, taking advantage of cheap labour. This increased Thailand exports, which grew by 29 per cent per annum in volume terms.93

Second: there was the surge in investment94 especially foreign direct investment (FDI) in the export-oriented manufacturing sector95. Much of the foreign direct investment from Japan was directed to labour intensive and relatively low-skilled manufacturing industries. Significantly, the export structure was changed during that period. Rice which was the major export of Thailand in 1988 has been replaced by manufactured goods.

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92 Following the Plaza Accord in 1985 which forced the Japanese authorities to appreciate the Japanese Yen against US dollar. As a effect, Japanese big firms moved production facilities to outside Japan.
94 Investment as a proportion of GDP grew from 32.6 per cent in 1988 to 41.6 per cent in 1995 (see Chareonwongsak , (1999)
93 Robinson et al. (1991), p 10
Table 7.1
Basic Economic Data for Thailand

<table>
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<tr>
<th>Year</th>
<th>GDP growth (annual %)</th>
<th>GDP per capita growth (annual %)</th>
<th>Consumer prices (annual %)</th>
<th>Exchange Rate: Thai Bhat/US $</th>
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Third: another important factor that contributed to the rapid economic growth was the activity and expansion of the financial sector. The government undertook several liberalization policies to develop the financial sector. These were: removal of exchange controls, liberalization of capital flows, freeing interest rates and development of both equity and bond markets. As a result of these policies, the financial sector which formed only 4 percent in 1988 grew to 8 percent of the economy by 1995. Market capitalization of the stock exchange in Thailand rose from US $ 2.9 billion in 1986 to US $ 141.5 billion in 1995, with the number of listed companies increasing from 98 to 416.\textsuperscript{96}

Finally: Bank loans played a vital role in increasing domestic investment. The Central Bank was relaxed about commercial Bank lending policies. Bank loans grew from 529.5 billion Baht\textsuperscript{97} in 1985 to 4558.4 billion Bhat in 1996.\textsuperscript{98} Loans to real estate business were remarkable and increased to 414.1 billion from 19.4 billion Bhat.

By the end of 1990, the Thailand economy faced infrastructural bottlenecks and shortage of skilled manpower both of which emerged as constraints to further economic expansion. Moreover, a large increase in foreign capital inflows increased balance of payments surpluses and resulted in accelerated growth of the money supply. Thus there was inflationary pressure as well as deterioration of the current account.\textsuperscript{99} But policy makers were very much concerned about emerging problems and took necessary measures in the late 1990s to reduce excess liquidity and dampen credit demand. These policies reduced

\textsuperscript{96} Chareonwongsak, K. (1999)
\textsuperscript{97} Thailand Currency.
\textsuperscript{98} Bank of Thailand, Various Annual Economic Reports from 1987-1996.
inflation from the peak of 6 percent in 1990 to around 3.5 percent in 1993. But it rose again in 1994 to 5 percent.

In the fiscal area, the situation also improved. The public sector deficit of 5 percent in 1984-85 was eliminated by 1987-88 and turned into a surplus by 1989-90. Domestic savings increased despite a decline in private savings. However, national savings still fell short of the investment needed to sustain growth of the economy. The current account deficit in 1994 was 20 percent higher than in the previous year.\textsuperscript{100} This deficit was not a problem because foreign investment inflows continued to surpass the deficit, but continuing sterilization of balance of payments surplus remained problematic given the limited availability of monetary instruments.\textsuperscript{101}

During the period 1981-1995, the government implemented various price control measures to control prices, production and sales volumes of domestic goods to prevent inflation and shortages after the devaluations of the baht especially after the 1984 devaluation.\textsuperscript{102} The Thailand government used price ceilings on most basic necessities such as gasoline, liquefied petroleum gas (LPG), fuel oil, kerosene and basic food items. As evident from Table 7.1, the prices were relatively stable with inflation under 5 percent throughout the period.

As for monetary policy, the Thai authorities brought domestic interest rates in line with world rates. As well as adjusting monetary conditions, the Bank of Thailand (BOT)

\textsuperscript{100} Bank of Thailand Annual Economic Report 1995.
reduced the bank rate down three times from 11 to 8 percent. The primary objective was to ensure financial stability, greater flexibility and to lower the commercial bank interest rates on loans. The latter move eased pressure on companies seeking loans for working capital and encouraged price stability. Officially BOT used ‘direct credit control and moral suasion’ as important monetary policy tools which were introduced in 1987 and remained in place until the first half of 1997. Despite the BOT credit control tools, commercial banks were exposed to competition and focused on their market-share of the product i.e bank loan. Therefore, the competition among banks and between banks and other financial institutions fueled excessive growth in aggregate credit.

In the case of exchange rate policy, Thailand maintained a fixed exchange rate in the early 1980s but moved to a crawling-peg exchange rate system against a basket of currencies in 1984. The authority did not disclose the basket to prevent speculative attacks. However, the nominal exchange rate tracks the US dollar closely. The Thai Bhat was devalued twice against the US dollar in 1981 first by 1.1 percent in May and 8.7 percent in July. This devaluation helped improve Thailand’s external balance but the improvement was short-lived due to the prolonged strength of the US dollar. In 1984, Thai Bhat was once again devalued by 14.8 percent shortly after the credit control scheme was revamped. In 1994, the Bhat appreciated against the US dollar by about 2 percent and depreciated against the Yen and Deutsche Mark by approximately 10 percent.

104 Official documents of Bank of Thailand states that it has “occasionally” restored to direct control and moral suasion as monetary tools. In fact, the measures were not “occasional” but regular and indeed the most important features of monetary policy. (see Werner, R.A., 1999).
The Thai economy during 1981-1995 managed to perform well with appropriate government policies and given certain favourable external situations. Thailand also managed to nurture much confidence in its economy which was essential for Foreign Direct Investment (FDI) and continued economic growth. However, the impressive growth started to slow down at the beginning of 1996 due to some unexpected factors.

7.2.2 Slowdown to crisis: 1996-2000

Export growth slowing from an impressive 23.6 percent in 1995 to 2 percent in 1996 was the first sign that alarmed Thai authorities. This slowdown in exports reflected declining competitiveness in certain sectors of the Thai economy, particularly the export sectors that were facing competition from other low cost emerging countries. There was a huge discussion about the slowdown of Thai exports at the beginning of 1996. One of the explanations by Phongpaicht and Baker\textsuperscript{106} (2000) was:

"Economic theory says that a country cannot have both an open capital account and fixed exchange rate without losing control over monetary policy. But the Thai monetary authorities had come to believe that a fixed exchange rate (roughly tied with US dollar) made Thailand attractively "stable" for foreign investors and trading partners. So they resisted the advice to relax control of the exchange rate. Then they struggled to manage the impact of this unprecedented flood of money."

The economy quickly became distorted. The capital inflows stoked inflation. Because the exchange rate remained fixed, the baht became overvalued, Thai products became less competitive in international markets and exports declined. At the same time, the flood of money boosted consumption, indicating consumption of imports, so the balance of trade slumped into deficit.

From 1996 onward, the Government recognized that the economy was heating up, fueled by credit expansion, and that the current account deficit was widening due to poor performance of the export sector which slowed down the economy. The growth rate fell

from 9.31 percent in 1995 to 5.88 percent in 1996. The economic crisis which began in 1997 led to the floating of exchange rate for the baht in July 1997. The causes of the Thai economic crisis have been extensively discussed (Phongpaichit and Baker 2000; Ammar and Orapin 1998; Chandrasekhar and Ghosh 1998; Hewison 2000, Lauridsen 1998; Phatra Research Institute 1997) and cover the following main points.

First: Rapid export-oriented industrialization funded by a large capital inflow of foreign direct investment created large structural problems (mentioned before) for the Thai economy which undermined export competitiveness. Moreover, the large capital inflows led to a version of “Dutch disease”- a rise in the price of non-traded goods (especially real estate) relative to traded goods, causing a misallocation of resources and real appreciation of the currency to the detriment of the export economy.\(^\text{107}\)

Second: Financial liberalization particularly deregulation of interest rates and capital account convertibility in 1991-93 brought a massive capital inflow into the Thai economy.\(^\text{108}\) This led to a rise in Gross Domestic Investment to above 40 percent of GDP,\(^\text{109}\) more than the economy could absorb. Moreover, in the absence of proper Government or Central Bank policy towards these inflows, a large proportion of the inflows went to both equity and bond markets raising market capitalization of the stock

\(^{107}\text{Warr, P., (1998)}\)

\(^{108}\text{Stiglitz and Weiss (1981) explained this situation as excess-demand disequilibrium in the credit market. If excess demand for credit cannot be met by domestic loans, but foreign-currency-denominated loans are easily available, then borrowers are likely to avail themselves of the latter. Since BOT guaranteed the continuation of the fixed exchange rate, firms perceived currency risk to be low or nil. In as much as interest rates on US-dollar loans were lower, they had incentive to avail themselves of US-dollar loans.}\)

exchange from US $2.9 billion in 1986 to US $141.5 billion in 1995 with the number of listed companies increasing more than four times, from 98 to 416.\textsuperscript{110}

Third: At the beginning of 1996, investors' confidence in Thailand made a sharp turnaround. The strong growth in Thailand during 1986-95 had been aided by strong capital inflows. As long as confidence remained high, these sources of funds could continue to finance the current account deficit and allow for continued growth. But an increasing current account deficit (which was 8 percent of GDP in 1996) worried investors about the future of the Thai economy. So they either slowed down investment or gradually withdrew money from the Thai economy.

Fourth: The economic slowdown also caused banks to reduce lending activities. By the end of 1997, the loan portfolio of the banks deteriorated in quality very quickly. The general slowdown of industrial activity meant that banks had to struggle in terms of non-performing loans, affecting their profitability. Reduction of the bank loans eventually contributed to the contraction of GDP growth.

Above are the most basic reasons for the slowdown of Thai economy in 1996 which ended up in a crisis. There are many different schools of thought, and variations in the weight given to each of the above factors and implications derived from them. But the general view of the crisis is not in serious dispute.

\textsuperscript{110} Chareonwongsak, K. (1999), p.4
7.2.3 Economic situation after the crisis: 1998-2000

After the crisis in 1997, the Thai economy contracted by 10 percent in 1998 but had positive GDP growth rates in 1999 and 2000. The 1998 contraction came from a decrease in domestic spending, both consumption and investment, by both the private and public sectors.\textsuperscript{111} The current account balance\textsuperscript{112} and inflation improved significantly and, most importantly, the pressure of exchange rate depreciation on inflation eased reducing inflation from 10.7 in June 1998 to 4.3 per cent in the last month of the year.\textsuperscript{113}

In 1999, the Thai economy recorded an expansion of 4.2 percent showing an overall improvement in economic performance. The inflation fell to at 0.31 percent per annum despite pressure from a rising oil price. Although the nominal interest rate declined, the real interest rate remained high. The external sector showed improvement with a surplus in the current account so the balance of payments.\textsuperscript{114} As for money supply, M1 grew 30.1 percent at the end of 1999 compared with 3.0 percent at the end of 1998. At the same time, M2 grew by 2.1 percent compared to 9.5 percent in 1998.\textsuperscript{115} The exchange rate was relatively stable.

\textsuperscript{112} Though the trade balance registered a surplus of US $12.2 billion, it was mainly due to the declining rate of import value which was cheaper than the export value. On the other hand, exports showed no significant signs of recovery, since the comparative advantage of the depreciation of the Thai baht was negated by the depreciation of the currencies of Thailand's neighbouring trade competitors, like Malaysia, Indonesia and South Korea. In addition, the major trade partners, such as Japan and ASEAN also faced economic recession declining demand for foreign goods in those countries.
\textsuperscript{114} Due to export expansion and an increase in FDI as well as capital inflow to the public sector. (Annual Economic Report, 1999)
\textsuperscript{115} Bank of Thailand, Annual Economic Report, 1999
In 2000, the economy was still recovering with a growth rate of 4.33 percent slightly better than 1999 growth but inflation had increased to 1.55 percent from 0.31 percent per annum. The current account surplus decreased compared with 1999. Exports expanded by 19.6 percent while imports grew by 31.1 percent. The Thai exchange rate had depreciated slightly in 2000. But major macro economic indicators showed improvement compared with the previous years in the post-crisis period.

Although after the crisis there are signs of economic recovery, analysts say that there are still vast problems plaguing key sectors of the economy for which no simple solutions are in sight. In this context Boonthan Sakanond(1999)\(^\text{116}\) noted "There has been no fundamental rethinking of the direction of national economic policies. And despite some minor measures, the country still remains vulnerable to the speculative flows of global capital that brought it down two years ago."

7.3 Empirical Model and Data

In section 7.2, we briefly discussed how, after 1980 Thailand integrated with the world economy gradually by implementing open economy policies. But open economy policies were not complete until 1984 when the Thai authority introduced a crawling-peg exchange rate system. Since 1980, especially from 1984 the Thai government introduced various monetary, exchange rate and fiscal policies targeting high economic growth, low inflation and economic stability. Keeping all this information in the background, we

developed our empirical model on Thailand. The theoretical basis of this empirical model was discussed extensively in Chapter Four. Our structural VAR model consists of five macroeconomic time series for Thailand. These are: Gross domestic Product (GDP), the nominal exchange rate (ER), the aggregate money supply (M), the consumer price index (CPI) and United States Treasury Bond rate (USTB) as foreign interest rate. All the values are in log form except USTB. Quarterly data from 1984Q4 to 2001Q4 are used for estimation purpose. In Thailand, the GDP data is available on an annual basis. This series is interpolated using Lisman and Sandee’s (1964)\textsuperscript{117} method to generate the quarterly series. All data are sourced from IFS CD-ROM, September 2002.

In the following section (7.4), the cointegration results indicate one long-run equilibrium relationships between exchange rate, the price level, output and money. Our estimation of equilibrium relationships for a small open economy like Thailand contains at least three features that separate it from earlier studies on Thailand. Firstly, it is derived from Structural VAR system. Secondly, we are able to test long-run monetary neutrality. Thirdly, by employing cointegration and error-correction techniques, we are able identify short-run and long-run relationships which were absent in most of the previous studies e.g. Upadhyaya and Upadhyaya(1999).

In the following SVAR system, there are four potential equilibrium relationships (equation 7.1 to 7.4) that were developed theoretically in Chapter Four and empirically in

Chapter Five. In addition we have one equation (equation 7.5) for the exogenous variable USTB.

\[
\text{LGDP} = a_{10} + a_{12}\text{LER} + a_{13}\text{LCPI} + a_{14}\text{LM} + a_{15}\text{USTB} + u_{gdp} 
\]  
(7.1)

\[
\text{LER} = a_{20} + a_{24}\text{LGDP} + a_{23}\text{LCPI} + a_{24}\text{LM} + a_{25}\text{USTB} + u_{er} 
\]  
(7.2)

\[
\text{LCPI} = a_{30} + a_{31}\text{LER} + a_{32}\text{LCPI} + a_{34}\text{LM} + a_{35}\text{USTB} + u_{cpi} 
\]  
(7.3)

\[
\text{LM} = a_{40} + a_{41}\text{LER} + a_{42}\text{LCPI} + a_{43}\text{LGDP} + a_{45}\text{USTB} + u_{lm} 
\]  
(7.4)

\[
\text{USTB} = a_{50} + u_{ustb} 
\]  
(7.5)

The above relationships can be written in matrix notations similar to that in Chapter Five as \( x_t = A x_t + a_0 + u_t \) where \( x_t = [\text{LGDP}, \text{LER}, \text{LCPI}, \text{LM}, \text{USTB}]' \), \( A \) is a matrix of coefficients, \( a_0 = [a_{10}, a_{20}, a_{30}, a_{40}, a_{50}]' \) and consists of intercept terms. The vector of structural shocks \( u_t = [u_{gdp}, u_{er}, u_{cpi}, u_{lm}, u_{ustb}]' \) contains the contemporaneous response of the variables to the disturbances or innovations. Specifically \( u_{gdp} \) represents a domestic output shock, \( u_{er} \) represents an exchange rate shock, \( u_{cpi} \) a domestic price level shock, \( u_{lm} \) is a domestic money supply shock and \( u_{ustb} \) is a foreign interest shock.

The final stage in the empirical set up is the construction of error-correction models. The error-correction specification is similar to that of equation (5.10) in Chapter Five with a replacement of LIP by LGDP for the output equation. As usual \( DZ_t \) consists of three seasonal dummies, SC1, SC2, SC3 and one Asian crisis dummy D97.
7.4 Time Series Properties

7.4.1 Unit Root Tests

Since we are using time-series data, the first step is to determine the order of integration of each variable. To determine the order of integration of variables we employ the Dickey-Fuller and Augmented (ADF) tests which are extensively discussed in Chapter Three. All variables in this case are in log form (except USTB). The graphs of all the series are shown in the Appendix 7.1. The unit root test results are reported in Table 7.2. The tests are applied to both 'levels' and 'first-difference' of all series. The test results indicate that all variables are non-stationary in their levels and stationarity is achieved after first differencing i.e. all variables are I(1).

7.4.2 Lag determination

The second step in our SVAR for Thailand is to choose the appropriate lag to be used in the model. Appropriate information criteria (such as SBC and AIC) and likelihood ratio (LR) statistics are used to determine optimum lag lengths.
Table 7.2

DF and ADF tests Results

Series in Levels

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test Statistic with intercept</th>
<th>Lag Length</th>
<th>Test Statistic with intercept + Trend</th>
<th>Lag Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGDP</td>
<td>-1.77</td>
<td>6</td>
<td>-.105</td>
<td>8</td>
</tr>
<tr>
<td>LER</td>
<td>-0.14</td>
<td>3</td>
<td>-1.24</td>
<td>3</td>
</tr>
<tr>
<td>LCPI</td>
<td>-0.03</td>
<td>1</td>
<td>-2.52</td>
<td>2</td>
</tr>
<tr>
<td>LM</td>
<td>-0.32</td>
<td>7</td>
<td>-2.99</td>
<td>5</td>
</tr>
<tr>
<td>USTB</td>
<td>-1.63</td>
<td>8</td>
<td>-2.80</td>
<td>8</td>
</tr>
</tbody>
</table>

Series in first Differences

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test Statistic with intercept</th>
<th>Lag Length</th>
<th>Test Statistic with intercept + Trend</th>
<th>Lag Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLGDP</td>
<td>-3.94</td>
<td>1</td>
<td>-4.58</td>
<td>1</td>
</tr>
<tr>
<td>DLER</td>
<td>-4.27</td>
<td>3</td>
<td>-6.14</td>
<td>2</td>
</tr>
<tr>
<td>DLCPI</td>
<td>-3.71</td>
<td>1</td>
<td>-5.44</td>
<td>0</td>
</tr>
<tr>
<td>DLM</td>
<td>-3.46</td>
<td>5</td>
<td>-3.68</td>
<td>6</td>
</tr>
<tr>
<td>DUSTB</td>
<td>-3.11</td>
<td>5</td>
<td>-4.46</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: 95% critical value for the ADF statistic is -2.9017 for a regression which includes an intercept but not a trend. But when the regression includes a intercept and a trend then the value is -3.4721. All variables except USTB are in logs. The Unit root tests reported above were conducted using MICROFIT 4.0 of Pesaran and Pesaran (1997).
Table 7.3 presents results of the lag-length tests. Starting with lag length of 10, LR and SBC chooses lag-length 4 while AIC chooses lag-length 10. Since we have 69 observations and Thailand’s policy changes occurred in our study period, it is appropriate to choose an intermediate lag-length such as 7 to capture the dynamics of the VAR system.

Table 7.3

Test statistic and choice criteria for selecting the order of the VAR model

<table>
<thead>
<tr>
<th>A: Likelihood ratio statistics:</th>
<th>B: Information Critereions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag</td>
<td>Adj.LR $\chi^2$ (16)</td>
</tr>
<tr>
<td>10:9</td>
<td>24.00 [.089]</td>
</tr>
<tr>
<td>9:8</td>
<td>32.43 [.445]</td>
</tr>
<tr>
<td>8:7</td>
<td>48.74 [.443]</td>
</tr>
<tr>
<td>7:6</td>
<td>61.14 [.578]</td>
</tr>
<tr>
<td>6:5</td>
<td>81.35 [.437]</td>
</tr>
<tr>
<td>5:4</td>
<td>94.24 [.532]</td>
</tr>
<tr>
<td>4:3</td>
<td>136.35 [.059]</td>
</tr>
<tr>
<td>3:2</td>
<td>158.39 [.035]</td>
</tr>
<tr>
<td>2:1</td>
<td>197.53 [.002]</td>
</tr>
</tbody>
</table>

Notes: LR statistics are calculated Sims’ (1980) modified likelihood ratio test statistics for the null hypothesis that lower lag VAR is an acceptable restriction on a higher order system (e.g. $H_0$: the 8-lag VAR is as good as 9-lag VAR system). The figures in the square brackets are the p-values which indicate the probability of finding a $\chi^2$ value greater than or equal to a calculated $\chi^2$ statistic under the null hypothesis. A p-value > 0.05 does not reject the null hypothesis at 5% level of significance. AIC & SBC selects the lag which has highest value. All the estimation in this table was conducted using MICROFIT 4.0 program of Pesaran and Pesaran (1997).
7.4.3 Cointegration

Since unit root tests confirm that all variables are I(1), the next stage of the estimation procedure involves testing for the cointegration vector. Our defined vector is \( X = [\text{LM}, \text{LER}, \text{LGDP}, \text{LCPI}, \text{USTB}] \) where the first four variables are endogenous and USTB is exogenous by structure. The cointegration tests are carried out using Johansen (1988) and Johansen and Juselius’s (1990) Maximum Likelihood Procedure.\(^{118}\) Table 7.4 reports cointegration test results.

The Maximum Eigenvalue test suggests that there is one cointegrating vector but Trace statistics show that there are two cointegrating vectors. The results are significant at the 5% level. The model selection criterion AIC suggests \( r = 3 \) and SBC suggests \( r = 2 \) (results not reported). Haug\(^{119}\) (1996) using the Monte Carlo Method for ten alternative tests for cointegration has found that Johansen and Juselius’s (1990) maximum Eigenvalue test has overall least size distortion over the trace test, so it is quite reasonable to take one cointegrating vector.\(^{120}\) Estimates of the long run cointegrating vector are given in panel C of Table 7.4.

---

\(^{118}\) This procedure is extensively discussed in Chapter Three. The superiority of this procedure over others is discussed in Chapter Five.


\(^{120}\) The results are consistent with findings of Bahmani-Ookooee and Shin (2002) and Chowdhury, A. (1997) where results indicate the presence of two cointegrating vectors for Thailand. Our findings can be compared with McKenzie (1992) and Leventakis (1993). Leventakis found that foreign interest rate variable has an important role in the money demand function in all the G-7 countries but there is little evidence supporting the inclusion of exchange rate variable in money demand function.
Table 7.4

**Johansen Cointegration Tests**

1984Q4 to 2001Q4 (69 observations). Cointegration with unrestricted intercepts and no trends in 7 lag VAR. Variables included in the cointegrating VAR is LM, LGDP, LER, LCPI, one I(1) exogenous variables are USTB and one dummy D97 & three seasonal dummies SC1, SC2 & SC3.

<table>
<thead>
<tr>
<th>Null</th>
<th>Alternative</th>
<th>Statistic</th>
<th>95% Critical value</th>
<th>90% Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = 0</td>
<td>r = 1</td>
<td>44.57</td>
<td>30.71</td>
<td>28.27</td>
</tr>
<tr>
<td>r &lt;= 1</td>
<td>r = 2</td>
<td>23.98</td>
<td>24.59</td>
<td>22.15</td>
</tr>
<tr>
<td>r &lt;= 2</td>
<td>r = 3</td>
<td>13.61</td>
<td>18.06</td>
<td>15.98</td>
</tr>
<tr>
<td>r &lt;= 3</td>
<td>r = 4</td>
<td>1.34</td>
<td>11.47</td>
<td>9.53</td>
</tr>
</tbody>
</table>

**A. Maximum Eigenvalue Test**

**B. Trace Tests**

| r = 0 | r >= 1 | 86.52 | 58.63 | 54.84 |
| r <= 0 | r >= 2 | 41.94 | 38.93 | 35.88 |
| r <= 2 | r >= 3 | 14.96 | 23.32 | 20.75 |
| r <= 3 | r = 4  | 1.34  | 11.47 | 9.53  |

**C. Standardized Eigenvectors** $\beta$

<table>
<thead>
<tr>
<th>LM</th>
<th>LGDP</th>
<th>LER</th>
<th>LCPI</th>
<th>USTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.22</td>
<td>0.76</td>
<td>1.96</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td>(0.27)</td>
<td>(0.97)</td>
<td>(0.01)</td>
</tr>
</tbody>
</table>

Note: (i) $r$ represents the number cointegrating vectors. The estimated cointegrated vector reported above has been normalized by first setting the estimated coefficients on LM equal to 1. Standard errors are in brackets. All the above estimations were done by Microfit 4.0.

(ii) There are two reasons for choosing unrestricted intercepts and no trends. First: although the underlying variables are trended, they move together, and it seems unlikely that there will be trend in the cointegrating relationships among the variables (see Pesaran and Pesaran, p. 293). Second: Allowing an intercept term in VAR model implies that we allow variables in levels to grow (i.e non-stationary). The VAR intercept may be linked to a) a linear deterministic trend in the levels, or b) a unit root in the levels variables. Because we tested our variables for unit roots and found all the variables in ‘levels’ are I(1), we don’t want a linear trend in cointegration equation.
The coefficient of LM is normalized with a value of one. It can be written in equilibrium form as:

\[ \text{LM} - 0.22 \text{LGDP} - 0.76 \text{LER} - 1.96 \text{LCPI} + 0.04 \text{USTB} = 0 \quad (7.6) \]

Equation (7.6) above represents the long-run relationship among Thailand's money supply (LM), gross domestic product (LGDP), the nominal exchange rate, price level (LCPI) and the foreign interest rate. Equation (7.6) also represents equation (4.24) of Chapter Four. The signs of the coefficients in the above equilibrium relationship are very important and need to be carefully analyzed. Signs of the estimated coefficients in the above long-run relationship are in accordance with what the theory would suggest. The long-run income elasticity of 0.22 is significantly lower than unity implying significant economizing in money holdings in the Thai economy during our study period; the opposite of the findings of Chowdhury (1997), Hataiseree (1994), and Dekle and Pradhan (1997). Chowdhury (1997) found income elasticity 0.91 for M1 and 1.29 for M2, Hataiseree (1994) found income elasticity of 1.48 for M2 and Dekle and Pradhan (1997) found 1.56 for nominal M2 and 1.26 for real M2. Major reasons for these differences are the study period under consideration and model framework. While Chowdhury (1997) used an appropriate open economy model, his study period was from 1980 to 1990 when the Thai economy was in the initial stage of financial liberalization. Hataiseree (1994) used a conservative\(^\text{121}\) open economy money demand model for the period 1981 to 1990. Dekle and Pradhan (1997) used closed economy money demand model. Using an open economy model in a IS-LM framework, our study covers both pre-boom and post-boom

\(^{121}\) Conservative in the sense that it includes financial innovation variable instead of exchange rate variable.
periods when the economy moved from fixed exchange rate to flexible exchange rate, economic growth moved from high to historical low and then the economy experienced severe financial crisis. Moreover, during our study period, the Thai economy went through significant financial innovation processes which could contribute to our results that show a lesser monetization of the Thai economy.

The positive sign on the exchange rate may be explained by the Purchasing Power Parity (PPP) theory.\textsuperscript{122} If other things are the same, according to PPP theory, the nominal exchange rate moves by the same proportion as prices in the long run. And according to the quantity theory of money, prices move by the same proportion as money in the long-run. Combining these two theories one can derive the proposition that money, exchange rates and prices all move proportionally in the long-run. But inflation level can affect these propositions. In particular, high and low inflation countries may experience different transmission processes of money to prices and exchange rates.\textsuperscript{123} This finding supports Chowdhury's (1997) findings and the views contained in Akrasanee et al. (1991) and Wilbulswadi (1987) who claimed that the real exchange rate was depreciated from time to time as part of exchange rate management by the Thai authorities in correcting external disequilibrium and promoting export-led growth. The foreign interest rate finding is inconsistent with the findings of Chowdhury (1997) and implies that when the

\textsuperscript{122} In the case of money demand, there is a different explanation for positive exchange rate coefficient and negative USTB coefficient. This explanation is supported by Chowdhury (1997) and Arango and Nadiri (1981). In the case of Thailand, the US dollar deposits and may be dollar currency are relevant substitutes for Thai monetary assets. In this case, one could argue for the possibility of currency substitution between Thai Bhat and US dollar. So an increase in the nominal exchange rate (depreciation) will lead to the increase the demand for money. A depreciation raises the value of foreign securities held by domestic residents and lowers the value of domestic securities held by foreigners, as valued in their own currency. This in turn increases the demand for domestic money.

\textsuperscript{123} See for example Kim (1990).
foreign interest rate goes up money supply decreases. Nevertheless the coefficient value is small indicating a very limited impact.

The price elasticity of 1.96 shows that a one per cent increase in the money supply associated with a 1.96 per cent increase in the price level has an important implication for the monetary authority in Thailand. This finding of price elasticity is largely consistent with the findings of Chowdhury (1997) which are 1.57 for M1 and .89 for M2. For Dekle and Pradhan’s (1997) study this coefficient is 1.06 for nominal M2. All these results show that in the case of Thailand, in the long-run, money is more than proportional (or proportional) to changes in the price level. The evidence mentioned above seems to suggest that authorities can use money to gauge the future movement of price level. This high price elasticity value could be explained in the context of the dependent economy model (Dornbusch 1980). In our study period Thailand experienced huge capital inflows which had a positive impact on domestic credit growth and on aggregate demand. This is likely to have resulted in pressures on prices of goods and assets both traded and non-traded. The excess demand for traded goods can be met through international trade, but the excess demand for non-traded goods led to an increase of their prices, i.e. inflation.

Finally, we formulate two hypotheses about long-run monetary neutrality on the basis of equation (4.24) in Chapter Four. The following two restrictions are used to test the long-run monetary neutrality on the equilibrium relationship established in equation (7.6).

1. $a_1 = -a_3$

2. $a_1 = -a_4$
where $a_1$, $a_3$, and $a_4$ are the coefficients of LM, LCPI and LER respectively. The restrictions results are presented in Table 7.5 below.

Table 7.5

Restrictions on cointegrating Vector

<table>
<thead>
<tr>
<th>When</th>
<th>Imposed restriction on cointegrating vectors (in normalized value)</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_1 = -a_3$</td>
<td></td>
<td>$a_1 = -a_4$</td>
</tr>
<tr>
<td>LM</td>
<td>-1.00</td>
<td>-1.00</td>
</tr>
<tr>
<td>LGDP</td>
<td>1.23</td>
<td>2.60</td>
</tr>
<tr>
<td>LCPI</td>
<td>1.00</td>
<td>-.62</td>
</tr>
<tr>
<td>LER</td>
<td>.14</td>
<td>1.00</td>
</tr>
<tr>
<td>USTB</td>
<td>.03</td>
<td>.07</td>
</tr>
<tr>
<td>LR: $\chi^2(1)$</td>
<td>.93 (.335)</td>
<td>.627 (.428)</td>
</tr>
</tbody>
</table>

LR is log-likelihood ratio tests. $P$ values are in the rounded brackets.

The log-likelihood test does not reject the first and second restrictions implying the presence of monetary neutrality in our study period. However, it also indicates how imprecise are the point estimates of -0.76 and - 1.96. In other words, in the case of Thailand, in the long-run, money is neutral. This finding is largely consistent with Boschen and Mills (1995) for the USA data, Olekalns (1996) for the Australian data for the period 1900-01 to 1993-94 and for narrowly defined money. Our finding is further
supported by Gregorio (2004)\textsuperscript{124} who argued that, in the long-run, there is no relationship between money growth and output growth and if anything, it is inflation that affects growth and welfare. This result could indicate the possibility of "bottlenecks" in the Thai economy during our study period. This type of "bottlenecks" Rao (1952) defined full employment and any policy change at this full employment level only increases price level. The findings of monetary neutrality could also be explained in terms of subsistence real wage (Dasgupta, 1985) as frequent upward adjustment of minimum wage took place in Thailand during our study period\textsuperscript{125}. The results are in line with our previous findings for Malaysia and Indonesia. In both the Malaysian and Indonesian case, we found monetary neutrality with respect to the price level. The second restriction implies the proportional relation between money and exchange which is not rejected by the log-likelihood test and therefore is inconsistent with our previous findings for Malaysia and Indonesia.

7.4.4 Weak-exogeneity Tests

In the cointegration estimation, we have established long-run equilibrium relationships as outlined in equation (7.6). The next step is to perform weak-exogeneity tests to examine whether there exists short-run dynamic relationships exist among the variables in our SVAR model. Weak-exogeneity tests results are presented in Table 7.6 assuming one

\textsuperscript{124} Gregorio examined money and inflation relationship using both M1 and M2 definition of money for all the countries with populations more than 1 million and per capital income more than one thousand dollars. This study provide empirical evidence based on simple regression using inflation, change in current inflation and change in future inflation as dependent variables of three separate equations.

\textsuperscript{125} Bank of Thailand, Quarterly Bulletin, 25(4), page 6. Real wage were stagnant because minimum wage were always closely linked to inflation rates. Saget (2001, p 11) argued that minimum wage used to be based on changes in CPI but since 1990, minimum wage adjustment also depend on GDP growth.
cointegration relationship. The null hypothesis of the existence of weak exogeneity is rejected for all variables except LGDP. Therefore, in theory, short-run error-correction models can be designed with a system of equations without LGDP.\textsuperscript{126}

### Table 7.6

**Weak-exogeneity test**

<table>
<thead>
<tr>
<th>Variables</th>
<th>LCPI</th>
<th>LGDP</th>
<th>LM</th>
<th>LER</th>
<th>USTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_1 = 0$</td>
<td>(\chi^2(1) = 3.19 \ [0.074])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_2 = 0$</td>
<td>(\chi^2(1) = 0.16 [0.688])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_3 = 0$</td>
<td>(\chi^2(1) = 14.26 [0.000])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_4 = 0$</td>
<td>(\chi^2(1) = 3.97 [0.020])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_5 = 0$</td>
<td>(\chi^2(1) = 12.59 [0.000])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The log-likelihood ratio statistic is used for testing each restriction separately. $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ are the representatives of LCPI, LGDP, LM, LER, USTB respectively. All the restrictions except $\alpha_2$ (LGDP) are statistically significant. In case of $\alpha_2$ (LGDP), the statistic suggests that it is not significant and the restriction $\alpha_2=0$ cannot be rejected. All the estimations were done by Microfit 4.0 by Pesaran and Pesaran (1997).

\textsuperscript{126} A null hypothesis is not rejected for LGDP, disequilibrium in the cointegration relationship does not feed back onto that variable; but any disequilibrium of a given variable will have impact on the cointegrating relationship (Sriram, 1999).
7.5 Short-run Dynamic Specification: The Error-correction Models

The results from integration, cointegration and weak-exogeneity tests support statistical justification for using the ECM. We have already outlined the nature and structure of the ECM in Chapters Five and Six.

Although, weak-exogeneity tests suggest only three equations (excluding LGDP equation) in our ECMs, we will keep all four equations in our ECM models so that we can get a complete picture of all error-correction models.

The results of the error-correction models are divided into two subsections; the first one analyzes the unrestricted error correction models while the second one is on parsimonious type modeling based on Hendry's general-to-specific approach discussed earlier in Chapter Five.

7.5.1 The Unrestricted ECM

Estimation results for the unrestricted ECM are presented in Table 7.7. Each variable on the right hand-side of each ECM has six lags to match the lag lengths of seven in the cointegration analysis discussed in the previous section. The right-hand side also includes the error-correction term which indicates the speed of convergence to equilibrium. Each equation also includes three seasonal dummies and one Asian crisis dummy D97.
Table 7.7

Empirical Estimates of the ECMs for LGDP, LCPI, LER, LM and USTB relationships

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>$\Delta$LGDP</th>
<th>$\Delta$LCPI</th>
<th>$\Delta$LER</th>
<th>$\Delta$LM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period</td>
<td>1984Q4-2001Q4</td>
<td>1984Q4-2001Q4</td>
<td>1984Q4-2001Q4</td>
<td>1984Q4-2001Q4</td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.14[-1.6]</td>
<td>.52[3.81]***</td>
<td>1.51[2.38]**</td>
<td>-2.12[-1.95]*</td>
</tr>
<tr>
<td>$\Delta$LGDP_{t-1}</td>
<td>1.80[11.20]***</td>
<td>.12[.48]</td>
<td>-5.7[-.48]</td>
<td>1.65[.82]</td>
</tr>
<tr>
<td>$\Delta$LGDP_{t-2}</td>
<td>-2.05[-6.66]***</td>
<td>.17[.37]</td>
<td>-1.2[-.56]</td>
<td>1.66[.43]</td>
</tr>
<tr>
<td>$\Delta$LGDP_{t-3}</td>
<td>1.99[4.96]***</td>
<td>-.30[-.49]</td>
<td>3.51[1.20]</td>
<td>-2.10[-.42]</td>
</tr>
<tr>
<td>$\Delta$LGDP_{t-4}</td>
<td>-.96[-2.34]***</td>
<td>.32[.50]</td>
<td>-6.38[-2.12]**</td>
<td>3.51[.68]</td>
</tr>
<tr>
<td>$\Delta$LGDP_{t-5}</td>
<td>.56[1.69]*</td>
<td>-.28[-.56]</td>
<td>3.21[1.33]</td>
<td>-1.64[-.41]</td>
</tr>
<tr>
<td>$\Delta$LGDP_{t-6}</td>
<td>-.11[-.66]</td>
<td>-.24[-.94]</td>
<td>.73[-.58]</td>
<td>-.89[-.42]</td>
</tr>
<tr>
<td>$\Delta$LCPI_{t-1}</td>
<td>.05[.62]</td>
<td>.05[.66]</td>
<td>-.88[-1.38]</td>
<td>1.10[1.02]</td>
</tr>
<tr>
<td>$\Delta$LCPI_{t-2}</td>
<td>-.07[-.78]</td>
<td>-.09[-.06]</td>
<td>-.47[-.72]</td>
<td>.59[.52]</td>
</tr>
<tr>
<td>$\Delta$LCPI_{t-3}</td>
<td>.05[.73]</td>
<td>-.04[-.40]</td>
<td>-1.43[-2.44]**</td>
<td>.77[.77]</td>
</tr>
<tr>
<td>$\Delta$LCPI_{t-4}</td>
<td>.07[.94]</td>
<td>-.13[-1.09]</td>
<td>-1.43[-2.42]**</td>
<td>1.21[1.20]</td>
</tr>
<tr>
<td>$\Delta$LCPI_{t-5}</td>
<td>-.06[-.79]</td>
<td>-.07[-.57]</td>
<td>-1.44[-2.33]**</td>
<td>.82[.78]</td>
</tr>
<tr>
<td>$\Delta$LCPI_{t-6}</td>
<td>.05[.64]</td>
<td>-.10[-.79]</td>
<td>-1.6[-.26]</td>
<td>.72[.66]</td>
</tr>
<tr>
<td>$\Delta$LER_{t-1}</td>
<td>.01[-.73]</td>
<td>.03[1.10]</td>
<td>-.28[-2.07]**</td>
<td>-.26[-1.14]</td>
</tr>
<tr>
<td>$\Delta$LER_{t-2}</td>
<td>-.04[-2.87]***</td>
<td>.06[2.47]**</td>
<td>-.014[-.122]</td>
<td>-.28[-1.34]</td>
</tr>
<tr>
<td>$\Delta$LER_{t-3}</td>
<td>.07[3.68]***</td>
<td>.007[.23]</td>
<td>-.74[-5.30]***</td>
<td>-.28[-1.19]</td>
</tr>
<tr>
<td>$\Delta$LER_{t-4}</td>
<td>.01[.93]</td>
<td>.05[1.85]***</td>
<td>-.36[-2.58]***</td>
<td>-.17[-.73]</td>
</tr>
<tr>
<td>$\Delta$LER_{t-5}</td>
<td>.005[.28]</td>
<td>.008[.28]</td>
<td>-.05[-.41]</td>
<td>-.17[-.72]</td>
</tr>
<tr>
<td>$\Delta$LER_{t-6}</td>
<td>.06[3.93]***</td>
<td>.01[.60]</td>
<td>-.24[-2.10]**</td>
<td>-.79[-3.96]***</td>
</tr>
<tr>
<td>$\Delta$LM_{t-1}</td>
<td>.02[1.96]*</td>
<td>-.02[-.24]</td>
<td>-1.17[-2.07]**</td>
<td>-.33[-2.37]**</td>
</tr>
<tr>
<td>$\Delta$LM_{t-2}</td>
<td>.01[1.78]*</td>
<td>-.018[-1.11]</td>
<td>-.03[-3.98]***</td>
<td>-.29[-2.20]***</td>
</tr>
<tr>
<td>$\Delta$LM_{t-3}</td>
<td>.01[1.09]</td>
<td>.01[.64]</td>
<td>-.11[-1.50]</td>
<td>-.13[-1.01]</td>
</tr>
<tr>
<td>$\Delta$LM_{t-4}</td>
<td>-.002[-.23]</td>
<td>-.04[-2.52]***</td>
<td>.00[.007]</td>
<td>-.09[-.74]</td>
</tr>
<tr>
<td>$\Delta$LM_{t-5}</td>
<td>.00[.66]</td>
<td>-.002[-.19]</td>
<td>-.09[-1.31]</td>
<td>-.03[-.25]</td>
</tr>
<tr>
<td>$\Delta$LM_{t-6}</td>
<td>-.00[-.10]</td>
<td>-.002[-1.95]</td>
<td>.05[.76]</td>
<td>-.09[-.77]</td>
</tr>
<tr>
<td>$\Delta$USTB_{t-1}</td>
<td>.00[.17]</td>
<td>-.0007[-.35]</td>
<td>-.015[-1.55]</td>
<td>.015[.90]</td>
</tr>
<tr>
<td>$\Delta$USTB_{t-2}</td>
<td>.000[.54]</td>
<td>-.004[-1.99]**</td>
<td>.00[.12]</td>
<td>.03[2.05]**</td>
</tr>
<tr>
<td>$\Delta$USTB_{t-3}</td>
<td>.00[.09]</td>
<td>.002[.101]</td>
<td>.00[.40]</td>
<td>-.002[-1.11]</td>
</tr>
<tr>
<td>$\Delta$USTB_{t-4}</td>
<td>.001[.88]</td>
<td>-.006[-2.88]***</td>
<td>-.01[-.96]</td>
<td>.006[.34]</td>
</tr>
<tr>
<td>$\Delta$USTB_{t-5}</td>
<td>.000[.04]</td>
<td>.001[.787]</td>
<td>.005[.63]</td>
<td>.01[.99]</td>
</tr>
<tr>
<td>$\Delta$USTB_{t-6}</td>
<td>-.00[.70]</td>
<td>-.003[-1.98]**</td>
<td>.008[1.04]</td>
<td>-.006[-.51]</td>
</tr>
<tr>
<td>ECM_{t-1}</td>
<td>.02[1.58]</td>
<td>-.06[-3.88]***</td>
<td>-.16[-2.29]**</td>
<td>.25[2.01]**</td>
</tr>
<tr>
<td>D97</td>
<td>-.002[-.67]</td>
<td>.02[3.46]***</td>
<td>.19[6.55]***</td>
<td>.012[.25]</td>
</tr>
<tr>
<td>SC1</td>
<td>.000[.15]</td>
<td>-.002[-.82]</td>
<td>.002[.22]</td>
<td>.04[2.21]**</td>
</tr>
<tr>
<td>SC2</td>
<td>-.002[-1.2]</td>
<td>-.000[-1.9]</td>
<td>.006[.53]</td>
<td>-.03[-1.44]</td>
</tr>
<tr>
<td>SC3</td>
<td>.000[.17]</td>
<td>.000[.22]</td>
<td>-.005[-.34]</td>
<td>-.03[-1.66]***</td>
</tr>
<tr>
<td>R²</td>
<td>.97</td>
<td>.79</td>
<td>.87</td>
<td>.86</td>
</tr>
<tr>
<td>D-W</td>
<td>1.88</td>
<td>2.25</td>
<td>2.11</td>
<td>2.10</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Serial corr: $\chi^2$ (4)</td>
<td>6.89(.142)</td>
<td>28.23(.000)</td>
<td>16.04(.003)</td>
<td>7.54(.112)</td>
</tr>
<tr>
<td>Functional Form : $\chi^2$ (1)</td>
<td>5.01(.025)</td>
<td>.28(.594)</td>
<td>3.17(.054)</td>
<td>19.60(.00)</td>
</tr>
<tr>
<td>Normality : $\chi^2$ (2)</td>
<td>.57(.749)</td>
<td>3.70(.157)</td>
<td>3.21(.201)</td>
<td>5.56(.000)</td>
</tr>
<tr>
<td>Heteroscedasticity: $\chi^2$ (1)</td>
<td>1.21(.271)</td>
<td>.000(.995)</td>
<td>.29(.588)</td>
<td>3.58(.058)</td>
</tr>
</tbody>
</table>

Note: Since weak-exogeneity tests suggest that ECM for LGDP may not exist, however we keep it just to have comparative analysis among different ECM models.

Notes:
1. t-values are in square brackets.
2. ** Significant at the 1% level.
3. * Significant at 5% level.
4. * Significant at 10% level.
5. The $p$-values are in rounded brackets.

The major findings are outlined below:

- The unrestricted ECM results for output equation indicate that the coefficients of $\Delta LGDP_{t-1}$, $\Delta LGDP_{t-3}$, $\Delta LGDP_{t-5}$, $\Delta LER_{t-3}$, $\Delta LER_{t-6}$, $\Delta LM_{t-1}$, $\Delta LM_{t-2}$ are significant and with correct signs. But the coefficients of $\Delta LGDP_{t-2}$, $\Delta LGDP_{t-4}$, $\Delta LER_{t-2}$, are significant with incorrect signs. The ECM term is found insignificant. Seasonal dummies and the Asian crisis dummy are found insignificant. The diagnostic tests reveal no econometric problems in this model.

- The unrestricted ECM for the price level shows that the intercept and coefficients on $\Delta LER_{t-2}$, $\Delta LER_{t-4}$ are significant with correct signs. But the coefficient of $\Delta LM_{t-4}$ is highly significant with incorrect sign. However, coefficients on $\Delta USTB_{t-2}$, is found significant with correct sign. But the coefficient value is very small (close to zero. The ECM term is negative and significant. Among the
dummies, the Asian crisis dummy is found significant. This ECM is not free from serial correlation problems.

- The unrestricted ECM for the exchange rate shows that the intercept, coefficients on $\Delta \text{LGDP}_{t-4}$, $\Delta \text{LCPI}_{t-3}$, $\Delta \text{LCPI}_{t-4}$, $\Delta \text{LCPI}_{t-5}$, $\Delta \text{LER}_{t-1}$, $\Delta \text{LER}_{t-3}$, $\Delta \text{LER}_{t-4}$, $\Delta \text{LER}_{t-6}$, $\Delta \text{LM}_{t-1}$, $\Delta \text{LM}_{t-2}$ are significant but most of them have incorrect signs. But none of the USTB coefficients is significant implying the closedness of the Thai economy during our study period. The ECM term is relatively large and significant. The Asian crisis dummy is significant as well. This model suffers from serial correlation problems.

- The unrestricted ECM results for monetary policy reaction function show that the intercept, coefficients of $\Delta \text{LER}_{t-6}$, $\Delta \text{LM}_{t-1}$, $\Delta \text{LM}_{t-2}$, $\Delta \text{USTB}_{t-2}$ are significant but only USTB has correct signs. The ECM term is significant. Among the dummy variables, the Asian crisis dummy $D97$ and one seasonal dummy are found significant. This ECM suffers from heteroscedasticity problems.

The above estimated results are neither expected, nor in line with what economic intuition would suggest. Moreover, most of them have econometric problems. We need to estimate parsimonious ECMs which will be free from statistical problems. There are many ways we can estimate parsimonious model which we have already discussed in Chapter Three as well as in Chapter Six (section 6.5). Our estimation strategy is (c) discussed in section 6.5.
Table 7.8

Parsimonious representations of Error correction Models

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>(\Delta LGDP)</th>
<th>(\Delta LCPI)</th>
<th>(\Delta LER)</th>
<th>(\Delta LM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimation Period</td>
<td>1984Q4-2001Q4</td>
<td>1984Q4-2001Q4</td>
<td>1984Q4-2001Q4</td>
<td>1984Q4-2001Q4</td>
</tr>
<tr>
<td>Intercept</td>
<td>.30[7.27]**</td>
<td>.91[2.48]**</td>
<td>1.32[3.01]**</td>
<td>2.08[3.04]**</td>
</tr>
<tr>
<td>(\Delta LGDP_{t-1})</td>
<td>1.89[17.10]**</td>
<td>-3.07[-3.26]**</td>
<td>1.94[-1.74]*</td>
<td>4.29[2.87]**</td>
</tr>
<tr>
<td>(\Delta LGDP_{t-2})</td>
<td>-2.10[-9.31]**</td>
<td>5.69[4.22]**</td>
<td>-7.81[-5.49]**</td>
<td>-5.71[-6.32]**</td>
</tr>
<tr>
<td>(\Delta LGDP_{t-3})</td>
<td>1.96[7.05]**</td>
<td>-1.10[-3.64]**</td>
<td>4.17[5.10]**</td>
<td>-1.29[-2.50]**</td>
</tr>
<tr>
<td>(\Delta LGDP_{t-5})</td>
<td>.51[2.50]**</td>
<td>-1.15[-2.02]**</td>
<td>-1.76[-3.29]**</td>
<td>-1.67[2.89]**</td>
</tr>
<tr>
<td>(\Delta LGDP_{t-6})</td>
<td>-.20[-2.23]**</td>
<td>-1.04[-1.27]</td>
<td>-1.56[-3.28]**</td>
<td>-1.29[-2.50]**</td>
</tr>
<tr>
<td>(\Delta LCPI_{t-1})</td>
<td>-1.15[2.98]**</td>
<td>-.26[-2.70]**</td>
<td>-1.76[-3.29]**</td>
<td>-.39[-2.98]**</td>
</tr>
<tr>
<td>(\Delta LCPI_{t-2})</td>
<td>-.03[-3.47]**</td>
<td>.059[3.76]**</td>
<td>-1.82[-8.48]**</td>
<td>-.50[-4.34]</td>
</tr>
<tr>
<td>(\Delta LCPI_{t-3})</td>
<td>.08[7.50]**</td>
<td>.023[1.19]</td>
<td>-50[4.34]</td>
<td></td>
</tr>
<tr>
<td>(\Delta LCPI_{t-4})</td>
<td>.07[1.50]</td>
<td>-.18[1.76]</td>
<td>-.54[-3.64]**</td>
<td></td>
</tr>
<tr>
<td>(\Delta LCPI_{t-5})</td>
<td>-.29[-4.63]**</td>
<td>.008[1.57]</td>
<td>-.39[-4.21]**</td>
<td></td>
</tr>
<tr>
<td>(\Delta LER_{t-1})</td>
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<td>-.25[-2.60]**</td>
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<td>-.11[-1.98]</td>
<td>-.08[-.96]</td>
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<td>.01[-1.22]</td>
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<td>.001[8.9]</td>
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<td>.01[3.41]**</td>
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7.5.2 Parsimonious Models

Table 7.8 reports the estimation results based on parsimonious ECM models using the same initial lag lengths as in the unrestricted models.

Several features of the results regarding the parsimonious equation are worth noting:

First: for the output equation, the expected sign of the EC term is negative but insignificant, validating our weak-exogeneity test results. All the dummy variables except one seasonal dummy (SC2) in the output equation are found insignificant.

Diagnostic tests reveal no econometric problem in this model. All the GDP coefficients in the output equation are found significant. But the sum of the GDP coefficients is equal to .96 indicating that strong growth performance during our study period contributed positively to further output growth. This is consistent with the findings of Waiquamee (2001) but in a different way. Waiquamee shows that GDP is determined by both short-
and long-term demand through private and public expenditures as well as international trade. The positive signs of the money supply coefficients indicate that money plays an important role in output growth. This is partly consistent with the finding of Waiquamdee (2001). Waiquamdee’s finding shows that real money supply partly determines GDP through private investment, as money supply is an indicator of liquidity or source of funds of private investment. There are several studies on Malaysian on money and output relations which support our results for Thailand. These are: Tan and Cheng (1995), Marashdeh (1993) and Tan and Baharumshah (1999). Similarly, a rise in the exchange rate in the short-run (i.e depreciation) plays a vital role in output growth. This is inconsistent with the finding of Upadhyaya and Upadhyaya (1999) for Thailand. They found a negative and significant effect of devaluation on output for Thailand during their study period. Interestingly, the foreign interest rate plays a very insignificant role in the output equation suggesting the limited openness of the economy (or the Thai monetary authorities conducted monetary policy which negated USTB’s influence).

Second: with regard to the price level equation, the parsimonious ECM results found no evidence supporting the hypothesis that output growth has a strong relationship with the price level. The results are consistent with the policy objectives of BOT. This is evident from the BOT Annual Report (1995, p. 7) “high credit growth was recorded in 1994, made possible by the increased use of foreign capital by the banking system. Therefore,

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128 Interesting in the sense that Thailand liberalized the financial markets, increased capital mobility and maintained fixed exchange rate. Liberalized financial markets and open capital account are linked to foreign interest rate. As Eichengreen and Fishlow (1998) show when US interest rate rises, capital flows to emerging countries fall.
to ensure that domestic demand does not rise too rapidly, commercial bank credit should grow at a more moderate pace in 1995. At the same time, commercial banks and finance companies should ensure that credit is channeled to productive uses and not to luxury consumption or speculative venture." But in the case of Thailand, an increase in exchange rate (depreciation) has a positive effect on the price level in the short-run. This seems to suggest that the government inflation control strategy (using contractionary monetary policy immediately after every depreciation) did not work perfectly during our study period. This is inconsistent with the findings of Rana and Dowling (1985) for nine Asian countries including Thailand. They found a negative relationship between small but continuous changes in effective exchange rate and inflation rate. The short-run money supply coefficients suggest a negative relationship between price level and money supply. This is consistent with the BOT objectives of monetary policy. In the 1994 Annual Report of BOT (p. 8) it is mentioned "With increased capital flows and the resulting volatility in the financial markets caused by monetary conditions abroad, it is important that the authorities maintain a cautious approach in their formulation of monetary policy." Moreover, this finding is consistent with the findings of Rana and Dowling (1985) mentioned above and for excess money supply and inflation relationships. In section 7.2, we already discussed the government's active strategy to control inflation. One of the explanations for this negative relationship is that the Thai government used expansionary monetary policy only when there was no danger of inflation. Although two foreign interest rate coefficients are found significant, the values are close to zero indicating little influence of foreign variables on the domestic price level. The error-correction term is negative (-.036) and significant at 1 percent level which indicates the speed of adjustment
toward long-run equilibrium is about 3.6% per quarter. The overall performance for this model is satisfactory as indicated by $R^2$. Moreover, the model is free from econometric problems as indicated by the various diagnostic statistics.

Third: with regard to the exchange rate equation, the parsimonious ECM results show that the error-correction term is negative and significant at the 5 percent level. The coefficient on the EC term indicates that the speed of adjustment of the foreign exchange market towards long-run equilibrium is about 9% per quarter. The Asian crisis dummy D97 is found significant suggesting the importance of our dummy D97 in the model. Among the seasonal dummies, only SC3 is found significant. This model is free from econometric problems and overall performance is quite satisfactory ($R^2$ is .83). Among the estimated coefficients, the intercept and those on $\Delta \text{LGDP}_{t-3}$, $\Delta \text{LGDP}_{t-5}$, $\Delta \text{LM}_{t-6}$ are found significant with correct signs. But those on $\Delta \text{LGDP}_{t-2}$, $\Delta \text{LGDP}_{t-4}$, $\Delta \text{LCPl}_{t-1}$, $\Delta \text{LCPl}_{t-3}$, $\Delta \text{LCPl}_{t-4}$, $\Delta \text{LCPl}_{t-5}$, $\Delta \text{LGDP}_{t-4}$, $\Delta \text{LM}_{t-2}$, $\Delta \text{LM}_{t-3}$ are found significant with incorrect signs. The negative relationship between exchange rate with output and price level is not unexpected in our study period. As mentioned earlier, Thailand experienced huge capital inflows which had a positive impact on domestic credit growth and on aggregate demand and hence increase pressure on the domestic price level. The increase in domestic price in a fixed exchange rate environment leads to an appreciation of real exchange rate, undermining export competitiveness. As exports are the main source of growth, authorities maintained a cautious approach of monetary policy\(^{129}\) to control aggregate demand and the price level. These are consistent with the findings of Hataiseree (2001), Alba and Papell (1998) and the explanations of Jansen (2001). The

\(^{129}\) See BOT annual reports 1994 (p.8) and 1995 (p.7).
liquidity in the financial markets went up as a result of huge capital inflows during our study period. To reduce market liquidity the BOT used open market operations, selling government securities. Jansen (2001) shows that between 1987 and 1995, the BOT issued a total of 33 billion bhat in bonds. The unexpected results further indicate that the short-run adjustment processes for the foreign exchange market are so complex that they cannot adequately be captured by a simple partial adjustment mechanism. Finally, only one foreign interest rate coefficient (ΔUSTB₁₋₅) is significant with the correct sign indicating that capital mobility plays an important role in the Thai economy. A rise in the foreign interest rate increases the demand for foreign currency which eventually depreciates the local currency, consistent with the finding of Eichengreen and Fishlow (1998).

Finally: with regard to the monetary policy reaction function, the coefficient of the EC term is -.14 and significant at 1 percent level. The coefficient indicates a relatively higher speed of adjustments is taking place in the money market once deviations from long-run equilibrium occurs. The Asian crisis dummy D97 and all the seasonal dummies are found significant. The model is free from econometric problems and the overall performance is quite satisfactory (R² is .82). The sum of ΔLGDP coefficients is negative indicating that higher growth leads to monetary tightening, consistent with the findings of Jansen (2001) and Hataiseree (1999) for Thailand. This is, however, inconsistent with the finding of Marashdeh (1993) for Malaysia. The price coefficients in this reaction function are negative indicating that government uses contractionary monetary policy at the time of inflationary pressure. This is, again, consistent with the findings of Hataiseree (1999) and
the explanations of Jansen (2001). This is also evident from our discussion in section 7.2 as well as BOT views on monetary policies discussed earlier (see BOT annual reports for 1994 and 1995). Finally, the exchange rate coefficient is negative indicating the use of contractionary monetary policy at the time of depreciation. This is inconsistent with the finding of Inoguchi (2003). Inoguchi shows that under fixed exchange rate regime, an increase in capital flows actually appreciates the currency value. The authorities increased official reserves (contractionary monetary policy) to maintain the exchange rate. But our results (and relevant discussions) indicate that Thai authority used contractionary monetary policy not only to maintain currency value but also to control the price level and aggregate demand arising from capital inflows. Both unrestricted and parsimonious ECM models (Table 7.7 and 7.8) failed to establish any significant relationship (except one count) between foreign interest rate and money supply in our policy reaction function. This could indicate absence of sterilization policy during our study period and could be interpret as an indication of some sort of capital control. This finding is inconsistent with the findings of Islam and Chowdhury (2000, p 103-107). Islam and Chowdhury documented that Thailand used sterilization policy between 1988 and 1993 to control capital inflows. This difference of findings between Islam and Chowdhury (2000) and this study could be our period of study. Our study period is well beyond the year 1993 and to 2001.
7.5.3 Stability Tests

We examine the stability of the coefficients by applying the CUSUM and CUSUMSQ proposed by Brown et al. (1975). The tests are applied to the residuals of all four EC models in table 7.7. Figures 7.1, 7.2, 7.3 and 7.4 are graphical representations of the CUSUM and CUSUMSQ plots applied to the error-correction models. All the graphs indicate no evidence of any significant structural instability.
Figure 7.1  CUSUM and CUSUMSQ test for Coefficient Stability: Output Equation

Plot of Cumulative Sum of Recursive Residuals (DLGDP)

The straight lines represent critical bounds at 5% significance level.

Plot of Cumulative Sum of Squares of Recursive Residuals (DLGDP)

The straight lines represent critical bounds at 5% significance level.
Figure 7.2 CUSUM and CUSUMSQ test for Coefficient Stability: Price level Equation

Plot of Cumulative Sum of Recursive Residuals (DLCPI)

The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals (DLCPI)

The straight lines represent critical bounds at 5% significance level
Figure 7.3 CUSUM and CUSUMSQ test for Coefficient Stability: Exchange rate Equation

Plot of Cumulative Sum of Recursive Residuals (DLER)

The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals (DLER)

The straight lines represent critical bounds at 5% significance level
Figure 7.4 CUSUM and CUSUMSQ test for Coefficient Stability: Monetary Policy Reaction Function

Plot of Cumulative Sum of Recursive Residuals (DLM)

The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals (DLM)

The straight lines represent critical bounds at 5% significance level
7.6 Conclusion

This chapter attempts to evaluate the macro economic relationships among the exchange rate, price level, output and money in a small open economy framework. We have applied the theoretical model developed in Chapter Four. In an empirical setting, we use structural cointegrating VAR to analyze this open economy relationship. In section 7.2, we have discussed the various stages of the Thai economy since 1981 and conclude that the advent of a much more open economy started after the massive devaluation in 1984 when the economy increasingly integrated with the world economy. The major macro variables in Thailand have been considered to be increasingly responsive to foreign influences since that time.

The major findings from this chapter may be broadly summarized as follows.

First: The unit-root tests suggest that the macro time series employed in this chapter are all integrated of order one. The evidence from Johansen Juselius cointegration tests suggests one cointegrating vector indicating long-run relationships among money, the exchange rate, price level and output. After normalizing on money, the long-run relationship provides (i) the support of the concept of less monetization in the Thai economy during our study period. (ii) The positive sign on the exchange rate indicates that increase in money supply are associated with depreciation (iii) The price elasticity in equation (7.6) shows that the money is more than proportional to changes in the price level but this coefficient is poorly determined (because of our earlier “monetary neutrality” restriction which basically says one cannot reject the restriction that is one).
Second: With regard to monetary neutrality, the test results indicate that money in the long-run is neutral and therefore has no impact on the real sector of the Thai economy in the long-run. This monetary neutrality could be the result of Thai economy's 'bottlenecks' and/or 'subsistence real wage' during our study period.

Third: with regard to short-run dynamics, the parsimonious ECM results for the price level equation suggest that there is no significant relationship between economic growth and the price level. However, exchange rate depreciation has a positive effect on the price level. The money supply has a negative effect on the price level only after fourth quarter. The error–correction term is negative and significant indicating adjustment towards the long-run equilibrium is possible after short period.

Fourth: In the case of foreign exchange market, the parsimonious ECM suggests the speed of adjustment of this market towards long-run equilibrium is about 9% per quarter. The relationship between output and exchange rate is zig-zag as there is no pattern. Exchange rate relationships with money and the price level are negative. Overall the results indicate that the short-run adjustment processes in the foreign exchange market in a country like Thailand are complex that they cannot adequately be captured by a simple partial adjustment process.

Fifth: with regard to the monetary policy reaction function, the coefficient of the EC term is -0.14 indicating a relatively higher speed of adjustments is taking place in the money market once deviations from long-run equilibrium occur. The sum of LGDP coefficients
is negative indicating a tighter monetary policy at the time of high economic growth. The price coefficients in this reaction function are negative indicating government’s use of contractionary monetary policy at the time of inflationary pressure. This is quite evident from earlier discussion in section 7.2. Finally, the exchange rate coefficient is negative indicating the use of contractionary monetary policy at the time of depreciation. Our results may also indicate that Thailand did not use any sterilization policy during our study period to control capital inflows. The Asian crisis dummy has significant impact on monetary policy reaction function.

Finally: the ECM results for the output equation suggests that the goods market is not responsible for long run equilibrium as weak-exogeneity tests already suggested. However, it is important from the point of view of this study to note that a depreciation of the Thai Bhat, while initially having a negative effect on output growth, eventually has an overwhelmingly positive effect. The price level has a negative and money supply has a positive effect on output.

The major implications of the findings of short-run and long-run results are: (i) To depreciate exchange rates in the long-run, the Thai authority uses expansionary monetary policy. This is consistent with a priori beliefs that monetary policy has been designed to favour the export sector of the economy (i.e. depreciation of the exchange rate increases the competitiveness of the export sector. However, in the short-run expansionary monetary policy has a negative effect on exchange rate. (ii) Money supply has a more than proportional effect on the price level in the long-run but a negative effect in the
short-run. (iii) Exchange rate policy is effective in raising output only after some time while it effects price level almost instantly. (iv) The Thai monetary policy reaction function suggests that, in the short-run, it is conservative in nature as it has a negative relationship with the exchange rate, the price level and output variables.
Appendix 7.1

Thailand Data Series

Nominal Exchange Rate (in log)

Gross Domestic Product (in log)
US Treasury Bill Rate

Value

Year

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

This thesis examined relationships among the exchange rate, price level, money and output for three major ASEAN countries namely Malaysia, Indonesia and Thailand. The period under investigation is different for each country; 1973-1999 for Malaysia, 1978-2001 for Indonesia, 1984-2001 for Thailand. During our study periods, these economies have embraced open economic policies but with varying degrees of openness as reflected by the differences in their trade liberalization measures and exchange rate and monetary policies. In this regard it is worth mentioning that Malaysia implemented its managed float exchange rate regime since 1973 while Indonesia since 1978. In the case of Thailand, it maintained a pegged exchange rate since 1970 but experienced major policy changes in 1984. The thesis began with reviewing relevant literature, identifying the gaps in the existing literature and establishing major empirical questions. In chapters Three and Four, methodological and theoretical issues were outlined to examine the empirical questions. Chapters Five to Seven contain empirical work carried out using quarterly data for all the variables in the model for each country. The Quarterly GDP data for Indonesia and Thailand are derived from annual data using the Lisman and Sandee (1964) method.

This thesis differs from other previous studies in various ways. First, the study derived a simple IS-LM for aggregate demand and combined it with a natural rate model of aggregate supply. The theoretical relationships are set out in Chapter Four. Theoretical
relationships are then confronted by empirical findings. Second, since all the countries examined here pursued open-economy policies during our study period, the thesis selects appropriate open economy variables and an appropriate analytical framework. The introduction of the exchange rate and the foreign interest rate to the traditional aggregate supply/demand models provides interesting results - there is a unique, statistically significant, long-run relationship relating aggregate money (M) to income (GDP/IP), the price level, the exchange rate and the foreign interest rate for all the three countries. Third, most of the previous studies failed to recognize the time-series characteristics of major macro-variables. This study used up-to-date econometric techniques in time series analysis which are designed to deal with non-stationary data for estimating long-run and short-run economic relationships. The major analyses and conclusions of this thesis relate to the following issues:

(i) theoretical linkages among the exchange rate, price level, output, money and the foreign interest rate in the context of a small open-economy (Chapter Four)

(ii) empirical examination of the above mentioned linkages and derivation of long-run relationships for each of the countries (Chapter Five for Malaysia, Chapter Six for Indonesia and Chapter Seven for Thailand).

(iii) long-run monetary neutrality is examined for all the countries, relating the theoretical development (in Chapter Four) with the empirical findings (in Chapters Five, Six and Seven).

(iv) examining the short-run dynamics through error-correction models for all three countries. In accomplishing this task, the study employs a step by step procedure and methodology in undertaking the cointegration and error –
correction analysis for short-run dynamic specifications. (Chapters Five, Six and Seven)

(v) A review of each individual economy since 1970 is introduced at the beginning of each empirical chapter (Chapters Five, Six and Seven) to get an overall idea of the monetary and exchange rate policies. This section also outlines various open economy policies for all three countries.

Since the thesis concentrates on three countries of ASEAN, our summary will be divided into three parts.

**Malaysia:** (i) The cointegration test results indicate that there is one cointegrating vector which we interpret as a long-run relationship among the exchange rate, price level, output and money. The signs and magnitudes of the estimated coefficients have significant policy implications. The cointegration results suggest that an increase in the price level close to one per cent accompanies an increase in the money supply of one percent. Currency depreciation in Malaysia has been associated with contractionary monetary policy. The long-run income elasticity is close to one which indicates that a one percent increase in real income is associated with a one percent increase in real demand for money. Finally, even though Malaysia is a small open economy with reasonable open-economic policies during our study period, the foreign interest rate seems to have had little influence on its macro economy. However, the significant foreign interest rate in the monetary policy reaction function could also indicate that there were sterilizations in Malaysia during our study period.
In regard to further implications, our estimated results raises questions about the usefulness of closed economy macroeconomic specification for monetary policy targeting in an open economy setting. This thesis argued both theoretically and empirically that authorities should include the exchange rate and foreign interest rate into open economy modelling to get the more robust results.

(ii) In our estimated long-run relationship, we tested the proposition of "Monetary Neutrality". The results suggest that money is neutral in the long-run for Malaysia only in regard to the price level. The Literature has evidence of monetary neutrality largely for the developed countries and only very few for the developing countries (for example Marashdeh (1993)). Also monetary neutrality in the developing countries like Malaysia does not have to result from rational expectations. It could be due to 'bottlenecks' as defined by Rao (1952). This empirical evidence suggests that the monetary authority should be careful in establishing money-output relationship. Money may not have impacts on real variables in the long-run. However, this needs to be clarified. Because, it looks as though money may impact on the real exchange rate in the long-run since the nominal exchange rate does not reflect movements in the price level.

(iii) The short-run formulation of ECMs shows that the error correction terms for all equations except the policy reaction function are significant. This implies that in the case of any random deviation from the long-run equilibrium path, the individual variables LCPI, LER and LIP react in a manner such that the system is brought back to the long-
run equilibrium path. Since the error-correction term for the policy reaction function is statistically insignificant, the contribution of the variable LM to bringing back the system to the long-run equilibrium path is zero. The interesting findings from the error correction models are: (1) Exchange rate depreciation and monetary expansion have substantial positive impacts on output in the short-run. But the effect on increase in the price level on output is ambiguous. (2) Exchange rate depreciation increases inflation in initial quarters but this is partly reversed after eight quarters. Increase in output and money supply increases inflation in the short-run. (3) Increase in output, money and the price level all lead to depreciation. (4) The findings of monetary policy reaction function suggest that authority uses contractionary monetary policy at the time of higher economic growth and higher inflation. But uses expansionary monetary policy at the time of depreciation. Moreover, results also suggest that Malaysia used sterilization policy to control short-run capital flows. (5) The foreign interest rate plays a minimal role in the movement of Malaysian output, the exchange rate, money supply and the price level which is inconsistent with most open economy macro models. The stability tests suggest that there are no significant evidence of structural instability among short-run EC models.

**Indonesia:** Using the same theoretical model, our empirical study examines Indonesian macroeconomic quarterly data for gross domestic product, money supply (M), the nominal exchange rate (ER), consumer Price Index (CPI) and the United States Treasury Bill Rate (USTB) as a foreign interest rate for the period 1978 to 2001. Quarterly GDP data are derived from annual data using Lisman and Sandee's (1964) method. Major findings from the Indonesian data are:
(i). Cointegration test results indicate one cointegrating vector among the exchange rate, the price level, output and money for Indonesia. Signs of the estimated coefficient are consistent with what economic theory would suggest. In the long-run, an upward movement in money supply in Indonesia is expected to be associated with an upward movement in output as well as depreciation and inflation.

(ii). A “Monetary Neutrality” proposition is tested on the estimated long-run relationship by imposing restrictions on money and price level coefficients. As in the case of Malaysia, the results suggest that money is neutral for Indonesia implying no effect on real sectors of the economy. This monetary neutrality could be due to ‘bottlenecks’ as defined by Rao (1952) but not due to ‘subsistence wage’ defined by Dasgupta (1985).

(iii). The estimated results for the error correction models for all four equations are different from the Malaysian ECMs results. The error-correction terms for the output and price level equation are very small (close to zero) indicating a longer period is required to restore equilibrium in these two markets once they have been shocked. In contrast, error correction terms for exchange rate and monetary policy reaction functions are -0.03 and -0.26 respectively and are found statistically significant. The most interesting findings from error correction models are: (1) Depreciation has positive effects on output only in the later periods (after 3 or 4 lags) while money supply has positive effects on output after two and four lags. Interestingly, price level has positive effect on output in initial quarter. (2) Output has a negative effect on the price level while the exchange rate and money supply have positive effects on the price level in the short-run. (3) Output has a
positive effect on depreciation after three lags while the price level has a negative effect on depreciation. The foreign interest rate plays a role in depreciation only after fourth quarter. (4) Monetary policy reaction function suggests that the foreign interest rate plays a role in determining Indonesian money supply, indicating use of sterilization policy during our study period. Moreover, output has a positive impact on money while the exchange rate has negative impact on money.

**Thailand:**

Using the same theoretical model established in Chapter Four, the empirical study considers the Thai macroeconomic quarterly data for gross domestic product (GDP), money supply (M), the nominal exchange rate (ER), consumer price index (CPI) and the United States Treasury Bill rate (USTB) as the foreign interest rate for the period 1984 to 2001. Quarterly GDP data are derived from annual data using Lisman and Sandee's (1964) method. The total number of observations is 69, fewer than the Malaysian and Indonesian data. Major findings from the Thai data are:

(i). Cointegration tests concluded one cointegrating vector which we interpret as a long-run relationship among the exchange rate, price level and output for Thailand. The long-run income elasticity is significantly lower than unity implying significant economizing in money holdings in the Thai economy. Moreover, depreciation increases the money supply in the long-run. The long-run relationship between the price level and money supply is more than proportional. Finally, the Thai authorities use contractionary
monetary policy at the time of high foreign interest rate. Nevertheless the foreign interest rate has minimum impact on money supply.

(ii). "Monetary neutrality" tests on the Thai cointegarting vector suggest that money is neutral in affecting real sectors of the Thai economy in the long-run. This monetary neutrality could be due to 'bottlenecks' as defined by Rao (1952) or 'subsistence wage' as defined by Dasgupta (1985) or a combination of both.

(iii). In the case of short-run models, the parsimonious ECM models, the error-correction terms for the price level equation, the exchange rate equation and the monetary policy reaction function indicated adjustment towards long-run equilibrium takes place once the system is shocked. The insignificant output market error-correction term indicates that the goods market does not contribute directly to adjustment toward long-run equilibrium. (1) Depreciation and money supply growth have positive impacts on output in the short-run while price level has negative effect on output. (2) Depreciation in the short-run increases inflation but money supply growth seems to have negative impact on inflation after few lags. (3) In the case of the monetary policy reaction function, the Thai authorities use contractionary monetary policy at the time of inflation, higher growth and depreciation. One of the interesting observations is that the foreign interest rate is significant with correct signs in all ECMs except the monetary policy reaction function (which is inconsistent with the Malaysian and Indonesian results) implying that monetary authority did not use sterilization policy to control capital inflows during our study period.
On the basis of above the findings, a number of important lessons for policy makers for Malaysia, Indonesia and Thailand are outlined below:

(i) Our estimated cointegrating results for each country suggests that most of the open economy variables move together in the long-run and the relationships reflect how and to what extent major macro variables change when there is a policy change (especially monetary and exchange rate policies) in these economies. If the economy is open, then including the exchange rate and the foreign interest rate is essential in any open-economy model for robust results.

(ii) Empirical results for all three countries indicate the existence of monetary neutrality only in terms of price level in the long-run. This neutrality is not the results of rational expectations as in Neo-classical models. Rather it could be the result of structural rigidities or subsistence real wage in these economies. In the short-run we found that money has positive impacts on output and inflation (except in Thailand). The monetary policy reaction function of Thailand suggests that authority is interested in conservative monetary policy targeting the price level.

(iii) Empirical results for all the three countries also indicate that depreciation increases output in the short-run. The effect of exchange rate depreciation on inflation is, however, mixed among the three countries.
(iii) All the three countries pursued open-economy policies during our study period and
foreign variable(s) were expected to play significant roles in these economies. However,
our findings point out that the foreign interest rate has played largely an insignificant
(with minor exceptions) role in the movement of the exchange rate, the price level, output
and money both in the short-run and in the long-run. The main reason could be
authorities' interventions (i.e. sterilization) in the respective economies whenever there is
a change in the overseas markets (i.e. a rise in foreign interest rate).

In the light of the results reported above, however, there are still a number of issues
needed to be explained in relation to the above conclusion. First, in Chapter Four, our
theoretical framework outlined the relationships among monetary and exchange rate
variables limiting the role of fiscal variables. Introducing fiscal variables both in the
theoretical framework and subsequently empirical models may produce different results.
This is beyond the scope of this thesis and is left for future research.

Second, in this thesis, I used a structural VAR approach with error-correction modelling
which means exactly identified matrices of contemporaneous shocks. But the introduction
of overidentified matrices may considerably increase the power of the analysis. Moreover,
unrestricted VAR with variance decomposition and impulse response may further
increase our understanding of the issue. Also it is possible to include other intermediate
targets, such as the domestic interest rate, in the model and estimate their relative
effectiveness.
Third, it would be of interest to see how the results change when we apply panel vector autoregressions (PVARs) where (i) the individual effects are either random or fixed; (ii) the time-series properties of the model variables are unknown a priori and may feature unit roots and cointegration relations; (iii) the time dimension of the panel is finite and its cross-sectional dimension is large.

Finally, since the Asian crisis in 1997-98, there have been huge changes in the monetary and fiscal policies of these countries. It would be interesting to see how the model estimation results change for the period after the Asian crisis. Further research should address the above issues in a proper framework.
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