Modelling Exchange Rates and Monetary Policy in Emerging Asian Economies:

Non-Linear Econometric Approach

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by

Muslimin Anwar

Department of Economics and Finance, Brunel University

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Brunel University

Uxbridge

Social Sciences School

Muslimin Anwar

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ABSTRACT

In this thesis we examine exchange rates and monetary policy of four emerging Asian countries, namely Indonesia, Malaysia, the Philippines and South Korea. We model equilibrium exchange rates using a general behavioural specification consistent with a variety of theoretical approaches; and short-run dynamics using a general non-linear adjustment model. We find in all countries examined, equilibrium nominal and real exchange rates are a function of permanent relative output and one or more variables from domestic and foreign price levels, nominal and real interest rate differentials, the level of and changes in net foreign assets, and a time trend. These results imply that individual countries present significant elements of idiosyncratic behaviour, casting doubt on empirical models using panel-data techniques. We also obtain evidence of non-linear exchange rate dynamics, with the speed of adjustment to equilibrium being in all cases a function of the size, and in two cases, the sign of the misalignment term.

With respect to monetary policy, we examined these countries' monetary policy reaction function based on an open economy augmented Taylor rule including the exchange rate and the foreign interest rate. Using a formal testing approach, our tests reject linearity, suggesting that monetary authorities in these four emerging economies are subject to non-linear inflation effects and that they respond more vigorously to inflation when it is further from the target. Our results also lead us to speculate that policymakers in three countries may have been attempting to keep inflation within the range, while those in the other country may have been pursuing a point inflation target. Finally, we also find monetary policy is asymmetric as policy makers respond differently to upward and downward deviations of inflation away from the target.

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ABSTRACT

In this thesis we examine exchange rates and monetary policy of four emerging Asian countries, namely Indonesia, Malaysia, the Philippines and South Korea. We model equilibrium exchange rates using a general behavioural specification consistent with a variety of theoretical approaches; and short-run dynamics using a general non-linear adjustment model. We find in all countries examined, equilibrium nominal and real exchange rates are a function of permanent relative output and one or more variables from domestic and foreign price levels, nominal and real interest rate differentials, the level of and changes in net foreign assets, and a time trend. These results imply that individual countries present significant elements of idiosyncratic behaviour, casting doubt on empirical models using panel-data techniques. We also obtain evidence of non-linear exchange rate dynamics, with the speed of adjustment to equilibrium being in all cases a function of the size, and in two cases, the sign of the misalignment term.

With respect to monetary policy, we examined these countries' monetary policy reaction function based on an open economy augmented Taylor rule including the exchange rate and the foreign interest rate. Using a formal testing approach, our tests reject linearity, suggesting that monetary authorities in these four emerging economies are subject to non-linear inflation effects and that they respond more vigorously to inflation when it is further from the target. Our results also lead us to speculate that policymakers in three countries may have been attempting to keep inflation within the range, while those in the other country may have been pursuing a point inflation target. Finally, we also find monetary policy is asymmetric as policy makers respond differently to upward and downward deviations of inflation away from the target.

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Introduction

The process of financial liberalization initiated back in late 1980s and the subsequent dismantling of most capital controls have led emerging economies to attract an increasing volume of direct investment and international portfolio funds. The growing importance of emerging economies to global economic stability has been ably demonstrated by financial crises such as those of Mexico in 1994, South-East Asia and Russia in 1997/98 and of Argentina in 2002. The global repercussions of these events highlights the importance of emerging economies, both for the purpose of determining optimal international investment strategies, as well as for designing and implementing economic policy.

A common feature of most financial crises in emerging economies is that they were triggered by turbulence in the foreign exchange market, typically resulting in discrete devaluation of the domestic currency. Therefore, identifying the determinants of exchange rate fundamentals and obtaining proper explanation of these currency movements, whether they represent movements in the underlying equilibrium and therefore the currency are correctly priced or whether they represent misalignment, are important diagnostic tools to assess the overall financial prospects of these countries.

In the first part of this thesis we aim to offer such an analysis for the nominal as well as the real exchange rates of four emerging Asian-Pacific economies, namely Indonesia, Malaysia, the Philippines and South Korea. These countries are particularly worthy of study on a number of grounds. Firstly, they have undergone rapid structural changes, particularly on the supply side, following the implementation of market reforms and financial liberalization in the early 1980s. These changes can bring about significant changes in the relative price structure between traded goods and non-traded goods in individual countries and eventually the equilibrium nominal and real exchange rate will adjust in response to these structural changes. Secondly, they all experienced turbulence period in the nineties characterized by frequent changes in the nominal and real exchange rate and speculative attacks.[1] In particular, during the financial crisis of 1997/98, the nominal and the real exchange rate depreciated and appear to be non-stationary. This evidence cannot be explained by the benchmark model of nominal and real exchange rate

[1] Kaminski et. al (1997) suggest that an overvalued currency may lead to an unsustainable current account deficit, increasing external debt and the risk of possible speculative attacks with unfavourable cost for the economy. On the other hand, Razin and Collins (1997) say that an undervalued currency has an equivocal effect on growth.

determination, Purchasing Power Parity (PPP), which predicts a constant real exchange rate or a cointegrated nominal exchange rate with domestic and foreign price levels.

However, as discovered in many industrial countries, earlier studies on the exchange rate of Asian Economies in fact has produced mixed evidence with regards to the validity of exchange rate models such as the PPP (see Ajayi and Karemera (1996), Lee (1996), Cheung and Lai (1998), Allsopp and Zurbruegg (2004), Liew et al (2004), Wu et al (2004)). These studies, which typically model real rather than nominal exchange rates, produce findings broadly supportive to some form of PPP. However, they also obtain evidence of trend-breaks in real exchange rates, which is not consistent with the textbook version of PPP, and their results are very sensitive to the testing methodology employed to test for real exchange rate stationarity. This may be a reflection of the relatively small sample sizes used by some of these studies or, for those employing longer data sets, the risks of bias associated with mixing periods of fixed with floating exchange rates.

In order to avoid such biases, we consider only those periods during which the countries examined followed a managed floating exchange rate policy. These are 1978(3)-2003(4) for Indonesia; 1975(3)-1998(3) for Malaysia, 1981(4)-2003(4) for the Philippines; and 1980(1)-2003(4) for South Korea. For the purpose of modelling exchange rates, these sample periods are better described as medium- rather than long-run. In such a context, fundamentals' based models suggest that exchange rates can be affected by a number of factors, such as price rigidities preventing the ratio of prices fully adjusting to changes in nominal exchange rates,[2] demand shocks,[3] shifts in real interest

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[2] See Dornbush (1976), Eichenbaum and Evans (1995), Rogers (1999).
[3] See Clarida and Gali (1994), Taylor (1995), Rogoff (1996), Chadha and Prasad (1997).

rates,[4] Balassa (1964)-Samuelson (1964) effects caused by productivity gains,[5] current account imbalances and net foreign assets accumulation.[6]

By concentrating on PPP only, previous studies on Asian economies have not accounted for all these factors. We do so by estimating a general behavioural equation such as those discussed by MacDonald (2000), nesting PPP as well as a number of other theoretical approaches. The specification we use, which to the best of our knowledge has not been used for modelling exchange rate in the Asia-Pacific Basin region, enables us to identify the behavioural determinants of nominal and real exchange rates and extract a measure of fundamental misalignment which previous studies have not been able to obtain. In addition, by working within a time-series rather than panel-data framework, our analysis is able to capture aspects of idiosyncratic behaviour in the nominal and real exchange rate of individual countries, which we would not be able to capture by using fixed parameters panel cointegration analysis.

The second topic of our analysis is to model the process of adjustment of the nominal and real exchange rate to its equilibrium. We do so first by estimating benchmark linear models of exchange rate adjustment, then testing formally for non-linear dynamics in the adjustment process and, finally, by estimating non-linear exchange rate models.

Short-run exchange rate fluctuations are known to be notoriously volatile and often very difficult to reconcile with mainstream theoretical models of exchange rate determination. In recent years, the excess volatility of the nominal and real exchange rate

[4] See Frankel (1979), Boughton (1987).
[5] See, among others, Dibooglu (1996) and Canzoneri et al. (1999).
[6] See Branson (1983), Dornbusch and Fischer (1980), Hooper and Morton (1982), Faruqee (1995), and Obstfeld and Rogoff (1995)

has been partially explained by the development of theoretical models of non-linear exchange rate dynamics.[7] In these models, transactions costs and other market imperfections[8] imply that within a certain range around its equilibrium level, the nominal and real exchange rate does not respond to changes in its fundamental determinants. But when nominal and real exchange rate misalignment exceeds certain thresholds, arbitrage forces ensure its reversion to its equilibrium level.

A number of empirical studies, mainly focusing on G7 economies, have provided substantial evidence in favour of the existence of non-linear exchange rate dynamics, finding the speed of adjustment to equilibrium to increase with the size of the misalignment term.[9] For Asian economies, evidence of non-linear exchange rate adjustment has been provided by Chen and Wu (2000), Baharumshah et al (2002), Lestari et.al (2003), and Liew et al (2003, 2004). However, like most of the non-linear exchange rate empirical literature, these studies use econometric models such as the Threshold Autoregressive (TAR)[10] and the Exponential Smooth Transition Autoregressive (ESTAR),[11] which impose symmetric reaction of the real exchange rate to episodes of over- and under-valuation. But such a restriction may in practice be invalid. Consider, for example, a situation where a policy-maker prefers to boost the export of domestic goods. This policy-maker is likely to tolerate higher values of undervaluation than overvaluation, as the former results in temporary positive trade balance while the latter leads to negative

[7] See Benninga and Protopapadakis (1988), Dixit (1989), Dumas (1992), Uppal (1993), Sercu et al (1995), Shleifer and Vishny (1997), and O'Connell (1998).
[8] Such as taxation, subsidies, actual or threatened trade restrictions, the existence of non-traded goods, imperfect competition, foreign exchange market interventions, and the differential composition of market baskets of price indices across countries
[9] See Michael et al (1997), Obstfeld and Taylor (1997), Sarantis (1999), Taylor and Peel (2000), Baum et al (2001), Taylor et al (2001), Lo and Zivot (2001), O'Connell and Wei (2002).
[10] See Tong (1990).
[11] See Granger and Teräsvirta (1993).

trade balance. Symmetry-imposing models such as the TAR and ESTAR cannot capture this kind of asymmetric policy preferences. We account for such effects by estimating a more general model of non-linear adjustment, namely the Quadratic Logistic Smooth Transition Error Correction Model (QL-STECM), allowing for the speed of adjustment to equilibrium to be a function of both the size and the sign of misalignment term. In this way we are able to capture a richer range of features of process characterizing nominal and real exchange rate adjustment.

Our econometric analysis yields a number of interesting results. Firstly, in all countries examined, equilibrium nominal and real exchange rates in the first two chapters are a function of permanent relative output and one or more variables from domestic and foreign price levels, nominal and real interest rate differentials, the level of and changes in net foreign assets, and a time trend.

In particular, in the case of Indonesia, we find that permanent relative output and nominal interest rate differentials play significant roles when we model both nominal and real exchange rate determination. However, the behaviour of nominal exchange rate discussed in chapter 1 differs from that of real exchange rates discussed in chapter 2 in that the latter takes into account the deterministic time trend in its long-run model to help capture the effects of missing fundamentals.

In the case of Malaysia, we find that all variables determining the nominal exchange rate model discussed in chapter 1 also play similar roles when modelling real exchange rate behaviour discussed in chapter 2. These include permanent relative output, real interest rate differentials, the level of and changes in net foreign assets. The only distinction between the nominal exchange rate model and the real one is the latter' positive sign for real net foreign assets, while we find a negative sign when modelling nominal exchange rate behaviour.

In the case of the Philippines, while we consider real interest rate differentials and the changes in net foreign assets in modelling nominal exchange rates, our real exchange rate model fails to take these two variables into account. Moreover, our real exchange rate model differs from the nominal exchange rate model in that it takes into consideration the time trend. However, there is no evidence to suggest that this time trend is added to replace missing fundamentals, in particular, real interest rate differentials and the changes in net foreign assets.

In the case of Korea, we find more interesting results as equilibrium real exchange rates are a function of all the variables considered in chapters 1 and 2; permanent relative output, nominal and real interest rate differentials, and the level of and changes in net foreign assets. The fact that all important fundamentals have been included in our real exchange rates model is probably the reason for our not obtaining a time trend variable in this case. This is in contrast to the results obtained in chapter 1 when modelling nominal exchange rates, where we find our nominal exchange rates model fails to take into account nominal and real interest rate differentials along with changes in net foreign assets.

Secondly, we suggest that it is more appropriate to use time-series data techniques, rather than fixed-parameter panel-data techniques applied by many empirical exchange rate studies, as our results show that when the former is used, individual currencies present elements of idiosyncratic exchange rate behaviour.

Thirdly, in relation to this, a new empirical finding is that the relationship between exchange rates on the one hand and real net foreign assets and/or current account balances on the other may be non-monotonic, depending upon the sign of net foreign assets and the current account balance.

Fourthly, for all countries we obtain strong evidence of non-linear exchange rate adjustment, with the speed of reversion to equilibrium being in all cases a function of the size. Nominal and real exchange rates follow a random-walk pattern when close to their equilibrium, but revert to it at high speed when the misalignment term becomes large.

Fifthly, in Indonesia nominal and real exchange rate adjustment is asymmetric, while in Malaysia only real exchange rate adjustment is asymmetric,[12] both with fundamental undervaluation corrected faster than overvaluation (a finding consistent with the monetary policy implemented by these countries for the larger part of the post-Bretton Woods period).

Finally, we find that the devaluations that took place in 1997-98 are justified by economic fundamentals, as prior to the crisis all exchange rates were significantly overvalued against the US dollar, particularly the one of the Indonesian Rupiah.

In the second part of this thesis, we examine monetary policy in these four economies. In chapter 3, we investigate the monetary policy reaction function and attempt to assess whether central banks in these four emerging economies are primarily concerned with fluctuations in inflation and output, or whether they are also concerned with fluctuations in the exchange rate and/or foreign interest rates. To do this we use a simple model of the augmented Taylor Rule including exchange rates and foreign interest

[12] This is to say that we obtain strong evidence of non-linear exchange rate adjustment, with the speed of reversion to equilibrium being a function of the sign, of the misalignment term

rates. We consider both backward-looking and forward-looking specifications. To the best of our knowledge, there is no research exploring this type of augmented Taylor rule for these four emerging economies.

The evidence in this chapter suggests that all central banks in these emerging market economies focus on pursuing the objective of price stability and maintaining output stability. In all four countries other objectives also play a role, monetary authorities adjusting interest rates systematically in response to foreign interest rates and exchange rates. The response to the foreign interest rate is typically strong in all countries in the sample. Additionally, in Indonesia and the Philippines, the response is found to be even more marked than that to changes in the inflation rate or the output gap. This emphasizes the importance of foreign interest rate fluctuations. The augmented Taylor rule including the exchange rate and the foreign interest rate is a better empirical model because it captures how a small open economy attempts to stabilize the exchange rate and the financial market. Finally, we also find evidence that monetary policy reaction functions in Indonesia and Korea were a combination of forward and backward-looking, while in the Philippines were a combination of forward-looking and contemporaneous and in Malaysia were essentially forward-looking. Surprisingly, we do not find any central bank considering purely backward-looking or contemporaneous specifications.

In chapter 4, we estimate models to test the hypothesis of non linear monetary policy responses to the inflation rate at Bank Indonesia, Bank of Korea, Bank ng Pilipinas, and Bank Negara Malaysia. In the presence of such non linear responses, we then create a model of non-linear interest rate behaviour in these four countries.

We obtain a number of novel and interesting findings. Firstly, using a formal testing approach proposed by Saikkonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993), Teräsvirta (1994), we reject linearity.

Secondly, when we use a two-regime model based on quadratic logistic function, we find that policy makers appear to behave asymmetrically. That is to say, in these four countries the monetary authority respond differently according to the size of inflation deviations, increasing the interest rate by a larger amount when inflation is far above or below the target than it will reduce it by when inflation is close to its target (a size effect).

Thirdly, we find that policy makers in all countries respond differently depending on whether inflation is above or below the target (a sign effect).

Fourthly, we find that when inflation is close to the target, the sole determinant of policy in Indonesia is inflation, whereas in Malaysia, the determinants are output gap and foreign interest rates. In the case of Korea and the Philippines, we find none of the variables - inflation, output gap, exchange rates, and foreign interest rates - are statistically significant, so interest rates are close to random walk.

Fifthly, when inflation is far from the target, we find that the most important determinant of all countries' monetary policy is inflation, although other variables such as output also play a role in the determination of monetary policy in Indonesia and Korea. The exchange rate is also important in Indonesia' and the Philippines' monetary policy. The U.S interest rate also plays a significant role in the determination of monetary policy in all countries, with the exception of Indonesia.

Finally, in the case of Indonesia, we find that the long-run response of interest rates to inflation in the inner and outer regime are statistically significant and positive, suggesting that the central bank pursued a point target rather than a target range, while in the case of the other three countries, we find that the long-run response of interest rates to inflation only statistically significant and positive in the outer regime, suggesting that these central banks pursued a target range rather than a point target. Policymakers have been attempting to keep inflation within the range of 1.2% to 8.7% in Korea, 5.7% to 9.2% in the Philippines, and 2.7% to 3.5% in Malaysia.

PART

I

CHAPTER I

NOMINAL EXCHANGE RATE DETERMINATION IN EMERGING ASIA-PACIFIC ECONOMIES:

A behavioural, non-linear analysis

1.1. INTRODUCTION

In recent years emerging markets have become increasingly important for the global financial system by attracting increasing volumes of portfolio and foreign direct investment, underpinned by fast economic growth and high rates of portfolio investment return (Solnik, 2004). However, investing in emerging economies can be risky (see Bekaert et al 1998). Financial crises such as those in Mexico in 1994, South-East Asia and Russia in 1997/98 and Argentina in 2002 have shown that adverse economic developments in emerging markets can have wider destabilizing repercussions with direct relevance to the economic performance of these economies themselves as well as those of major industrial countries. Therefore, obtaining an understanding of the determinants of economic developments in emerging economies is an issue of importance both for international investors and policy-makers.

A common denominator of most financial crises in emerging economies is that their starting point has been a speculative attack against the domestic currency, typically resulting in sizeable devaluation. Therefore, studying the determinants of exchange rates and being able to identify pronounced currency movements is an important diagnostic tool to assess the vulnerability of emerging economies to a wider financial crisis. In this chapter, we attempt to assess whether currency movements represent misalignment or changes in the underlying equilibrium and therefore whether the currency is correctly priced. We do this for four emerging Asian-Pacific economies, namely Indonesia, Malaysia, the Philippines and South Korea, all of which were at the epicentre of the South-East Asia crisis of 1997/98.

Empirical modelling of exchange rates has proved over the years to be a difficult task for economic researchers, giving rise to what has been defined as the two "puzzles" in exchange rate economics (see Rogoff 1996, Taylor et al 2001). The first puzzle is that many studies fail to support the long-run validity of mainstream theoretical models of exchange rate determination based upon the fact that no cointegration is found in familiar models of exchange rate determination such as Purchasing Power Parity (PPP);[13] the second is that even when these models are found to hold in the long-run, the estimated speed of adjustment of exchange rates to their fundamental values is very slow.

A popular explanation for the empirical failure of mainstream exchange rate models is the low power of the cointegration tests used to test for their validity. A number of authors have sought to increase the tests' power either by allowing for longer sample periods (see, for example, Abuaf and Jorion (1990), Diebold et al (1991), Lothian and Taylor (1996), and Cheung and Lai (1998)), or by using panel unit root tests (see, for example, Wei and Parsely (1995), Frankel and Rose (1996), Sarno and Taylor (1998)). These studies typically obtain more favourable results,[14] however they have their own drawbacks: longer-span data sets usually involve mixing periods from fixed and flexible exchange rates, which affects the statistical properties of the tests employed (Hegwood and Papell, 1998). In addition, although tests on very long run series reject unit roots, these tests often assume invariance of data generating process (Ahmad and Glosser, 2006). On the other hand, most panel data sets studied impose the null hypothesis that all exchange rates examined are not consistent with the model tested, which implies a high probability of rejecting the null, even when only one of the series is consistent with the theory (Taylor and Sarno, 1998). In other words, while tests on panels reject unit roots, in fact these tests frequently do not allow sufficient heterogeneity. Also, by using exchange rates relative to a common currency, panel data tests lead to cross-sectional dependence

[13] Every cointegration test and unit root test ever invented has been used to test PPP. The results mostly confirm that the nominal exchange rate is not cointegrated with relative domestic and foreign prices or the real exchange rate does not follow a random walk.
[14] For a review of the empirical literature on exchange rate modelling see Taylor (1995), Rogoff (1996), Sarno and Taylor (1998, 2002a, 2002b).

in the time series involved in the analysis, which reduces the probability of rejecting the null when in reality it is not valid (O'Connell 1998).

Another explanation is that standard unit root tests are likely to be biased and have low power in rejecting the null of a unit root because exchange rates follow a nonlinear adjustment process. In recent years, authors such as Dixit (1989), Dumas (1992), Uppal (1993), Sercu et al. (1995), Shleifer and Vishny (1997), Michael et al (1997), O'Connell (1998), Bergman and Hansson (2000), Yilmaz (2001), De Grauwe and Vansteenkiste (2001), and Kilian and Taylor (2001) have developed theoretical models of non-linear exchange rate behaviour, in which arbitrage costs and other market frictions[15] lead rational optimizing agents to correct large but not small deviations of the exchange rate from its fundamentals-consistent equilibrium value. This implies that the exchange rate will change in periods of large misalignment of exchange rates from fundamental, but not in periods of small misalignment of exchange rates from fundamentals.[16] If this hypothesis is upheld by the data, empirical models of the exchange rate estimated within a linear estimation framework making no distinction between periods of large and small currency misalignment will be mispecified.

[15] Kilian and Taylor (2003) argue that heterogeneity in agents' expectations, given different investment horizons, risk profiles, and institutional constraints, can also cause nonlinearity in the exchange rates. On the other hand, Feenstra and Kendall (1997) and Haskel and Wolf (2001) suggest that local-to-currency pricing (LCP), under which producers selling abroad are assumed to set prices in the currency of consumers rather than their own, is considered as another source of nonlinearity in exchange rates.

[16] The initial thought of deviations from PPP are assumed not corrected if they are small relative to the costs of trading can be credited to Eli Heckscher (1916) and Gustav Cassel (1922). Proportional costs form thresholds/band for nominal rates in that the marginal cost of arbitrage exceeds the marginal benefit. On the other hand, Dixit (1989) and Krugman (1989) say that sunk costs of international arbitrage and the tendency for traders to wait for sufficiently large arbitrage opportunities before entering the market may rise thresholds. Meanwhile, Dutta and Leon (2002) claim that government intervention when the exchange rate beyond its fundamental rate can generate thresholds. They find that governments more concern about large and persistent exchange rate deviations from its desired value since these circumstances will change net exports, as well as the cost of servicing debt denominated in foreign currency.

Papers such as those by Obstfeld and Taylor (1997), Michael et al. (1997), Sarantis (1999), Taylor and Peel (2000), Taylor et al (2001) and Baum et al (2001) have found evidence of non-linear exchange rate adjustment, thus restoring some faith in fundamental based models of exchange rate determination. To model non-linearities, these studies typically use the TAR (Tong, 1990) or the ESTAR model (Granger and Teräsvirta, 1993) both of which make a distinction between an inner regime, where the exchange rate either follows a random-walk or adjusts to its equilibrium very slowly, and an outer regime where adjustment to equilibrium is fast. The inner regime is defined by two threshold values which in the context of the TAR and ESTAR models are by default symmetric. This is justified on the grounds that there is no reason to assume that agents will change their behaviour according to whether a currency is undervalued or overvalued.

More recently, the use of symmetry-imposing models such as the TAR and the ESTAR has been criticized on the grounds that it is unnecessarily restrictive. Consider, for example, a policy-maker attaching in their policy loss function a higher weight to output rather than inflation gains. This policy-maker is likely to tolerate higher values of undervaluation than overvaluation, as the former results in temporary output gains while the latter leads to output losses. Symmetry-imposing models such as the TAR and ESTAR cannot capture this kind of asymmetric policy preferences. Papers such as those by Enders and Dibooglu (2001) and Arghyrou et al (2005) have provided evidence of asymmetries in non-linear exchange rate adjustment. We follow the latter approach in our second topic of analysis based on their satisfaction results in employing Smooth Transition Error Correction Model (STECM). We utilize its branch model namely

Quadratic Logistic Smooth Transition Error Correction (QL-STECM) model in order to capture the dynamics of exchange rates in this region.

In order to avoid the risks of bias associated with mixing periods of fixed with floating exchange rates, as experienced by many researchers in the past, our first topic of analysis considers only those periods during which the countries examined followed a managed floating exchange rate policy. These are 1978(3)-2003(4) for Indonesia; 1975(3)-1998(3) for Malaysia, 1981(4)-2003(4) for the Philippines; and 1980(1)-2003(4) for South Korea. For the purpose of modelling exchange rates, these sample periods are better described as medium- rather than long-run. In such a context, fundamentals' based models suggest that exchange rates can be affected by a number of factors, such as price rigidities preventing the ratio of prices fully adjusting to changes in nominal exchange rates,[17] demand shocks,[18] shifts in real interest rates,[19] Balassa (1964)-Samuelson (1964) effects caused by productivity gains,[20] current account imbalances and net foreign assets accumulation.[21]

By concentrating on PPP only, previous studies on Asian economies have not accounted for all these factors in the context of the four Asia-Pacific countries we examine. We do so by estimating a general behavioural equation such as those discussed by MacDonald (2000), nesting PPP as well as a number of other theoretical approaches. The specification we use, which to the best of our knowledge has not been used for modelling exchange rates in the Asia-Pacific Basin region, enables us to identify the

[17] See Dornbush (1976), Eichenbaum and Evans (1995), and Rogers (1999).
[18] See Clarida and Gali (1994), Taylor (1995), Rogoff (1996), and Chadha and Prasad (1997).
[19] See Frankel (1979) and Boughton (1987).
[20] See, among others, Dibooglu (1996) and Canzoneri et al. (1999).
[21] See Branson (1983), Dornbusch and Fischer (1980), Hooper and Morton (1982), Faruqee (1995), and Obstfeld and Rogoff (1995).

behavioural determinants of nominal exchange rates and extract a measure of fundamental misalignment which previous studies have not been able to obtain. In addition, by working within a time-series rather than panel-data framework, our analysis is able to capture aspects of idiosyncratic behaviour in the exchange rates of individual countries, which we would not be able to capture by using fixed parameters panel cointegration analysis.

The second topic of our analysis is to model the process of adjustment of the nominal exchange rate to its extracted equilibrium. We do so first by estimating benchmark linear models of exchange rate adjustment, then testing formally for non-linear dynamics in the adjustment process and, finally, by estimating non-linear exchange rate models. For Asian economies, evidence of non-linear exchange rate adjustment has been provided by Chen and Wu (2000), Baharumshah et al (2002), Lestari et al (2003), and Liew et al (2003, 2004). However, like most of the non-linear exchange rate empirical literature, these studies use econometric models such as the TAR and the ESTAR which cannot account for asymmetric exchange rate behaviour. We model non-linear exchange rate adjustment using a more general model of QL-STECM, allowing for the speed of adjustment to equilibrium to be a function of both the size and the sign of misalignment term.

Our econometric analysis yields a number of interesting results. Firstly, we find that in all four countries equilibrium exchange rates are a function of domestic and foreign price levels, relative output and, according to the case, nominal and real interest rate differentials, and the level of and changes in net foreign assets. Secondly, we find that individual currencies present elements of idiosyncratic exchange rate behaviour.

which confirms the risks of biases associated with the use of fixed-parameter panel-data techniques in exchange rate modelling. In relation to this, a new empirical finding is that the relationship between exchange rates on the one hand and real net foreign assets and/or current account balances on the other may be non-monotonic, depending upon the sign of net foreign assets and the current account balance. Thirdly, we obtain strong evidence of non-linear exchange rate adjustment, with the speed of reversion to equilibrium being in all cases a function of the size, and at least in one case the sign, of the misalignment term. Finally, we find that the devaluations that took place in 1997-98 are justified by economic fundamentals, as prior to the crisis all exchange rates were significantly overvalued against the US dollar, particularly the one of the Indonesian Rupiah.

The remainder of the chapter is structured as follows: Section 1.2 presents the literature review. Section 1.3 illustrates exchange rates regime in these four countries. Section 1.4 introduces the methodology we employ. Section 1.5 describes our data. Section 1.6.1 models equilibrium exchange rates. Section 1.6.2 estimates linear models of exchange rate adjustment. Section 1.6.3 tests formally for the existence of non-linearities in exchange rate behaviour. Section 1.6.4 estimates non-linear models of exchange rate behaviour. Finally, Section 1.7 summarises and offers concluding remarks.

1.2. LITERATURE REVIEW

1.2.1. Purchasing Power Parity

Of all the models of exchange rate determination, Purchasing Power Parity (PPP) is probably the framework most commonly employed by economists to evaluate long-term rate in the foreign exchange markets. It is also considered as an important input in other models of exchange rate determination. Absolute PPP states that a common basket of real goods, when quoted in the same currency, costs the same in all countries based upon an assumption of perfect inter-country commodity arbitrage. However, we may expect PPP to be valid only in the long-run because of transaction costs, taxation, subsidies, actual or threatened trade restrictions, the existence of non-traded goods, imperfect competition, foreign exchange market interventions, and the differential composition of price indices across countries. However, earlier studies by Corbae and Ouliaris (1988), Meese and Rogoff (1988), Grilli and Kaminsky (1991) and Edison and Fisher (1991) have had difficulty detecting convergence to long-run PPP, suggesting the absence of a link between nominal exchange rates and prices in open economies, thereby invalidating the PPP hypothesis.

Previous studies on the exchange rates of Asian economies, typically model real rather than nominal exchange rates. They also produce mixed evidence with regard to the validity of exchange rate models such as PPP. Numerous studies reach different conclusion, depending on the coverage of fixed versus flexible exchange rates. the countries and numeraire[22] currencies considered, the length of data span, and so on.

Lee (1999), using a generalized error correction model, examines the validity of the PPP hypothesis as a long run equilibrium for bilateral exchange rates between thirteen Asia Pacific economies- Australia, Canada, Chile, Hong Kong, Indonesia, Japan, Malaysia, Mexico, the Philippines, Singapore, South Korea, Taiwan, and Thailand- and the United States. Eight bilateral exchange rates-Australia, Chile, Korea, Malaysia, Mexico, Philippines, Singapore, and Indonesia- are found to support PPP. However, unit root tests find evidence of PPP in only one case (the Mexican peso/U.S. dollar rate).

Wu et al (2004) allow for a one-time structural change in panel data unit-root tests in order to re-examine the unit-root hypothesis of real exchange rates among countries in the Pacific Rim, namely Taiwan, Thailand, the Philippines, Malaysia, Indonesia, Singapore, Japan, and South Korea. Contrary to findings in the existing literature, their experiment, using monthly data from 1980 to 2000, provides evidence that real exchange rates among Pacific Basin countries are stationary, although subject to a one-time structural break. It implies that their empirical evidence supports long-run PPP.

Cheung and Lai (1998) analyze the possible implications of economic growth on the behaviour of dollar-based real exchange rates of several fast-growing Asian countries, namely Hong Kong, Indonesia, Korea, Malaysia, and Singapore. They find that when excluding trend breaks, unit-root tests reject stationarity in real exchange rates, implying that deviations from PPP are driven mainly by permanent disturbances. Conversely, by including a trend shift, unit-root tests reveal stationarity in real exchange rates for these

[22] "The numeraire is the money unit of measure within an abstract macroeconomic model in which there is no actual money or currency. A standard use is to define one unit of some kind of goods output as the money unit of measure for wages".(http://economics.about.com/cs/economicsglossary/g/ numeraire.htm)

countries, implying a large permanent component in the dynamics of PPP deviations are never exist. This finding suggests that real exchange rates may appear nonstationary when in fact they are not. It seems that trend shifts may be responsible. In conclusion, their empirical results support the trend-shift hypothesis and reject the unit-root hypothesis.

Liew et al (2004) examine the stationary properties of 11 Asian real exchange rates using the stationarity test for nonlinear models proposed by Kapetanios et al (2003). Their results reveal that the null of a unit root in 8 US dollar based and 6 Japanese yen based rates are rejected, whereas the augmented Dickey-Fuller (ADF) test gives no rejection at all. This implies that exchange rate stationarity is allowed for nonlinearity and relevant for what follows.

Ajayi and Karemera (1996) employ the variance ratio tests first proposed by Cochrane (1988), in testing the random walk hypothesis (RWH) for the currencies of eight economies of the Pacific Basin- Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand. Their results provide evidence against a random walk in exchange rates, supporting classical monetary models of exchange rates in which the PPP is a long-run equilibrium condition. The estimates of the variance ratios, using the data of daily closing (bid) exchange rates from 1 January 1986 to 12 December 1991, which are generally observed to be less than unity, suggest that the exchange rate series exhibit negative serial correlation. A negative serial correlation in exchange rates implies that deviations from long-term paths are temporary. This phenomenon is consistent with PPP.

Allsopp and Zurbruegg (2004) re-examine the question of whether PPP holds in Hong Kong, Singapore, Thailand, the Philippines, Indonesia, Korea, Japan and Malaysia. for a period that includes the 1997/98 crisis. They suspect that the crisis has brought about a change in long run exchange rate dynamics which is incorporated into their cointegration analysis. Applying Inoue (1999) and Johansen et al (2000) cointegration procedures to bilateral exchange rates, deflated using consumer price indices, along with endogenously determining a structural break at the time of the crisis, the empirical results explain the significance of the East Asian crisis on long-run PPP within the region. Using monthly data for the period between 1990 and the beginning of 2002, the findings are generally supportive of PPP with the crisis leading to only shifts in long-run trends.

The above studies produce findings broadly supportive of some form of PPP. However, they also obtain evidence of trend-breaks in real exchange rates, which is not consistent with the textbook version of PPP, and their results are very sensitive to the testing methodology employed. This may be a reflection of the relatively small sample sizes used by some of these studies or, for those employing longer data sets, the risks of bias associated with mixing periods of fixed with floating exchange rates.

1.2.2. Augmented Purchasing Power Parity

As current studies on the exchange rates have produced mixed evidence with regards to the validity of exchange rate models, such as the PPP, academics and poiicy makers keep trying to establish sensible long-run relationships for a single currency using data from the recent floating exchange rate regime. MacDonald and Marsh (1997) argue that the failure of strong-form PPP model is mainly caused by Dornbusch (1976)' price rigidities in the face of nominal shocks and the impact of real disturbances. They verify that proxing such real and nominal disturbances using interest rates gives sensible augmented PPP equilibrium exchange rates and also impressive out-of-sample forecasts.

MacDonald (2000) argues that PPP is not a good model to estimate exchange rates if currencies are misaligned. He describes various ways of modelling an equilibrium exchange rate under floating exchange rates regime, one among others, the balance of payments exchange rate approach. This model states that the spot exchange rate is the function of domestic and foreign price level, domestic and foreign income, domestic and foreign interest rate, and net interest payment on net foreign assets.

On the other hand, Chinn (1998) augments the monetary model by placing a relative productivity term.[23] He employs data from 1974(1) to 1997(4) for the US dollar bilaterals of the Indonesian rupiah, Korean won, Malaysian ringgit, Philippine peso, Singapore dollar, Taiwanese dollar and the Thai baht, and finds that this augmented monetary model is valid and the adjustment speeds are relatively rapid. He also finds that all currencies, with the exception of Korea won and Philippine peso, are overvalued on the eve of the 1997 currency crisis. These results give evidence that the augmented monetary model overrule the basic so-called flex-price monetary model in which the nominal exchange rate is simply driven by relative excess money supplies, the difference between domestic and foreign income, and interest differential.

[23] He is inspired by the fact that the monetary model is basically an extension of PPP which expand the determination of prices in each country by enforcing prolong money market clearing.

In another paper, Chinn (2000) extends the monetary model by the inclusion of a Balassa Samuelson effect, for the synthetic euro/U.S dollar.[24] Employing Johansen' cointegration method on monthly data from 1991 to 1999, he finds that the model is valid and suggests an implied undervaluation of the euro against U.S dollar in December 1999 of approximately 12 per cent.

Cavallo and Ghironi (2002) suggest that nominal exchange rate depends on the stock of real net foreign assets accumulated in the previous period. Their empirical results reveal that the predictive power of real net foreign assets for the nominal exchange rate is stronger the closer the net assets to non-stationary and the higher the degree of substitutability between domestic and foreign goods in consumption. They also find that the current level of the nominal exchange rate depends on the past GDP differential, along with net foreign assets.

1.2.3. Non-linear dynamical models: TAR and its Variants

We learn from various studies on modelling nominal exchange rates that the empirical results are obviously sensitive to the model specification and the econometric methods employed. Applying different econometric methodologies gives conflicting evidence. For instance, the standard Dickey-Fuller unit root tests typically reject the PPP hypothesis, while the more freshly developed panel unit root tests tend to support the PPP

[24] Synthetic euro consists of a weighted average of the currencies of all countries that comprise the Euro area.

hypothesis. The latter conclusion has been provided by Frankel and Rose (1996), McDonald (1996), Wu (1996) and Papell (1997), while O'Connell (1997) and Chortareas and Driver (2001) find evidence to the contrary. The model specification and the econometric methods adopted will also help to examine the short-run dynamic behaviour of our chosen exchange rates, in particular how an exchange rate returns to its equilibrium value after a disturbance.

Innovations in time series methods have led researchers to develop nonlinear dynamical methods to portray the dynamics of exchange rates. Engle and Granger (1987) propose a linear cointegration methodology in which the speed of adjustment towards equilibrium is independent of the magnitude of disequilibrium.

Other models, such as Balke and Fomby's (1997) threshold cointegration methodology, propose that the exchange rate can be modelled as a regime-switching process, with a band in place separating an inner regime, in which no adjustment takes place, from outer regimes in which equilibrating forces operate.

Other researchers, such as Obstfeld & Taylor (1997), Zussman (2003), Sarno et al (2004), and Canjels et al (2004) apply a Threshold Autoregressive Models (TAR) specification in developed countries, incorporating non-linear dynamics in exchange rates. In the context of South East Asian economies, Lestari et al (2003) use this TAR method and provide evidence of non-linear exchange rate adjustment. TAR models imply that the evolution of the exchange rate for different sub samples may follow different time series processes. The particular time series process implemented depends on the observed historical value of that variable and the transition from one regime to another. TAR models have the characteristic that adjustment is slower when the exchange rate is close to the equilibrium. On the contrary, adjustment is faster when it is far from the equilibrium or outside the threshold.

Baum et al (2001) argue that this discrete threshold methodology may be suitable for those adopting regimes with an explicit band such as the EMS exchange rate mechanism. On the other hand, the real impacts of transaction costs in international trade may differ depending upon the combination of goods imported and exported by a pair of trading partners. In addition, beyond the analytical structure of a two-country, one-good world, the specification of fixed transaction costs and accordingly fixed thresholds turn out to be awkward. As a result, a crucial issue arises as to whether the shift from one regime to another takes place smoothly or suddenly.

Obstfeld and Taylor (1997) suggest that reversion is sudden, while Michael et al (1997) claim the adjustment process to parity is smooth rather than discrete since heterogeneous economic agents do not act simultaneously. Michael et al (1997) replace the fixed thresholds of a standard TAR model with a 'smooth function', which need only be continuous and non-decreasing (Tong (1993), p.108), and ultimately name the model as the 'smooth transition' threshold autoregressive (STAR) model. Dumas (1992) and Teräsvirta (1994) also argue that nonsynchronous trading and time aggregation may be the cause of smooth transition between regimes. Therefore, in many applications a smooth transition model may be more attractive than a threshold model.

Another crucial issue is whether the reversion on either side of the band generates symmetric or asymmetric adjustment behaviour. Lo and Zivot (2001) argue that transactions costs imply symmetry of thresholds and adjustment parameters. Similarly, Michael et al (1997) propose a symmetric TAR model based on the assumption that adjustment of the deviations of PPP from its equilibrium will be the same whether it is positive or negative value. Lundberg and Teräsvirta (2003) propose a smooth transition autoregressive (STAR) target zone model to describe the dynamic behaviour of an exchange rate fluctuating within a target zone. They suggest that the exchange rate adjustment depends nonlinearly but symmetrically on the distance between the value of the process and the central parity of the target zone.

Baum et al (2001) suggest to use the exponential threshold autoregressive (ESTAR) framework to investigate the dynamic behaviour of deviations from PPP may be more useful relative to the standard TAR framework in which regime changes occur abruptly. Echoing them, Taylor et al (2001) estimate an ESTAR model assuming symmetric adjustment of the exchange rate above and below equilibrium because economic intuition suggests that both positive and negative deviations from equilibrium would have symmetric effects on the speed of adjustment. Coakley and Fuertes (2001) also employ a symmetric model to examine market segmentation in Europe. Their nonlinear models exhibit random behaviour near equilibrium but mean-reverting behaviour for large departures from fundamentals.

For Asian economies, evidence of such non-linear exchange rate adjustment has been provided by Chen and Wu (2000), Baharumshah et al (2002), and Liew et al (2003, 2004). Chen and Wu (2000) re-examine the hypothesis of PPP allowing for the adjustment to follow a nonlinear process. The analysis is conducted using monthly data of the local currencies against the US dollar for two countries, Taiwan and Japan, over the period 1974:1–1997:12. The results reject the linear framework in favour of an exponential smooth transition autoregressive (ESTAR) process for PPP deviations.

offering another explanation for the failure of long-run PPP in the existing literature. Moreover, the results provide evidence that in the presence of transaction costs. equilibrium models of real exchange rate determination present a nonlinear adjustment process toward PPP.

Liew et al (2004) find that deviations from long run PPP of the major ASEAN exchange rates follow a nonlinear adjustment process which may be characterised by the Smooth Transition Autoregressive (STAR) model.

Baharumshah et al (2002) employ formal nonlinear unit root tests as developed by Sarno (2001) to provide robust evidence of nonlinear mean reversion in the real exchange rates of four (Indonesia, the Philippines, Singapore and Thailand) out of five (the exception is Malaysia) ASEAN countries. Sarno expands the Augmented Dickey and Fuller (ADF) test to its nonlinear version based on practical evidence that exchange rate adjustment follows the STAR process. Baharumshah et al (2002) suggest that current massive evidence based on traditional unit root tests may lead to misspecification and be biased against long run PPP.

1.2.4. Non-linear dynamical models: Smooth Transition Error Correction Models

As we mentioned in the introduction of this chapter, more recently, the use of symmetry-imposing models such as the TAR and its variants: the STAR and the ESTAR models have been criticized. Escribano and Jorda (1999) and van Dijk et al. (1999), when examining STAR models, find that the presence of outliers, due to data contamination or "aberrant" observations, can considerably misrepresent the distributional properties of the LM type tests used to reject linearity, and may eventually lead researchers following a Teräsvirta (1994) type methodology to incorrectly reject linearity and conclude nonlinear dynamics.

On the other hand, Almekinders and Eijffinger (1996) find that in the post-Louvre period the monetary authorities in the USA and Germany appear to act "leaning-against-the-wind" and responded to the appreciations of their currency more strongly than to depreciations, suggesting asymmetry in intervention behaviour. Symmetry-imposing models such as the TAR and its variant models cannot capture this kind of asymmetric policy response. Similarly, Dutta and Leon (2002) argue that countries may choose to defend depreciations more or less vigorously than appreciations, thereby generating asymmetric rather than symmetric adjustment behaviour.

In a recent paper, Arghyrou et al (2005) have argued that an assumption that the symmetric adjustment of exchange rates to over- and under-valuations of the same magnitude may not be true, considering the possibility that a policymaker may be more responsive to exchange rate over-valuations than to under-valuations.

Cerrato et al (2004) use two recently developed nonlinear unit root tests by Sollis et al (2002) and Kapetanios et al (2003), and a unique set of monthly data on black market exchange rates to provide evidence on nonlinear mean reversion in real exchange rates from thirty five developing and emerging market economies. Contrary to the results obtained from the standard linear ADF test, they find in more than half of their countries under observation that the black market real exchange rate exhibits significant nonlinear mean reversion behaviour, described by the smooth transition autoregressive (STAR) model. Compared to that reported for industrial countries, this fact is considered much stronger. They also find that the mean reversion process for most real exchange rates is significantly asymmetric. However, their results appear to support the logistic STAR model of Sollis et al (2002) rather than exponential STAR mean reversion process of Kapetanios et al (2003). These experimental results indicate that the exchange rate adjust to its long-run PPP level through a nonlinear STAR process. Their empirical findings also suggest that the linear methods employed in the literature for estimating half-life deviations from PPP might be inappropriate when the mean reversion process is nonlinear.

Liew et al (2004) use sequential tests as proposed in Teräsvirta and Anderson (1993) to provide robust empirical evidence of asymmetrical adjustment dynamics in response of the appreciation and depreciation of real exchange rates and the overvaluation and undervaluation of nominal exchange rates towards the PPP equilibrium levels. These results appear to support the argument that the US dollar based real exchange rates of Indonesia, the Philippines, Singapore and Thailand display more evidence in favour of LSTAR−type nonlinearity rather than ESTAR type nonlinearity. This implies that the LSTAR model is a more effective tool to predict the future behaviour of these exchange rates. Choosing the appropriate form of nonlinear exchange rate adjustment towards its equilibrium level is necessary as the exchange rate may act as a policy tool in stabilizing the economy of this region.

Caporale and Spagnolo (2004) compare the ability of nonlinear and standard linear models to capture the dynamics of foreign exchanges rates in the presence of structural breaks. The analysis is conducted using monthly data of the local currencies against the US dollar for three countries, Indonesia, South Korea and Thailand, over the period 1970:1–2001:5. The results suggest that a Markov regime-switching model with shifts in the mean and variance is more appropriate than a STAR model and a standard random walk model to capture the nonlinearities in exchange rates.

Given the finding of a unit root in the exchange rate is not robust to nonlinear specifications, Leon and Najarian (2003) use three alternative nonlinear models to examine the stationarity of deviations from PPP in the context of nonlinearity and the symmetry of adjustment toward PPP. These three alternative nonlinear models are: (i) a Time Varying Threshold Autoregressive Model (TVTAR), which allows asymmetrical adjustment when real exchange rates deviate from forecasts, (ii) a Bi-parameter Smooth Transition Regression (BSTR), which allows for asymmetric adjustment between the middle and outer regimes, and (iii) a Markov Switching Model (MSM), where the change in the regimes in exchange rates dynamics is governed by an unobservable Markov chain. Among these models, a 3-regime smooth transition autoregressive model with asymmetric speeds of adjustment between regimes performs best, but not across all countries, while the Markov-Switching model performed the least.

Employing monthly data to estimate the models for 26 countries, their results provide evidence to support stationarity in almost every case when nonlinearity is allowed for. Their results also provide evidence to support asymmetric adjustment dynamics although that asymmetry differs across countries. In this case, they uncover variations in magnitudes, frequencies, and durations of the deviations of exchange rates from fixed and time-varying thresholds, both between over-appreciations and over-depreciations and between industrial (all G7 members) and emerging (Asia and Latin America) economies. In particular, deviations during periods when the exchange rate is below forecasts (over-valued) are double that of during periods of under-valued, and is larger for emerging than for industrial economies.

Arghyrou et al (2005) use the Quadratic Logistic Smooth Transition Error Correction Model (QL-STECM), as introduced by van Dijk et al (2002), when investigating asymmetric adjustment in the nominal exchange rates between the Greek Drachma and the Turkish Lira against the ECU (the Euro since 1999). The QL-STECM is considered better than the TAR and ESTAR models since it not only allows the response of exchange rates to depend on the size of the deviation from equilibrium, but also the sign of the deviation from fundamentals. This model allows for different responses to under-valuations and over-valuations, allowing assessment of the importance of asymmetry in the exchange rate. Employing quarterly data over the period of 1982(1)-2000(4) for Greece and 1986(1)-2001(3) for Turkey where they model fundamentals using PPP and 1980(1)-2000(4) for Greece and 1987(1)- 2001(3) for Turkey in the case of FPMM fundamentals, they present some results of non-linear adjustment. This evidence in moderate and high inflation environments, of which Greece and Turkey are representative examples, would suggest that non-linearity is persistent.

1.3. EXCHANGE RATE REGIMES IN EAST ASIA

Over decades, most of these four emerging economies have shifted from fixed exchange rate regimes, to fixed-but-adjustable exchange rate regimes with sporadic abrupt devaluations, to managed floats, and finally, in the aftermath of the 1997 currency crisis, to a free-floating exchange rate arrangement. Each regime has its advantages and disadvantages. Fixing the exchange rate helps to reduce transaction costs and exchange rate risk. It can also operate as a credible nominal anchor for monetary policy. However, the dollar peg system employed before the crisis is believed to be part of the cause of a loss of confidence in their currencies in 1997. Alternatively, a floating exchange rate regime enables the domestic central bank to pursue an independent monetary policy. Indonesia, Korea, and the Philippines moved to a floating exchange rate regime following the crisis, while Malaysia started pegging its currency to the U.S. dollar in September 1998.

In the following discussion of each country's exchange rate regime, we refer to, firstly, Table 1 which shows the official IMF categorizations of exchange rate regimes for these four countries, which is based on their own declaration concerning their exchange rate regimes, and, secondly, Table 2 showing the de facto classifications of exchange rate regimes identified by Reinhart and Rogoff (2004). These two tables explore contradictions between the prevailing exchange rate regime and the de facto way exchange rate policy is actually conducted. As an illustration, a regime that is categorized as floating-rate -independently or managed- might, in effect, be a peg with which the country keeps its exchange rate within a narrow margin close to a fixed rate.

Tables 1 and 2 compare the exchange rate regime for each of these economies, in particular with respect to three major categories; fixed, intermediate and floating regimes. We identify a contradiction between measures in the case of the Philippines, whose exchange rate regime since 1984 is classified by the IMF as floating, while the de facto classification is intermediate before August 1995, fixed between September 1995 and June 1997, and intermediate from December 1997 until the present-day.

1.3.1. Indonesia

The government of Indonesia fixed the rupiah to the U.S. dollar between 1970 and 1971. On 15 August 1971, following the floating of the U.S. Dollar, the Rupiah was devalued by 9.7% from Rp378.00 to Rp415.00 per American dollar.[25] Since then, the floating of the U.S. Dollar has led to the continuing devaluation of the Rupiah and reduction of gold content, forcing the country to adopt the exchange rate arrangement of crawling band to US dollar. In November 1978, after a major devaluation, the Bank Indonesia de jure introduced an effective rate on a controlled, floating basis, with the external value of the Rupiah determined against a basket of currencies of its main trading partners. Although this attempt was considered by most economists to be of little help, the central bank insisted on maintaining the managed float policy and even considered a wider range of currencies in 1983, immediately following another major devaluation. By contrast, Reinhart and Rogoff (2004) claim that the de facto exchange rate regime adopted by Indonesia during this period is a crawling peg to the U.S. dollar, in which the

[25] See http://intl.econ.cuhk.edu.hk/exchange_rate_regime

Rupiah slides by several percent per year to offset the inflation gap between home and abroad.

In the face of free capital mobility and inadequate international reserves during prominent Asian financial crisis, on 14 August 1997, Bank Indonesia swapped a managed floating exchange rate regime for a free-floating one, implying that the exchange rate of the Rupiah against the US dollar was to be determined solely by the market. Thus, the ongoing exchange rate mirrors the crossing point of supply and demand of domestic currency in terms of the US dollar. During periods of irregular exchange rate fluctuation, the bank intervenes in the foreign exchange market, buying or selling Rupiah in order to counter, respectively excess demand for or supply of the dollar, and so facilitate a stable exchange rate.[26]

The free-floating exchange rate regime is designed to discourage imprudent overseas borrowing, since market players have to consider the cost of possible movements of the Rupiah. With imperfect domestic financial markets, such as a thin foreign exchange market and limited availability of hedging instruments, a floating rate system often leads to high volatility with adverse consequences for stability. Therefore although the bank formally adopts a floating rate system, in practice it considers that smoothing of exchange rate movements is necessary. This is in line with Calvo and Reinhart (2000)'s proposition that very few countries adopting a floating rate system rule out interventions to curb volatility in their exchange rates. Such interventions are conducted both through direct intervention on the foreign exchange market and through the use of interest rates.

[26] This is commonly known as sterilization.

1.3.2. South Korea

Korea pegged its currency to the US dollar between 1974 and 1980, during which time it suffered four major devaluations. The first devaluation occurred in mid 1971 in response to the establishment of a fluctuating certificate rate system. The Korean Won was cut from W327.40(Buy)/328.90(Sell) to W370.00/371.60 per U.S. Dollar.[27] The second devaluation happened in December of the same year when the government of Korea reduced the gold content of the Korean Won by 7.89%, following the devaluation of the U.S. Dollar. The next devaluation came in mid 1972 when the Won declined to W399.00 per U.S. Dollar. Following the 1973 devaluation of the dollar, Seoul reduced the gold content of the Korean Won by 10% so as to retain the unit's exchange rate at W399.00 per U.S. Dollar. With increasing oil prices and higher imports costs, the gold content of the Korean Won was cut by 46.88%, and the basic rate devalued to W480.00 per U.S. Dollar. At the same time, the fluctuating certificate rate depreciated to W484.00 per U.S. Dollar. The exchange rate in the exchange certificate market was maintained around W484.00 per U.S. Dollar.[28] The Ministry of Finance delegated to the Bank of Korea additional powers to approve foreign exchange transactions.

In February 1980, almost 19 years after it was implemented, the single currency peg system against the U.S. Dollar was abolished. The government introduced a controlled, floating effective rate, linking to a basket of its major trading partners' currencies, in particular the U.S dollar, the Japanese Yen, German Mark and Canadian

[27] World Currency Year Book 1984
[28] IMF Annual Report on Exchange Arrangement and Exchange Restriction (IMF)

Dollar. The regime, commonly known as the multiple currency basket peg system. allows the currency to fluctuate within a percentage range against the fundamental rate.[29]

In March 1990, the bank swapped the effective rate for a Market Average Rate (MAR), which is known as a managed floating exchange rate regime, with the exchange rate determined by the market forces in the interbank market, the Seoul foreign exchange market. Under the MAR system, the intra-day variation of the Korean Won-U.S. Dollar spot rate is fixed within a narrow band. The central bank of Korea restricted the banks from quoting rates too close to the upper or lower limits of the band (Chung et al, 2000, p.9-11). The fluctuation range of the exchange rate in the inter-bank market was widened from 0.4% to 2.25% during 1990-1995.[30]

The contagion factor from the Thai Baht's steep devaluation and Thailand's decision to float its currency on 2 July 1997 pushed the Korean Won to depreciate rapidly. Attempting to defend the local currency, the Korean government widened its Won trading band from 2.25% to 10% on 19 November 1997, and finally abolished the band, allowing the Won to float on 12 December 1997 (Chung et. al, 2000, p.12).

1.3.3. The Philippines

During the 1970s, the country had a multiple rate structure whereby rates for foreign exchange transactions on exports, imports and foreign debts were set on the basis

[29] This is commonly known as crawling band.
[30] See http://intl.econ.cuhk.edu.hk/exchange_rate_regime

of a daily "guided rate". From 1970 to 1973, the government forced exporters to change around 80% of their foreign exchange earnings at an "official rate" which was fixed at 3.90 peso per U.S dollar. The rate was considered low and detrimental to exporters. leading to massive complaints from business players. As a result, the government exchanged the policy for stabilization tax on traditional exports. However, this new policy was also considered to be another form of stealing from traditional exporters (Bautista, 1987).

During the 1980s, following increasing economic growth in the region and the 1983 financial crisis, the government of the Philippines liberalized the foreign trading sector. In October 1984, the multiple rate structure was abolished and a floating exchange rate regime introduced. Under the new regime, supply and demand in the exchange market determined the inter-bank rate. The central bank only intervened in the market in order to maintain an orderly market condition and any other objectives related to political interests.

In 1992, the government liberalized and simplified exchange regulations for trade and non-trade transactions, allowing direct repatriation and remittances without preceding endorsement from the central bank. Exporters were allowed to buy and sell foreign exchange without restriction, as well as to maintain foreign currency accounts and transfer foreign exchange abroad for deposit or investment purposes. However, restrictions on foreign investments and foreign borrowings remained in place. The central bank continued to enforce a ceiling on foreign exchange positions in domestic banks' account balance and compel them to sell their excess foreign exchange to other commercial banks or to the monetary authority. In mid 1993, the peso began to depreciate because of speculative pressures following a sizable trade deficit.

Between September 1995 and June 1997, the bank tied its currency to the dollar, albeit rather loosely, by combining discretion and market pressure with varying weights. However, following the end of a long period of relative exchange-rate stability in East Asia with the devaluation of the Thai baht in July 1997, the Philippine peso also devalued with monthly year-on-year depreciation jumping to 10.45% in July 1997, compared with only 0.69% the previous month and single digit annual rates of change prior to the crisis.[31] A conventional prescription given by the IMF is to use contractionary monetary policy to counter depreciation pressures rather than targeting any particular exchange rate level (see Boorman et al., 2000, p. 8). In the aftermath of this well known Asian financial crisis, the country adopted a free-floating regime in December 1997, which remains in place until the present.

1.3.4. Malaysia

Malaysia pegged its currency to the Pound Sterling during the Bretton Woods period. In June 1967, the unit of M$ was created but still linked to the British currency. In June 1972, following the floating of Sterling and the breaking up of the Sterling area, the government of Malaysia adopted the U.S. Dollar as the intervention currency replacing Sterling. As with most East Asian economies, during this period, Malaysia adopted U.S.

[31] The annual depreciation rate of the peso stood at 52.06% in 1997 compared with 0.28% in 1996.

dollar peg systems for its exchange rate mechanism. In support of the Malaysian Government, the Bank Negara Malaysia managed exchange rate controls in which the effective rate was set up with a variable range.

In June 1973, Malaysia replaced the effective rate to its dollar on a controlled. floating basis, with the Bank Negara Malaysia intervening only to maintain orderly market conditions and to avoid excessive fluctuations in the value of the Ringgit in terms of Malaysia's trading partners and the currencies of settlement (Ariff, p.329).

In June 1975, the Malaysian government replaced the controlled, floating effective rate with a new exchange rate regime in which the external value of the Ringgit was to be determined in terms of a basket of representative major currencies, weighted on the basis of the major currencies of settlement, as well as that of currencies of countries which were the major trading partners of Malaysia (Ariff, p.159).

From the time the M$ was officially renamed in August 1975, becoming the Ringgit (RM), it was stable against the dollar, although the monetary authority officially adopted a multiple currency basket system. However, following the Asian financial crisis, in July 1997, the exchange rate of the Ringgit ceased to be determined by the demand and supply in the foreign exchange market. In September 1998, the Bank returned to a fixed exchange rate system, pegging the Ringgit to the U.S. Dollar at a rate of RM3.80 per $1. The peg remains in place now.

1.4. Methodology

1.4.1. Models of equilibrium nominal exchange rates

Exchange rates are extremely complex variables that economists and financial engineers historically have found to be difficult to model effectively. However, a new approach concentrating on six popular explanations for nominal exchange rate determination as extended to the PPP, will be examined in this section. The first explanation is, naturally the PPP itself. According to PPP theory, the exchange rate will adjust so as to offset differences in domestic and foreign inflation rates, with the result that the same quantity of internationally traded goods can be bought at home as abroad with a given amount of the domestic currency.[32] This condition should hold, otherwise there is an arbitrage opportunity to purchase goods in the country where they are cheaper, by converting money into the currency of that country, and resell them in the country where they are more expensive.

The second explanation is the relative permanent output shock model. Balassa (1964) says that exchange rates appreciate when the differentials in the production of traded goods between two countries increases. In addition, Bahmani-Oskooee (1992) and Dibooglu (1996) employ cointegration analysis to show that exchange rates and productivity differentials are cointegrated and thus have a long-run relationship in developed economies when compared to the USA, supporting the Balassa model, evidence for which has also been found by Halpern and Wyplosz (1997), Grafe and

[32] While the word parity basically means equality, the phrase purchasing power itself refers to the value of money. Accordingly, purchasing power parity is considered as the equal value of money.

Wyplosz (1999), Krajnyak and Zettelmeyer (1998), and Crespo-Cuaresma et al (2004).[13] Exchange rates will also appreciate permanently following positive and permanent demand shocks (Rogoff, 1996) relative to its main trading partners. Conversely, the exchange rate will depreciate if there are economy-wide supply shocks. On the other hand, in the Balance of Payment (BOP) flows model, a relative rise in domestic economic activity, which leads to increase imports and/or decrease export, results in a depreciation of the domestic currency value.

The reason for this disparity is as follows. In the monetary model, an increase in domestic economic activity gives rise to an increase in the demand for domestic money, which leads to an appreciation of the domestic currency. By contrast, in the BOP flows model, an increase in domestic economic activity results in a deterioration of the domestic trade balance, leading to a depreciation of the domestic currency. So the overall effects of permanent output shocks are ambiguous.

In the third explanation, the Flexible Price Monetary Model (FPMM), a rising interest rate differential is assumed to lead to a decline in the value of the domestic currency. The reason for this is that, in the monetary model, interest rate differentials reflect differences in expected inflation rates, which in turn reflect differences in expected future monetary growth rates. If a country experiences a rise in domestic interest rates, it is because inflationary expectations in that country have risen. Thus, according to the FPMM, a relative rise in domestic interest rates, which reflects an increase in domestic inflationary expectations, will give rise to a depreciation of the domestic currency's value. By contrast, the traditional BOP flows model of exchange rate

[13] See also Bahamani-Oskooee and Rhee (1996), De Broeck and Slok (2001), Sarno and Taylor (2001), Egert (2002), Egert and Lahreche-Revil (2003).

determination, where a relative rise in domestic interest rates results in an appreciation in the value of the domestic currency.

The reason for this disparity is as follows. In the case of a rise in domestic interest rates, the domestic currency will depreciate in the monetary model as the demand for domestic money declines. In contrast, in the BOP flows model, a rise in domestic interest rates increases the capital into the country, which results in an appreciation of the domestic currency. So the overall effects of interest rate differentials are ambiguous.

In the next explanation, Shafer and Loopesko (1983) and Boughton (1987) present empirical results confirming a long-run relationship between exchange rates and interest rate differentials. Assuming perfect asset substitutability, the real exchange rate will appreciate significantly if the real interest differentials become wider. In addition, Frankel (1979) develops a model of real interest rate differentials in which he states that a rapid and unexpected domestic money supply growth may cause sizeable downward pressure on the value of domestic currency if it (1) works to lower real interest rates temporarily leading to capital out-flow and (2) indicates to the market that monetary growth will proceed at a new faster pace in the future.

In the fifth model, we take empirical results from Dornbusch and Fischer (1980), Hooper and Morton (1982), Gavin (1991), Faruqee (1995), and Obstfeld and Rogoff (1995), in particular their finding that, in the long-run, the relationship between net foreign assets and the exchange rate is negative. This implies that, in equilibrium, a country suffering from negative net foreign assets must have a trade surplus in order to finance their payments on interest and dividends which could be done through depreciating its exchange rates. Hence, any changes in net foreign assets have a long-run effect on the exchange rate given that goods produced in different countries are not perfect substitutes.

Finally, in the sixth explanation, Gross (1987) extends the popular asset market model of exchange rate determination when testing the model on DM, Yen, and UK pound exchange rates vis-à-vis the dollar by examining the implications of having two large countries and allowing trade in assets denominated in multiple currencies. He presents a strong theoretical case for the importance of the current account in determining exchange rates in which nonzero current account balances imply changes in a country's net foreign asset position which affect exchange rates as investors rebalance their portfolios. On the other hand, Macfarlane and Tease (1989) say that it was difficult to find and quantify any systematic link between the current account and the exchange rate.

Bring these various accounts together, we model equilibrium exchange rates using the general behavioural specification described in equation (1.1) below:[34]

$$s_t = \alpha + \beta_1 p_t + \beta_2 p_{usa,t} + \beta_3 (y^P - y^P{}_{usa})_t + \beta_4 (r - r_{usa})_t + \beta_5 (i - i_{usa})_t + \beta_6\, rnfa_t + \beta_7\, \Delta rnfa_t + \varepsilon_t \tag{1.1}$$

In (1.1), s denotes the market (observed) exchange rate of the domestic currency against the US dollar, p the price level approximated by the consumer price index, y^P the level of permanent output; r and i real and nominal interest rates respectively; $rnfa$ real net foreign assets, $\Delta rnfa$ the change in real net foreign assets, which serves as a proxy for current account; and ε_t a white noise error term. All variables, except from nominal and

[34] Equation (1) can be seen as the likely MacDonald (2003)' general behaviour model.

real interest rates are expressed in logs, with the subscript USA denoting variables referring to the USA and Δ being the first difference operator. Given that the log of negative numbers is not defined, when a country's net foreign asset position is recorded by IFS to be negative, an extra variable, real net foreign liabilities (*rnfl*), is added in (1.1). In such cases, real net foreign liabilities (assets) are defined as the maximum of the log of the absolute value of the liabilities (assets) and zero.

Equation (1.1) nests the benchmark model of exchange rate determination, PPP, which postulates that nominal exchange rates are a function only of the ratio of domestic to foreign price level. In particular, if $\alpha = 0$ and $\beta_1 = -\beta_2 = 1$ and $\beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$, the absolute form of PPP holds, while relative PPP allows for a non-zero constant. However, measurement errors in price levels result in weak-form PPP, which only requires $\beta_1 > 0$ and $\beta_2 < 0$ (see Taylor, 1988).

Our specification extends the benchmark PPP model by accounting for factors that can have an effect on exchange rates in the medium/long-run. First, it allows for the exchange rate effects of productivity shocks predicted by equilibrium models of the exchange rate, originally developed by Stockman (1980) and Lucas (1982), and discussed by Taylor (1995, pp. 24-26). Equilibrium models assume two countries producing two separate goods under full price flexibility, in which case y^p and y^p_{usa} respectively denote domestic and foreign (USA) full-employment output levels. In equilibrium models, an increase in domestic output relative to the foreign one has two analytically separate effects. The first, defined by Taylor as a money demand effect, results in an increase in demand for money which in turn reduces equilibrium domestic prices and ultimately leads to real and nominal exchange rate appreciation. This outcome is identical to the one caused by increases in domestic output in monetary models of exchange rate determination (see e.g. Frenkel, 1976). But monetary models do not account for a second possible effect captured by equilibrium models. This is defined by Taylor as a relative price effect according to which increased domestic output results in a reduction in its relative price vis-à-vis foreign production contributing towards real and nominal home currency depreciation.

Ultimately, whether the exchange rate will finally appreciate or depreciate as a result of a shock in productivity depends on the degree of substitutability between domestic and foreign goods, with real and nominal appreciation (depreciation) being more likely the higher (lower) the degree of substitutability. Real and nominal appreciation as a result of increased domestic productivity becomes higher if the domestic economy experiences Balassa (1964) – Samuelson (1964) effects. Such effects take place within the context of a two-sector (traded and non-traded) economy, when the productivity shocks apply to the traded sector only. Increased productivity in the traded sector results in higher wages throughout the economy. Although the prices of the traded sector remain fixed as a result of international goods' arbitrage, higher wages increase the prices of non-traded goods and the general price level, thus leading to real exchange rate appreciation.

Equation (1.1) also includes the nominal interest rate differential $(i-i_{USA})_t$, which aims to capture the effects of shifting medium-term inflation expectations, reflecting in turn demand conditions. In monetary models such as the one by Frenkel (1976), an increase in the domestic nominal interest rate relative to the foreign one signals an increase in domestic relative inflation and thus to nominal home-currency depreciation.

On the other hand, the real interest rate differential $(r-r_{USA})_t$, is included to capture the effects of price rigidities on exchange rates predicted by Dornbuch's (1976) sticky-price overshooting model. In Dornbuch's model, price rigidities imply that an increase in short-term interest rates also results in increases in real interest rates, leading to capital inflows and, finally, domestic currency appreciation (see also Hallwood and MacDonald 2000, pp. 175-209).

Modelling nominal exchange rates on price levels, relative output and nominal and real interest rate differentials is a variant of the hybrid monetary model proposed by Frankel (1979). We extend this specification by adding another two variables. The first is real net foreign assets $(rnfa)_t$, included to capture the wealth effects of accumulated current account imbalances. Portfolio balance models of the exchange rate, such as Branson (1983), predict that increasing the stock of foreign assets held by domestic agents results in expectations of future capital inflows, leading to a real appreciation of the domestic currency. More recently, however, authors such as Faruqee (1995) have developed stock-flow models of the exchange rate, arguing that in the medium-run the negative relationship between exchange rates and net foreign assets may be reversed. This is because the higher growth prospects of emerging economies cannot be financed by domestic savings only, but also through increased foreign borrowing leading to foreign liabilities. Nevertheless, in the long-run, payments on the existing stock of foreign liabilities would restore the negative relationship, as the higher the stock of foreign liabilities, the higher the need for real exchange rate depreciation to service the debt through an improved current account.

The last variable included in (1.1) is the change in the stock of real net foreign assets, $(\Delta rnfa)_t$, which serves as a proxy for the movements of the current account. The effects of the latter on the exchange rate remain unclear and subject to debate. Rogoff (1996, p. 663) has described the literature's agnostic state by stating that, "from a theoretical perspective, virtually any correlation between the current account and the real exchange rate can be easily rationalise. Ultimately, the correlation between the current account and the real exchange rate is an empirical matter, one that remains the subject of debate".

To summarize, in estimating (1.1) we expect to obtain $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3, \beta_4, \beta_5, \beta_6$, and β_7 can take both a positive and a negative sign. The fitted values of (1.1), denoted by $\bar{s}$, provide an estimate for the behavioural equilibrium level of the nominal exchange rate, in which case the estimated residuals of (1.1) represent the deviation of the market nominal exchange rate from its equilibrium level (the misalignment term).

1.4.2. Linear-error correction models

In this section we estimate benchmark linear models of exchange rate adjustment, described by equation (1.2) below:

$$\Delta s_t = \sum_{i=1}^{n} \beta_i \Delta s_{t-i} + \sum_{i=0}^{m} \gamma_i \Delta \bar{s}_{t-i} + \delta (s - \bar{s})_{t-1} + v_t \qquad (1.2)$$

where s denotes the market (observed) nominal exchange rate, $\bar{s}$ the equilibrium nominal exchange rate obtained from the fitted values of equation (1.1), Δ is the first difference operator and v is a white-noise error term. The speed of adjustment of the market exchange rate towards its equilibrium level is given by the coefficient of the error correction term $(s-\bar{s})_{t-1}$, which measures exchange rate misalignment.[35] According to the Granger representation theorem, a cointegrating relationship can be represented as an error correction specification and vice-versa, therefore lack of statistical significance of the δ coefficient suggests lack of cointegration in equation (1.1).

1.4.3. Tests for non-linear exchange-rate adjustment

Non-linearity is a hypothesis which we can test formally using the testing approach proposed by Saikonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993) and Teräsvirta (1994). This involves estimation of the artificial regression given by (1.3):

$$(s-\bar{s})_t = \rho_{00} + \sum_{j=1}^{k} \{\gamma_{0j}(s-\bar{s})_{t-j} + \rho_{1j}(s-\bar{s})_{t-j}(s-\bar{s})_{t-d} + \rho_{2j}(s-\bar{s})_{t-j}(s-\bar{s})_{t-d}^2$$
$$+ \rho_{3j}(s-\bar{s})_{t-j}(s-\bar{s})_{t-d}^3\} + \rho_4(s-\bar{s})_{t-d}^2 + \rho_5(s-\bar{s})_{t-d}^3 + u_t \qquad (1.3)$$

[35] An alternative modelling approach would be to substitute (1.1) into (1.2) and estimate the resulting equation $\Delta s_t = \beta(L)\,\Delta s_{t-1} + \gamma(L)\,\Delta(\pi' z_t) + \delta(s - \pi' z)_{t-1} + \varepsilon_t$, with z_t' defined as $[p_t, p_{usa,t}, (y^p - y^p_{usa})_t, (r-r_{usa})_t, (i - i_{usa})_t, rnfa_t,$ and $\Delta rnfa_t]$ We prefer equation (1.2) to this alternative because it requires estimation of a smaller number of parameters, an important consideration when estimating non-linear models using relatively short samples.

where $(s-\bar{s})_t$ is the exchange rate misalignment measured by residual from equation (1.1), d is the delay parameter of the transition function to be used in the non-linear models discussed below, $u(t)$ is a white-noise error term; and the rest of the variables are defined as per above. The null hypothesis of linear adjustment of the market exchange rate s to its equilibrium level $\bar{s}$ is described by H_0: $[\rho_{1j}=\rho_{2j}=\rho_{3j}=\rho_4=\rho_5=0]$ for all $j \in (1,2\ldots,k)$, with the autoregressive parameter k being determined by the partial autocorrelation function of the transition function $(s-\bar{s})$.[36] The testing procedure involves estimating (1.3) for all plausible values of d, testing in each estimation round the statistical significance of the linearity restrictions. If linearity is rejected for more than one values of d, the latter's optimal value is determined by the test score with the lowest p-value (i.e. the highest value for the test's score).

1.4.4. Non-linear error correction models

In this section we model the non-linear exchange rate dynamics identified above using the Quadratic Logistic Smooth Transition Error Correction Model (QL-STECM), discussed in detail by van Dijk et al (2002) and described by equations (1.4) to (1.7) below:[37]

[36] Granger and Teräsvirta (1993) and Teräsvirta (1994) advise against choosing k using information criteria such as the Akaike on the grounds that this may result in a downward bias, affecting the results of the non-linearity tests.
[37] Being a model of smooth transition, the QL-STECM is consistent with the assumptions of theoretical models of non-linear exchange rate dynamics which explicitly postulate a smooth adjustment between the inner and outer regimes (see e.g. Dumas, 1992). In addition, even if individuals are assumed to switch

$$\Delta s_t = \pi_t \mathrm{R}_{\mathrm{I}t} + (1-\pi_t)\, \mathrm{R}_{\mathrm{O}t} + \varepsilon_t \tag{1.4}$$

$$\mathrm{R}_{\mathrm{I}t} = \sum_{i=1}^{n} \beta_{iI} \Delta s_{t-i} + \sum_{i=1}^{k} \gamma_{iI} \Delta \bar{s}_{t-i} + \delta_{\mathrm{I}} (s-\bar{s})_{t-1} + \varepsilon_{\mathrm{I}t} \tag{1.5}$$

$$\mathrm{R}_{\mathrm{O}t} = \sum_{i=1}^{n} \beta_{iO} \Delta s_{t-i} + \sum_{i=1}^{k} \gamma_{iO} \Delta \bar{s}_{t-i} + \delta_{\mathrm{O}} (s-\bar{s})_{t-1} + \varepsilon_{\mathrm{O}t} \tag{1.6}$$

$$\pi_t = pr\,\{\, \tau^L \leq (s-\bar{s})_{t-d} \leq \tau^U \,\} = 1 - \frac{1}{1 + e^{-\sigma[(s-\bar{s})_{t-d} - \tau^L][(s-\bar{s})_{t-d} - \tau^U]}} \tag{1.7}$$

The QL-STECM models non-linear exchange rate dynamics through equations (1.5) and (1.6). These are linear error-correction models describing exchange rate dynamics under conditions of small and large exchange rate misalignment, respectively, describing two regimes, the inner ($\mathrm{R}_{\mathrm{I}t}$) and outer ($\mathrm{R}_{\mathrm{O}t}$) regime. The regimes are defined by two threshold values, the upper *(τ^U)* and the lower *(τ^L),* which define a band within which the speed of adjustment to equilibrium assumes a value different from the one prevailing outside the band. In addition, the regime is also determined by the value of the transition variable $(s - \bar{s})_{t-d}$, a lagged value of the misalignment term which can be interpreted as the publicly available market signal whose size agents use in order to assess whether currency trading takes place in conditions of inner or outer regime. We expect $\tau^L < 0$ and $\tau^U > 0$. Nominal exchange rates are mainly determined by $\mathrm{R}_{\mathrm{I}t}$ (the inner

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between random-walk and mean reverting behaviour in a sudden, discrete way, aggregate regime shifts are expected to be smooth rather than discrete, given that heterogeneous agents are unlikely to act simultaneously, even when making dichotomous decisions (Dumas, 1994).

regime) when the nominal exchange rate is close to its equilibrium value described by (1.1) and mainly by R_{O}, (outer regime) in periods of significant exchange rate misalignment. The speed of adjustment of the exchange rate differs between regimes if $\delta_I \neq \delta_O$. Size misalignment effects in the process of exchange rate adjustment would exist if $\delta_I < \delta_O$. A combination of $\delta_I = 0$ and $\delta_O < 0$ would be a special case of such effects, indicating that the exchange rate follows a random walk in the inner regime (R_I) but converges to its fundamentals' consistent equilibrium in the outer regime (R_O). It implies that nominal exchange rates adjust towards its fundamental value in the outer regime.

We could also see that the QL-STECM models actual exchange rate changes, Δs_t, as a weighted average of R_I and R_O, with the weights of each regime determined by π_t, the probability of the transition variable $(s-\bar{s})_{t-d}$ taking values in the inner regime. This probability is modelled using the quadratic logistic function in equation (1.7), where σ denotes the speed of transition between the two regimes while τ^L and τ^U, respectively denote the upper and lower limit of the inner regime. This functions has the properties that (i) π_t becomes constant as $\sigma \rightarrow 0$ and (ii) as $\sigma \rightarrow \infty$, $\pi_t = 0$ if $(s-\bar{s})_{t-d} < \tau^L$ or $(s-\bar{s})_{t-d} > \tau^U$ and $\pi_t = 1$ if $\tau^L < (s-\bar{s})_t < \tau^U$ (see Jansen and Teräsvirta, 1996). All three parameters (σ, τ^L and τ^U) are estimated by the model and suggest that the model also captures a certain type of sign effects implied from non-symmetric regime thresholds. This is another advantage of the QL-STECM as it implies that unlike the TAR and the ESTAR models[38], it does not impose symmetry on the values of the inner regime

[38] In the QL-STECM model, we test whether $\tau^L + \tau^U = 0$. In the case where $\tau^L + \tau^U = 0$, we conclude that the model is in effect equivalent to the ESTAR model since the speed of adjustment depends only on the size of the deviation of exchange rates from fundamentals. If $\tau^L + \tau^U \neq 0$, we say that the model is more

thresholds, thus allowing the capture of asymmetries in the process of exchange rate adjustment. Such asymmetries exist if $\tau^L + \tau^U \neq 0$; in particular if $\tau^L + \tau^U > 0$, negative misalignment values are corrected faster than positive ones, which implies that fundamental undervaluation is more likely than overvaluation. If, on the other hand $\tau^L+\tau^U<0$, fundamental undervaluation is corrected faster than overvaluation. Finally, if $\tau^L + \tau^U = 0$, exchange rate adjustment is symmetric, in which case the QL-STECM reduces to an ESTAR type-model, since the speed of adjustment depends only on the size of the deviation of exchange rates from fundamentals. It implies that deviations of exchange rates from the equilibrium in either direction are seen as equally bad.

1.5. DATA

Our data source is the International Financial Statistics (IFS) database of the International Monetary Fund (IMF) made available through Datastream. Due to non-availability of some of the series involved in our analysis on a monthly basis, we work with data of quarterly frequency. To avoid potential biases from mixing periods of fixed and floating exchange rate regime, we focus on those periods during which the exchange rates of the currencies we examine were not rigidly pegged to the US dollar, against which the countries examined followed a monetary policy of managed-floating. These are 1978(3)-2003(4) for Indonesia; 1975(3)-1998(3) for Malaysia, 1981(4)-2003(4) for the

general than the ESTAR model since the speed of adjustment depends both on the size and on the sign of the deviation from equilibrium.

Philippines; and 1980(1)-2003(4) for South Korea. Concentrating in periods of managed exchange rates makes our previous discussion on asymmetries in the process of exchange rate adjustment even more relevant.

Nominal exchange rates are defined as number of units of domestic currency per unit of foreign currency, so that an increase (reduction) denotes depreciation (appreciation) of the domestic currency. The movements of nominal exchange rates during the periods covered by our samples are presented in Figure 1.1. For all countries we observe a depreciation trend, with spikes in periods of discrete devaluations, most notably during the crisis of 1997/98. Not surprisingly, the Augmented Dickey-Fuller (ADF) unit root tests we have calculated and presented in Table 1.3 suggest that all series are non-stationary and they are integrated of order 1.

The econometric approach we use in section 1.4.1 above is based on a behavioural specification that includes variables accounting for a number of theoretical approaches to exchange rate determination. These are domestic and foreign (USA) price levels, relative permanent (full-employment) output levels, real and nominal interest rate differentials, current account imbalances and real net foreign assets. We define price levels to be consumer price indexes, and as shown in Table 1.3 all of which were found to be I(1) series when tested by ADF tests. GDP data is not available for the countries we examine on a quarterly basis; as a result, we follow studies such as the one by Clarida et al (1998) and approximate output using industrial or manufacturing volume indexes.[39,40,41] To smooth out the effects of demand shocks and thus obtain a measure of

[39] For Indonesia, an industrial or manufacturing production series was not available for the whole of the sample period covered by our analysis. Given the high importance of oil production for this country, we approximate output using the crude petroleum production index provided by IFS.

full-employment output, we follow the same studies and de-trend the output-proxy series by means of using a Hodrick-Prescott filter (Hodrick and Prescott, 1997).[42, 43] As shown in Table 1.3, the ADF and PP tests applied to all relative permanent output series reject the stationarity hypothesis.

Nominal interest rates are typically included in exchange rate modelling to capture the effects of inflation expectations and, by implication, cyclical demand conditions. For this purpose, our preferred variable is long-term government bond yields, however such a series was not available for all countries. As the best available proxy, we use the long-term lending rate (working-capital loans' rate) for Indonesia; the one-year money market rate for Malaysia, the one-year lending rate for the Philippines; the 10-year government bond yield for South Korea; and the 10-year government bond yield for the USA. Real interest rates are calculated using the Fischer equation, $r = i - \pi^e$ where r, i and π^e respectively denote real interest rate, nominal interest rate and expected inflation.

Real interest rates are used in real exchange rate modelling to capture Dornbusch (1976) type overshooting effects. These are based on price rigidities and result from expected capital gains created by increases in short-term interest rates. As a result, for all countries real interest rates are calculated using a short-term nominal interest rate, namely

[40] Given the high importance of manufacturing production for all four countries involved in our analysis, this approximation, also widely used in other econometric applications such as empirical models of monetary policy (see for example Clarida et al, 1998), can be considered a reasonable one.

[41] We are certainly believe that using available GDP data is more appropriate to estimate this model. We reserve this for our further research. However, the industrial, manufacturing or crude petroleum production index seem to capture relatively well the fundamentals driving aggregate production and can in principle be considered as a good proxy available.

[42] To obtain the Hodrick-Prescott trend, we set the value of a smoothing parameter at the recommended value for quarterly data of 1600.

[43] The size of our sample periods implies that in addition to permanent relative supply shocks, ultimately transitory yet relatively persistent demand shocks may also have an effect on the fitted output series. This implies that our relative permanent output series may capture both permanent supply and demand shocks dying out at a slow rate. As a highly persistent positive demand shock would result in real appreciation for the domestic country, this increases the possibility of obtaining a negative coefficient for β_3 in equation (1.1).

the domestic money-market overnight rate (federal funds rate for the USA). We define π to be CPI inflation over a period of a calendar year, with expected inflation π^e approximated using actual CPI inflation rates four quarters ahead so that $\pi_t^e = \pi_{t+4}$.[44] The ADF tests, as shown in Table 1.3, suggest that with two possible exceptions (the nominal interest rate differential in Korea and Malaysia), all interest rate differential series (both nominal and real) are stationary.

Finally, regarding real net foreign assets and current account imbalances, we would have liked to include these series into the analysis as percentages in GDP. However, due to the lack of availability of GDP on a quarterly basis, that was not possible. We have therefore used the level of real net foreign assets, calculated by deflating the nominal net foreign assets series provided by IFS using the CPI index. We use the change in the stock of real net foreign assets as a proxy for a country's current account position. All real net foreign series were found to be I(1), with their changes being stationary. Non-stationarity for nominal exchange rates, relative output and real net foreign assets implies that any econometric analysis aiming to model the nominal exchange rate using the variables discussed above has to be undertaken within a cointegration framework.

[44] This approximation is very common in empirical models of monetary policy (see Clarida et al, 1998).

1.6. EMPIRICAL RESULTS

1.6.1. Models of equilibrium exchange rates

Our sample periods cover approximately twenty five years, a data-span which, for the purpose of modelling real exchange rates, is better described as medium- rather than long-run. Within this medium-term time horizon, ultimately transitory yet long-memory shocks, such as shifts in relative demand and real interest rate differentials, can cause exchange rate effects, along with those caused by changes of a more permanent nature, such as productivity gains. To capture the full range of these effects, we estimate (1.1) using a general-to-specific approach, involving sequential elimination of all statistically insignificant variables.

Estimate of our parsimonious specifications are reported in Table 1.4. For all countries, p and p_{usa} are statistically significant and have the theoretically expected signs. Relative output is also statistically significant for all equations, however its sign differs across countries. For Indonesia and the Philippines β_3 is negative, which suggests that the Balassa-Samuelson and money demand effects discussed above dominate the relative price effect. The opposite holds for Malaysia and South Korea, countries for which we obtain a positive sign for β_3. Nominal interest rate differentials are significant for two countries (Indonesia and the Philippines), with the theory-consistent positive sign, while real interest rates are also significant for two countries, Malaysia and the Philippines, again entering (1.1) with the expected negative sign.

Turning to real net foreign assets, these are significant for three out of four countries but with varying sign. For the Philippines and South Korea, foreign assets accumulation results in nominal depreciation. This finding is consistent with the predictions of the stock-flow approach, and is not surprising, given the high-growth of these economies during the relatively short time period we work with. By contrast, in Malaysia, for which our sample period is larger, net foreign assets enter (1.1) with a negative sign, which is consistent with the predictions of traditional models of the nominal exchange rate, as well as with those of the stock-flow approach for the long-run horizon. It is interesting to note that in the case of Malaysia, the nominal exchange rate responses to the stock of net foreign assets only, not to those of net foreign liabilities.

Similar non-monotonic results are obtained for the two countries for which our proxy for the current account, the change in real net foreign assets or liabilities, is statistically significant. In the case of Malaysia, the exchange rate responds (with a positive sign) to changes in real net foreign assets, but not to those of net foreign liabilities; in the case of the Philippines, the link is even more complex with the exchange rate depreciating when the change in real net foreign assets increases and appreciating when net foreign liabilities increase. These findings reaffirm the ambiguity of the nature of the link between exchange rates on the one hand and current account/real assets' accumulation on the other, but add an extra element to it, as they suggest that the nature of the link may differ not only across countries, but also within the same country, depending on the sign of the current account balance and the net foreign assets' position (surplus/deficit, net assets/net liabilities). Providing a theoretical explanation for this ambiguity exceeds the scope of an empirical study such as the present one; however our empirical findings can motivate theoretical work rationalizing and formalizing the non-monotonic link identified here.

The cointegration ADF tests reported at the end of Table 1.4 suggest that three out of four equations are clearly cointegrated at the 5 per cent level or better, which ensures that the findings discussed above are not reflecting spurious correlation among the variables involved. For the remaining equation (Malaysia), the cointegration test is less clear, with the ADF score being significant only at the 10 per cent level. As discussed in the introduction, this ambiguity may reflect the low-power of the ADF test and/or the existence of non-linear cointegration, a hypothesis formally tested in section 1.6.3 below. Finally, it is worthy to note that as a test of robustness we have estimated equation (1.1) adjusting the Hodrick-Prescott filter by 10, 20, 30, 40 and 50 percent upwards and downwards. The results reported in Table 1.4 remain robust to these changes.

To summarise, our empirical findings in this section suggest that over the past three decades nominal exchange rates in all four Asian economies examined by our analysis have been influenced by both monetary and output shocks and, at different degrees and ways, by factors such as nominal and real interest rate differentials, foreign assets' accumulation and changes in current account balances. These, combined with the fact that the exchange rate effects of changes in relative output differs across countries, leads us to the conclusion that the exchange rates of the four Asian economies we examine presents similarities but, at the same time, strong elements of idiosyncratic behaviour, which confirms the possible biases that may arise by modelling exchange rate using fixed-parameter panel data techniques.

1.6.2. Linear-error correction models

We estimate (1.2) using a general-to-specific approach starting with 16 lags and gradually reducing the model so that it only includes statistically significant terms. Table 1.5 presents our parsimonious estimates. All equations were estimated including intercept dummy variables taking the value of 1 for periods of currency crises and other major economic events, zero otherwise. The dummies which proved to be statistically significant are reported at the bottom of the Table 1.5. Excluding the crisis dummies does not change significantly the qualitative nature of our findings, but results in non-normality and heteroscedasticity in the residuals.

The picture emerging from Table 1.5 is rather mixed. For two countries, the Philippines and South Korea, the error-correction coefficient is statistically significant, confirming our cointegration findings reported above; for Indonesia and Malaysia, the opposite holds. In addition, for the two countries for which we obtain cointegration, the speed of adjustment to equilibrium is rather slow, particularly in the case of Korea. These results may be yet another reflection of the two exchange-rate puzzles earlier discussed, or an indication of misspecification due to the existence of non-linearities in the process of exchange rate adjustment.

1.6.3. Tests for non-linear exchange-rate adjustment

Table 1.6 presents the results of our non-linearity tests. In all cases we reject the hypothesis of linear exchange rate adjustment at the 5 per cent level or better, which implies that the linear equations reported in Table 1.5 are mispeficied.

1.6.4. Non-linear error correction models

We estimate the QL-STECM following the same general-to-specific econometric approach used in section 1.6.1 above, reporting our parsimonious estimates in Table 1.7. Like their linear counterparts, the models in Table 1.7 include dummy variables defined for periods of exchange rate crisis and other important economic events. This ensures that our estimated models capture systematic non-linearity rather than the effect of isolated events.

Table 1.7 provides strong evidence of non-linear exchange rate adjustment. In all countries we find the error correction term to be statistically insignificant in the inner regime, suggesting that for low values of the misalignment term nominal exchange rates follow a random-walk pattern. On the other hand, the error-correction term is always significant in the outer regime, which suggests that for larger misalignment values arbitrage forces ensure the reversion of the exchange rate toward its fundamentals-determined equilibrium value. The speed of adjustment to equilibrium in the outer regime differs across countries, being faster in Indonesia and the Philippines and relatively moderate in Malaysia and South Korea. For Indonesia and the Philippines, the width of the band defining the inner regime is wider, which suggests that in these countries exchange rate misalignment is more persistent, but then corrected in a way more abrupt.

With regards to asymmetry, for three out of four countries, the absolute value of the estimated lower threshold is slightly higher than that of the upper, whereas in the remaining one (South Korea) the two thresholds are equal in absolute terms. These findings are consistent with the floating-rate exchange rate policy followed by the countries we examine during the larger part of the post-Bretton Woods system, which involved targets for the rate of depreciation against the US dollar, however the difference between the regime thresholds is statistically significant only in the case of Indonesia, which suggests that the evidence in favour of sign misalignment effects in exchange rate behaviour is not as strong as that in favour of size effects. The equations reported in Table 1.7 are well-specified and present higher explanatory power than the linear models in Table 1.5, as suggested by the lower regression standard error they produce.

Figure 1.2 presents the estimated exchange rate misalignment term obtained by plotting the estimated residuals of equation (1.1) against the estimated thresholds of the inner regime. A number of interesting observations emerge. First, exchange rate misalignment is typically within the inner regime, although outer-regime values are not uncommon, particularly for Malaysia and South Korea. Second, we observe that incidences of discrete devaluations are typically preceded by pronounced exchange rate overvaluation that fall within the outer regime. In particular, Figure 1.2 suggests that in all countries the crisis of 1997-98 was preceded by substantial overvaluation against the US dollar. This overvaluation seems to have been particularly pronounced in the case of

Indonesia, where the overvaluation of the market rate relative to its equilibrium value seems to have been in the range of 20 percent. Overall, Figure 1.2 suggests that the devaluations which took place in the region in 1997/98 were justified by the movements of the underlying economic fundamentals. Our findings are contrary to the findings of Saxena (2002) who find that over the period of 1980-1998, none of three models used to estimate the equilibrium level of real exchange rate for Indonesia, namely co-integration approach, unobserved component model and structural vector autoregression (SVAR), suggest overvaluation of the Rupiah prior to the depreciation at the time of the Asian crisis in 1997.

Finally, Figure 1.2 suggests that at the end of our sample periods the dollar exchange rate of the Indonesian Rupiah and the South Korean Won were overvalued quite significantly, whereas that of the Malaysian Ringgit was fundamentally undervalued. To restore equilibrium, Figure 1.2 suggests that the Rupiah and the Won would subsequently have to depreciate against the US dollar, while the Ringgit would have to appreciate. In 2004-2005 the Rupiah has indeed depreciated against the US dollar, whereas the recent re-floating of the Ringgit has also led to a slight appreciation of the Malaysian currency. By contrast, during 2004-2005 the South Korean Won has appreciated even further against the US dollar, suggesting that the Korean currency may be vulnerable to currency turbulence in the future.

1.7. CONCLUSIONS

This chapter has modelled nominal exchange rate behaviour in four fast-growing emerging Asian countries, namely Indonesia, Malaysia, the Philippines and South Korea for the period during which these countries implemented a policy of managed exchange rate floating against the US dollar. We modelled equilibrium nominal exchange rates using a general behavioural equation, consistent with a variety of theoretical approaches and found equilibrium nominal exchange rates to be a function of domestic and foreign price levels, relative permanent output shocks, nominal and real interest rate differentials as well as the level of and change in net foreign assets. We also found that individual countries present significant elements of idiosyncratic exchange rate behaviour, highlighting the risks of biases involved in modelling exchange rates using panel-data techniques. In relation to this, an interesting empirical finding of our analysis is that the relationship between nominal exchange rates on the one hand and real net foreign assets/current account on the other is in some cases non-monotonic. Finally, we obtained strong evidence of non-linear dynamics in the process of the adjustment of the nominal exchange rate to its extracted equilibrium level. More specifically, for all countries examined we found that the speed of reversion of the exchange rate to its equilibrium value is a function of the size and, at least in one case, the sign of the misalignment term. Our findings suggest that the currency devaluations that took place in 1997-98 were entirely justified by economic fundamentals, as prior to the financial crisis that hit the region the exchange rates of all four countries, especially the one of Indonesia, were significantly overvalued against the US dollar.

Our work can be extended in several ways. In the empirical level, we could use our empirical methodology to study the dynamics of nominal exchange rates in other sets of countries and determine whether the non-linear/asymmetric exchange rate dynamics are a common future of exchange rate behaviour. In terms of theoretical work, we can use the empirical findings of our study to motivate work on the non-monotonic link between the current account and the nominal exchange rate and, also, to build a model of non-linear exchange rate behavior based on asymmetric policy preferences.

Table 1.1. De Jure Exchange Rate Regime (Official Classification by the IMF)

Country	Period		Exchange rate regime classification	
	From	To	Narrow	Broad
Indonesia	Nov 78	Jul 97	Managed Floating	Intermediate
	Aug 97	Dec 04	Free Floating (Managed floating with no pre-determined path for the exchange rate)	Floating
Korea	Aug 76	Jan 80	Peg to USD	Fixed
	Feb 80	Nov 97	Managed Floating	Intermediate
	Dec 97	Dec 04	Independently floating	Floating
Philippines	Oct 81	June 82	Limited flexibility with respect to USD	Intermediate
	Jul 82	Sept 84	Managed Floating	
	Oct 84	Dec 04	Independently Floating	Floating
Malaysia	Sep 75	Mar 93	Limited flexibility with respect to USD	Intermediate
	Apr 93	Aug 98	Managed Floating	
	Sep 98	Dec 04	Pegged to USD	Fixed

Sources: Frankel, et al. (2002) and IMF Annual Report on Exchange Arrangements and Exchange restriction (Dec 2004)

Note: This classification of exchange rate regimes is based on a quarterly database from the IMF which encompasses a total of ten regime categories, based on officially reported exchange arrangements.

Table 1.2. De Facto Exchange Rate Regime (Reinhart and Rogoff, 2004)

Country	Period		Exchange rate regime classification	
	From	To	Narrow	Broad
Indonesia	Dec70	Aug71	Peg to US dollar	Fixed
	Aug 71	Oct 78	De facto crawling band to US dollar	Intermediate
	Nov78	Jul97	De facto crawling peg to US dollar	
	Aug97	Jan02	Freely floating/Free falling*	Floating
	Apr99	Dec01	Freely floating	
Korea	May74	Feb80	Peg to US dollar	Fixed
	Feb80	Nov94	Pre announced crawling band	Intermediate
	Nov94	Nov97	De facto crawling peg to US dollar	
	Dec97	Jun98	Freely falling*	Floating
	Jul98	Dec01	Freely floating	
Philippines	Dec 72	Sep 83	De facto crawling band around USD	Intermediate
	Oct83	Feb85	Managed floating	
	Mar85	Apr92	De facto crawling peg to US dollar	
	May92	Aug95	De facto band around US dollar	
	Sep95	Jun97	De facto peg to US dollar	Fixed
	Jul97	Dec97	Freely floating/Free falling*	Floating
	Dec97	Dec01	Managed floating	Intermediate
Malaysia	Jun67	Aug75	Peg to pound sterling	Fixed
	Sep75	Jul97	Limited flexibility with respect to US dollar	Intermediate
	Aug97	Sep98	Freely floating/Free falling*	Floating
	Sep98	Dec01	Pegged arrangement	Fixed

Source: Reinhart and Rogoff (2004).

Note: *) Free falling is a new separate category for countries whose twelve – month rate of inflation is above 40%.

Table 1.3. Unit Root Tests

Level	Indonesia		Korea		Philippines		Malaysia	
	1978(3)-2003(4)		1980(1)-2003(4)		1981(4)-2003(4)		1975(3)-1998(3)	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
s	-0.637	-1.040	-1.217	-1.583	-1.931	-1.751	-0.932	-0.353
p	0.355	-0.063	-0.263	-2.736*	-2.515	-2.253	-0.306	-1.541
p_{usa}	-1.801	-6.089***	-1.839	-4.793***	-2.011	-4.185***	-2.063	-5.118***
$y^p - y_{usa}{}^p$	-0.127	-0.570	-1.575	-1.740	-1.819	-1.885	-1.225	-1.279
$i - i_{usa}$	-3.593***	-3.019**	-1.985	-2.653*	-3.797***	-3.997***	-1.960	-2.088
$r - r_{usa}$	-4.785***	-4.064***	-3.083**	-3.854***	-3.482**	-3.309**	-2.614*	-2.952**
rnfa	-1.709	-2.619***	-1.276	-0.916	-1.434	-1.250	-0.766	-0.551
rnfl			-1.466	-1.419	-0.903	-1.078		
Δ *rnfa*	-4.473***	-11.253***	-4.294***	-8.110***	-5.204***	-8.541***	-4.299***	-8.438***
Δ *rnfl*			-4.386***	-6.887***	-4.349***	-6.974***		
1st Difference								
	Indonesia		Korea		Philippines		Malaysia	
	1978(3)-2003(4)		1980(1)-2003(4)		1981(4)-2003(4)		1975(3)-1998(3)	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
s	-4.621***	-7.860***	-4.089***	-7.003***	-4.432***	-6.251***	-4.528***	-6.239***
p	-4.725***	-4.998***	-5.237***	-6.440***	-3.753***	-5.319***	-2.644*	-8.209***
p_{usa}	-2.984**	-3.013***	-3.992***	-5.786***	-3.080**	-5.694***	-1.607	-3.126**
$y^p - y_{usa}{}^p$	-5.932***	-14.824***	-4.471***	-7.805***	-4.248***	-10.08***	-4.941***	-10.02***
$i - i_{usa}$	-5.673***	-9.155***	-4.780***	-7.914***	-4.929***	-12.08***	-4.169***	-8.560***
$r - r_{usa}$	-7.126***	-6.613***	-5.334***	-7.394***	-4.826***	-5.751***	-4.377***	-8.454***
rnfa	-4.473*	-11.254***	-4.294***	-8.110***	-5.204***	-8.541***	-4.299***	-8.437***
rnfl			-4.386***	-8.637***	-4.349***	-6.974***		
Δ *rnfa*	-8.081***	-25.987***	-6.869***	-19.296***	-6.394***	-19.715***	-6.048***	-21.72***
Δ *rnfl*			-8.634***	-23.369***	-6.848***	-15.96***		

*Notes: */**/*** denote significance at the 10%/5%/1% level respectively following MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 1.4. Equilibrium nominal exchange rate models

	Indonesia	Malaysia	Philippines	South Korea
Sample	1978(3)-2003(4)	1975(3)-1998(3)	1981(4)-2003(4)	1980(1)-2003(4)
Constant	2.080 (0.238)	0.966 (0.356)	1.014 (0.732)	6.295 (2.043)
P	0.982 (0.153)	0.930 (0.228)	1.514 (0.181)	2.362 (0.556)
p_{usa}	-0.343 (0.121)	-0.951 (0.165)	-1.345 (0.536)	-4.125 (1.557)
$y^p - y_{usa}^p$	-0.827 (0.305)	0.504 (0.106)	-0.194 (0.033)	0.740 (0.414)
$i - i_{usa}$	0.451 (0.062)		0.244 (0.082)	
$r - r_{usa}$		-0.196 (0.112)	-0.170 (0.062)	
Rnfa		-0.101 (0.030)	0.033 (0.013)	0.048 (0.024)
Rnfl			0.084 (0.015)	0.074 (0.020)
$\Delta rnfa$		0.346 (0.074)	0.029 (0.015)	
$\Delta rnfl$			-0.071 (0.019)	
R^2	0.97	0.61	0.98	0.79
ADF	-3.540	-2.604	-3.255	-2.954

Notes: Standard errors in parentheses; all variables are significant at 5% level or better; the lag structure of the reported ADF tests has been chosen using the Akaike information criterion.

Table 1.5. Linear error-correction models

	Indonesia	Malaysia	Philippines	South Korea
Sample	1978(3)-2003(4)	1975(3)-1998(3)	1981(4)-2003(4)	1980(1)-2003(4)
constant	0.000 (0.001)	-0.000 (0.001)	0.002 (0.002)	0.000 (0.001)
Δs_{t-1}				0.532 (0.063)
Δs_{t-2}				0.100 (0.037)
Δs_{t-3}	0.198 (0.033)	-0.231 (0.088)	-0.134 (0.064)	
Δs_{t-4}	0.077 (0.018)			
Δs_{t-5}			-0.145 (0.052)	
Δs_{t-6}	0.048 (0.024)			
Δs_{t-7}	0.040 (0.021)			
Δs_{t-8}				-0.113 (0.032)
Δs_{t-11}	-0.051 (0.024)		0.196 (0.054)	
Δs_{t-12}	-0.102 (0.019)			0.139 (0.032)
$\Delta\bar{s}$	0.273 (0.034)	0.126(0.063)	0.198 (0.055)	
$\Delta\bar{s}_{t-1}$		0.137(0.065)	0.271 (0.050)	
$\Delta\bar{s}_{t-5}$	-0.140 (0.042)			
$\Delta\bar{s}_{t-6}$				
$\Delta\bar{s}_{t-7}$	-0.173 (0.034)			
$\Delta\bar{s}_{t-8}$	0.134 (0.036)			
$\Delta\bar{s}_{t-11}$	0.370 (0.036)			
$(s-\bar{s})_{t-1}$	-0.003 (0.015)	-0.062 (0.040)	-0.117 (0.047)	-0.042 (0.019)
R^2	0.98	0.71	0.78	0.93
Regression S.E.	0.00776	0.00929	0.01018	0.00665
AR	1.41 [0.23]	0.99 [0.43]	1.26 [0.23]	0.48 [0.79]
ARCH	0.79 [0.54]	0.29 [0.89]	1.15 [0.35]	0.76 [0.56]
Normality	0.90 [0.64]	3.67 [0.16]	0.66 [0.72]	1.97 [0.37]
Hetero test	1.33 [0.21]	0.99 [0.47]	0.40 [0.98]	1.19 [0.31]
RESET	0.45 [0.51]	0.56 [0.46]	1.99 [0.16]	2.65 [0.11]

NOTES: Standard errors in parentheses, p-values in square brackets. All models have been estimated including dummy variables for periods of major currency turbulence. These are defined as follows: For Indonesia 1983(2), 1984(1), 1986(4), 1987(2), 1997(4), 1998(1), 1998(4), and 2001(3); for Malaysia: and 1975(3), 1997(3), 1997(4), 1998(1), 1998(3); for the Philippines 1984(3), 1990(3), 1990(4), 1997(3), 1998(1) and 1998(3); and for South Korea 1997(4), 1998(1), 1998(2), 2002(2), and 2002(4). AR is the Lagrange Multiplier F- test for residual serial correlation of up to fifth order. ARCH is an F-test for Autoregressive Conditional Heteroskedasticity and general mispecification. Normality is a Chi-square test for residuals' normality. Hetero is an F-test for residuals heteroskedasticity. RESET is an F-test for functional form.

Table 1.6. Tests for non-linear exchange-rate adjustment

	k	*d*	F-test [p-value]
Indonesia	1	2	7.515 [0.000]
Malaysia	1	4	2.326 [0.049]
Philippines	1	2	5.336 [0.000]
South Korea	3	8	4.217 [0.000]

NOTES: k is the order of the autoregressive component and d the order of the delay parameter in the artificial regression described by (1.3)

Table 1.7. Non-Linear Error Correction Models

	Indonesia	Malaysia	Philippines	South Korea
Sample	1978(3)-2003(4)	1975(3)-1998(3)	1981(4)-2003(4)	1980(1)-2003(4)
M_I				
constant	0.0008 (0.0008)	0.0004 (0.001)	0.002 (0.002)	0.000 (0.0008)
Δs_{t-1}		0.313 (0.101)		0.586 (0.088)
Δs_{t-2}	0.185 (0.017)			
Δs_{t-3}	0.091 (0.017)			
Δs_{t-4}	0.047 (0.012)		-0.155 (0.063)	
Δs_{t-8}				-0.086 (0.029)
Δs_{t-11}			0.124 (0.058)	0.088 (0.031)
Δs_{t-12}			0.124 (0.059)	
Δs_{t-14}	0.123 (0.020)			
Δs_{t-15}	0.044 (0.012)			
$\Delta \bar{s}_{t-5}$	-0.134 (0.021)			
$\Delta \bar{s}_{t-11}$	0.269 (0.023)			
$(s - \bar{s})_{t-1}$	0.001 (0.013)	-0.091 (0.059)	-0.083 (0.058)	-0.005 (0.030)
M_O				
constant	-0.093 (0.008)	-0.007 (0.003)	0.017 (0.006)	-0.008 (0.001)
Δs_{t-1}	0.419 (0.028)			
Δs_{t-6}				0.152 (0.057)
Δs_{t-7}				-1.298 (0.171)
Δs_{t-14}			-4.129 (1.186)	
$\Delta \bar{s}_{t-4}$		-0.294 (0.139)		
$\Delta \bar{s}_{t-5}$	4.877 (0.406)		-0.587 (0.149)	
$(s - \bar{s})_{t-1}$	-0.478 (0.044)	-0.130 (0.044)	-0.387 (0.089)	-0.156 (0.019)
σ	4.572 (1.364)	10.082 (16.14)	2.132 (1.440)	50.928 (59.07)
τ^U	0.095 (0.003)	0.036 (0.003)	0.058 (0.010)	0.047 (0.001)
τ^L	-0.108 (0.003)	-0.038 (0.003)	-0.061 (0.002)	-0.047 (0.001)
Regression S.E.	0.00520	0.00822	0.00996	0.00579
R^2	0.994	0.794	0.782	0.953
AR 1-5	0.975 [0.442]	0.859 [0.513]	1.964 [0.100]	1.317 [0.269]
ARCH 1-4	0.535 [0.712]	0.895 [0.472]	0.150 [0.962]	0.298 [0.878]
Normality	0.008 [0.996]	3.332 [0.189]	2.777 [0.250]	1.630 [0.443]
hetero	0.428 [0.987]	0.416 [0.989]	0.431 [0.985]	0.305 [0.999]
F-test H_0: $\tau^L + \tau^U = 0$	54.065	0.842	0.121	0.090

NOTES: Numbers in parentheses are standard errors. All models have been estimated including dummy variables for periods of major currency crises. These are defined: For Indonesia 1983(4), 1986(3), 1986(4), 1987(2), 1997(3), 1997(4), 1998(1), 1998(4), 2000(3), 2002(4), 2003(2); for Malaysia 1975(3), 1985(1), 1994(1), 1994(2), 1997(3), 1997(4), 1998(1) and 1998(3); for the Philippines 1984(4), 1985(1), 1990(3), 1990(4), 1993(2), 1997(3) and 1998(3); and for South Korea 1986(2), 1988(1), 1997(4), 1998(1), 1998(4), 2001(1), 2002(1), 2002(4). AR is the Lagrange Multiplier F- test for residual serial correlation of up to fifth order. ARCH is an F-test for Autoregressive Conditional Heteroskedasticity and general mispecification. Normality is a Chi-square test for residuals' normality. Hetero is an F-test for residuals heteroskedasticity. RESET is an F-test for functional form.

Figure 1.1: Nominal exchange rates in Asian Economies

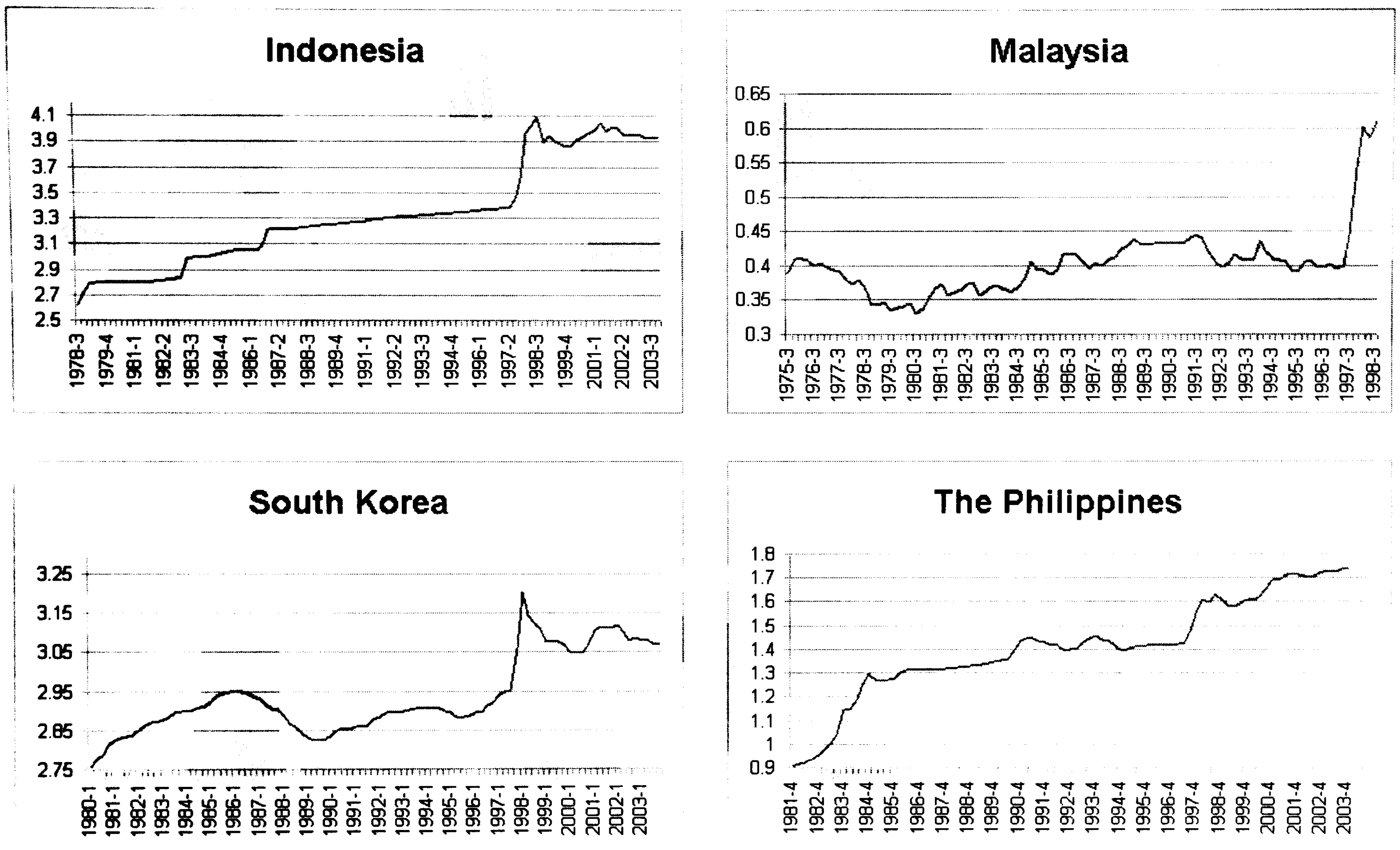
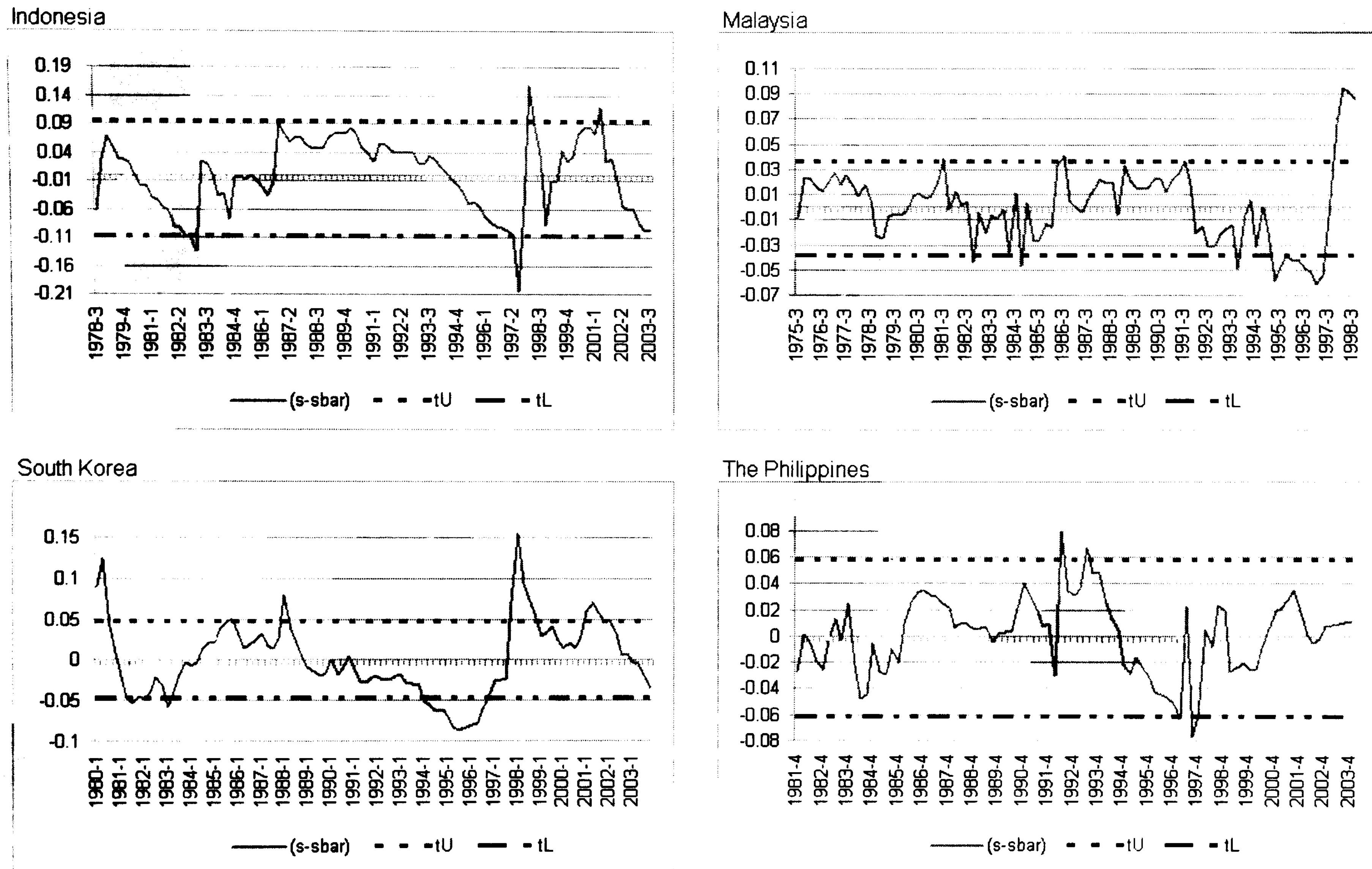


Figure 1.2: Exchange rate misalignment (s-sbar) against the upper (tU) and lower (tL) threshold of the inner regime



CHAPTER II

MODELLING REAL EXCHANGE RATES

IN EMERGING ASIAN ECONOMIES:

New insights using a behavioural, non-linear econometric approach

2.1. INTRODUCTION

Our focus in this chapter is on the real exchange rate. We are interested in examining the behaviour of real exchange rates because of the fact that over the past three decades, the real exchange rate of all four countries examined in our analysis, namely Indonesia, Malaysia, the Philippines, and Korea, has been depreciating. This implies that the benchmark real exchange rate model, Purchasing Power Parity, which predicts a constant equilibrium real exchange rate, is not adequate to describe their movements.[45] Considering movements in real exchange rate are vital for competitiveness and hence the stability of trade flows,[46] the first step of our empirical analysis is to identify the determinants of the equilibrium real exchange rate and the implied misalignments of the actual real exchange rate.

We revisit a number of theoretical explanations offered for medium- and long-run shifts in real exchange rates. These include Balassa (1964)-Samuelson (1964) effects caused by productivity gains, shifts in real and nominal interest rates, current account imbalances, net foreign asset accumulation, and a time trend. With the exception of the latter, all of these have been discussed in chapter 1. A time trend is added to help capture the effects of missing fundamentals. Given the medium-run span covered by our sample periods, we model equilibrium real exchange rates using a general behavioural equation nesting all the theoretical arguments listed above. This approach enables us to identify the behavioural determinants of real exchange rates and extract a measure of fundamental misalignment at each point in time. We then contribute to the literature by considering and contrasting the results of determining the behaviour of real and nominal exchange rates in these emerging economies, as obtained in this and the previous chapter.

We resume our analysis by modelling the process of adjustment of the real exchange rate to its equilibrium. Short-run real exchange rate fluctuations are known to

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[45] Frankel and Rose (1995) and Taylor (1995) argue that empirical models of exchange rate determination, econometrically, perform very poor in predicting or explaining future or past exchange rate movements.

[46] Kaminski et.al (1997) argue that an overvalued currency may lead to an unsustainable current account deficit, increasing external debt and the risk of possible speculative attacks, with unfavourable consequences for the economy. Adversely, Razin and Collins (1997) argue that there is also a general belief that an overvalued currency leads to lower economic growth, but that an undervalued currency has an unclear effect on growth.

be large and notoriously volatile[47] and often very difficult to reconcile with mainstream theoretical models of exchange rate determination, even when the effects of price rigidities have been accounted for. In recent years, the excess volatility of the real exchange rate has been partially explained by the development of theoretical models of non-linear exchange rate dynamics.[48] In these models, transaction costs, information costs, transportation costs, non-tariff barriers, susceptible or actual tariffs, or lack of labour mobility and other market imperfections imply that within a certain range around its equilibrium level, the real exchange rate does not respond to changes in its fundamental determinants. But when real exchange rate misalignment exceeds certain thresholds, arbitrage forces ensure its reversion to its equilibrium level.

To test the nonlinearity of real exchange rates, we employ a new testing procedure suggested by Saikonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993) and Teräsvirta (1994). They develop a new technique for the null hypothesis of linear adjustment of the market real exchange rate to its equilibrium level against an alternative of nonlinear smooth transition autoregressive process. Assuming real exchange rates follow nonlinear stationary processes, the alternative hypothesis of the augmented Dickey–Fuller (ADF) unit root tests based on the linear model will be mispecified. Thus, we follow Saikonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993) and Teräsvirta (1994) as we consider their tests are more powerful than the ADF tests.

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[47] Rogoff (1996) finds that short run deviations from PPP are large and volatile. His findings are known as "PPP puzzle", which he describes as follows: "How is it possible to reconcile the extremely high short-term volatility of real exchange rates with the glacial rate (15 percent per year) at which deviations from PPP seem to die out?" (p. 664).

[48] See Benninga and Protopapadakis (1988), Dixit (1989), Dumas (1992), Uppal (1993), Sercu et al (1995), Shleifer and Vishny (1997), and O'Connell (1998).

As stated previously, various studies of mostly industrial economies present strong evidence to support the existence of non-linear exchange rate dynamics. The authors of these studies suggest that the speed of adjustment to equilibrium increases with the size of the misalignment term. Chen and Wu (2000), Baharumshah et al. (2003), Lestari et al (2003), and Liew et al (2003,2004) present similar evidence of non-linear real exchange rate adjustment in Asian economies, employing econometric models proposed by Tong (1990), namely the TAR, and Granger and Terärvista (1993), namely the ESTAR. However, these models require a symmetric reaction of the real exchange rate to episodes of real overvaluation and undervaluation, a restriction which, in practice, may be invalid as argued in the introductory chapter. Instead, we employ the QL-STECM, which caters for the speed of adjustment to equilibrium as a function of both the size and the sign of misalignment term, allowing us to capture a wider range of features of process characterizing real exchange rate adjustment.

We find a number of striking results. Firstly, in all countries examined, equilibrium real exchange rates are a function of the permanent component of relative output. In the case of Indonesia, we find that nominal interest rate differentials also play a key role. This is similar to when we model nominal exchange rate determination in the previous chapter. However, the behaviour of real exchange rate differs from that of nominal exchange rates in that the former takes into account the deterministic time trend in its long-run model.

Meanwhile, in the case of Malaysia, we find that all variables determining the nominal exchange rate model discussed in the previous chapter also play similar roles. These include permanent relative output, real interest rate differentials, the level of and changes in net foreign assets. The only distinction between the real exchange rate model and the nominal one is the former' positive sign for real net foreign assets, while we find a negative sign when modelling nominal exchange rate behaviour.

In the case of the Philippines, while we consider real interest rate differentials and the changes in net foreign assets in modelling nominal exchange rates, our real exchange rate model does not include these two variables because they are not empirically useful. Moreover, our real exchange rate model differs from the nominal exchange rate model in that it takes into consideration the time trend. However, there are no evidences to suggest that this time trend replaces missing fundamentals, in particular, real interest rate differentials and the changes in net foreign assets.

Our results in the case of Korea are interesting as equilibrium exchange rates are a function of all the variables considered in this chapter; permanent relative output, nominal and real interest rate differentials, and the level of and changes in net foreign assets. The fact that all important fundamentals have been included in our real exchange rates model is probably the reason for our not obtaining a significant role for a time trend variable in this case. This is in contrast to our nominal exchange rates model in chapter 1, in which we fail to take into account nominal and real interest rate differentials, and changes in net foreign assets.

Secondly, despite these similarities, our above findings suggest that equilibrium real exchange rates in individual countries present elements of idiosyncratic behaviour, casting doubt on the use of fixed-parameter panel techniques applied by many empirical exchange rate studies.

Thirdly, in relation to the above, a new empirical finding, also observed in the case of nominal exchange rates, is that the relationship between real exchange rates on the one hand and real net foreign assets and/or current account balances on the other may be non-monotonic, depending upon the sign of net foreign assets and the current account balance. For instance, in the case of the Philippines, our robust model presents a positive sign for the changes in real net foreign liabilities, while in the case of Korea we find a negative sign.

Fourthly, for all countries we obtain strong evidence of non-linear exchange rate adjustment. Real exchange rates may or may not react to changes in their determinants when close to their equilibrium, but revert to it at higher speed when the misalignment term becomes large (a size effect). In the case of Indonesia, the error correction coefficients in our non-linear real exchange rate adjustment present a somewhat slower reversion to equilibrium compared to that in modelling non-linear nominal exchange rate adjustment. On the other hand, in the case of Malaysia, the error correction coefficients in our non-linear real exchange rate adjustment present a much faster reversion to equilibrium compared to that in modelling non-linear nominal exchange rate adjustment. Meanwhile, in the case of the Philippines, the speed of adjustment to equilibrium in our non-linear real exchange rate adjustment is slower than the one obtained when modelling non-linear nominal exchange rate adjustment. On the contrary, in the case of Korea, our non-linear real exchange rate adjustment presents a faster reversion to equilibrium compared to that in modelling non-linear nominal exchange rate adjustment.

Fifthly, in Indonesia and Malaysia real exchange rate adjustment is asymmetric (a sign effect), with fundamental undervaluation corrected faster than overvaluation (a finding consistent with the monetary policy implemented by these countries for the larger part of the post-Bretton Woods period). This is in contrast to the results obtained in the previous chapter when modelling nominal exchange rates, where we find asymmetric nominal exchange rate adjustment only in the case of Indonesia. This asymmetry is a new finding, which previous studies using symmetry-imposing non-linear models such as the TAR or the ESTAR, are not in a position to capture.

Finally, we find that the currency devaluations that took place in 1997-98 were fundamentally justified, as, prior to the crisis, all real exchange rates were significantly overvalued against the US dollar. This is similar to our findings in the previous chapter.

The remainder of the chapter is structured as follows: Section 2.2 presents the literature review. Section 2.3 describes our data. Section 2.4 introduces the methodology we employ. Section 2.5.1 estimates our behavioural model of the real exchange rate. Section 2.5.2 estimates linear models of real exchange rate adjustment. Section 2.5.3 tests for non-linearities in the adjustment process. Section 2.5.4 estimates non-linear real exchange rate adjustment models. Section 2.6 presents our conclusions.

2.2. LITERATURE REVIEW

As some contemporary studies provide evidence that the equilibrium real exchange rate appears to change over time, in other words, it tends to be nonstationary, one would need to search for other variables cointegrated with it.[49] Indeed, researchers

[49] See Chinn (1997)

identify several possible reasons for these changes, all of which can be considered as the determinant of the real exchange rate.

Balassa (1964)-Samuelson (1964), followed by Chinn and Johnston (1996), and Canzoneri et al (1999) find that most long-run movements in real exchange rates are due to relative productivity shocks in the tradable and non-tradable sectors between a particular country and its main trading partners. By employing cointegration analysis, Bahamani-Oskooee (1992) and Dibooglu (1996) show that real exchange rates and the productivity differentials are cointegrated and thus do have a long-run relationship in the advanced countries against the USA, supporting the Balassa model. Evidence for this has also been found by Miyakoshi (2003) when re-examining three popular models of the real exchange rate developed by: (i) Edison and Pauls (1993), (ii) Kawai (1986), and (iii) Dibooglu (1996), using multivariate cointegration techniques and data from Indonesia and the Philippines against Japan. Furthermore, Bahamani-Oskooee and Rhee (1996) also find that the productivity-bias model does provide a valid explanation of the long-run real exchange rate between advanced countries and Korea. De Broeck and Slok (2001), Sarno and Taylor (2001), Egert (2002), and Egert and Lahreche-Revil (2003) also support the productivity-bias model. According to this model, a sustained decrease in the home country's productivity will lead to a permanent depreciation in the real exchange rate. Conversely, Balassa (1964) argues that when productivity differentials are greater in the production of traded goods between two countries, the real exchange rates appreciate.

Furthermore, Rogoff (1996) argues that real exchange rates will also appreciate permanently following positive and permanent demand shocks relative to the home country' main trading partners. An increase in domestic economic activity gives rise to an increase in the demand for domestic money, and the increased demand for domestic money leads to an appreciation of the domestic currency. However, in the Balance of Payments (BOP) flows model, a relative rise in domestic activity results in a depreciation of the domestic currency value. This is because an increase in domestic economic activity results in a deterioration of the domestic trade balance, which leads to a depreciation of the domestic currency.

On the other hand, Alexius (2000) argues that supply shocks are the dominant cause of long-run variation in real exchange rates. The real exchange rate will depreciate, if there are economy-wide supply shocks. However, Sachs and Wyplosz (1984), Frenkel and Razin (1986), Clarida and Gali (1994), Taylor (1995), Rogoff (1996), Weber (1997), Chadha and Prasad (1997) suggest that such fluctuations in real exchange rates are driven by relative real demand factors in the short-run as well as in the long-run, with supply shocks having little impact on long-run real exchange rates. Interestingly, Weber (1997) concludes that these supply shocks account for only about a third of the long-run variance of bilateral real exchange rates.

For Dornbush (1976), Eichenbaum and Evans (1995), and Rogers (1999), meanwhile, the main sources of short-to medium-run movements in the real exchange rate, given that prices are sticky in the short-run, are monetary shocks. Dornbusch (1976) argues that, in the short run, a monetary expansion causes the exchange rate to depreciate and saving to fall due to terms of trade deterioration. He says that the exchange rate depreciation, in the short run, may be in excess of the long-run depreciation. Eichenbaum and Evans (1995) find evidence that a contractionary shock to U.S. monetary policy leads to persistent, significant appreciations in U.S. nominal and real exchange rates. Rogers

(1999) provides evidence that monetary shocks (both to the monetary base and the money multiplier) are empirically important in explaining variation in the real pound-dollar exchange rate.

In contrast with earlier studies,[50] Chortareas and Driver (2001) find evidence supporting a long-run relationship between real exchange rates and real interest rate differentials. They use new non-stationary panel estimation techniques for 11 OECD (Non G-7)[51] economies using the United States as a numeraire for the post-Bretton Woods era. Kanas (2005) employs a bivariate Markov switching vector auto regression model to find strong empirical link between the US/UK real exchange rate and real interest differential for the period 1959-2002. His results suggest that the real interest differential is an important variable in building better models aiming at explaining the behaviour of the US/UK real exchange rate. Their findings also provide a reconciliation between Campbell and Clarida (1987), Meese and Rogoff (1988) and Clarida and Gali (1994), who failed to uncover a relation between the two variables during the recent period of floating exchange rates, and theories of real exchange rate which predict a link between the two variables. Bleany and Laxton (1999) also find a significant positive correlation between the real interest rate differential and the real exchange rate. Shafer and Loopesko (1983) and Boughton (1987) argue that when the real interest differential is positive, the real exchange rate appreciates. Miyakoshi (2003) also suggests that the real interest rate-bias model does provide a valid explanation of the long-run real

[50] See Meese and Rogoff (1988) and Edison and Pauls (1993).

[51] They are Australia, Austria, Belgium, Ireland, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, and Switzerland, whereas the G7 countries are Canada, France, Germany, Italy, Japan, the USA, and the UK.

exchange rate between Japan and the East-Asian countries, namely Indonesia, Korea, the Philippines, and Malaysia.

In addition, Frankel (1979)'s real interest rate differential model implies that a sudden unexpected expansion in domestic money supply growth may exert downward pressure on a domestic currency's value if it (1) acts to push real interest rates temporarily lower, which, in turn, invites capital to flow overseas and (2) signals to the market that monetary growth will proceed at a new faster pace in the future. Another important point to be gleaned from the real interest rate differential model is that the response of the exchange rate to a change in interest rates is only transitory. A rise in the real exchange rate induced by a widening of the real interest rate differential can only be temporary if there is, at the same time, an expectation that the real exchange rate must eventually decline back to its long-run equilibrium level. Even though the magnitude of the response of the exchange rate to a change in relative interest rates may be large, and real interest rate differentials may be expected to persist, the actual rise or fall in the exchange rate is expected to be instantaneous, after which the initial rise or fall in the real exchange rate is expected to be gradually unwound as the real exchange rate returns to its long-run equilibrium level. This adjustment path is similar to the overshooting path described in the Dornbusch sticky-price monetary model.

In the last model, Gagnon (1996) finds a significant and robust relationship between real exchange rates and net foreign assets when exploiting the information in a panel data set for Australia, Japan, New Zealand, Switzerland, and the United States from 1973 through 1995. His estimates reveal that the half-life of real exchange rate disequilibria is about one-half and two years. A falling of net foreign assets means permanent real exchange rate depreciation. Conversely. a raising of net foreign assets implies a permanent real exchange rate appreciation. In addition, Lane and Milesi-Ferretti (2004) use cross-country data on real exchange rates and a newly constructed data set on countries' net external positions to find that countries with net external liabilities have more depreciated real exchange rates.

Dornbusch and Fischer (1980), Hooper and Morton (1982), Gavin (1991). Faruqee (1995), and Obstfeld and Rogoff (1995) present theoretical treatments of the relationship between net foreign assets and the real exchange rate. Hooper and Morton (1982) develop a model in which exogenous shocks to trade flows create a long-run positive correlation between net foreign assets and the real exchange rate. In a more complete theoretical model, Gavin (1991) shows that exogenous shocks to wealth create a positive correlation between net foreign assets and the exchange rate when the Marshall-Lerner condition is satisfied. Faruqee (1995), and Obstfeld and Rogoff (1995) also present empirical results confirming a positive correlation between net foreign assets and the real exchange rate.

The papers cited above focus on exogenous shocks that affect net foreign assets directly. The transmission to the exchange rate is based on the fact that in equilibrium, a country with negative net foreign assets must have a trade surplus to finance the stream of interest and dividend payments. The mechanism to generate this trade surplus is exchange rate depreciation. Similarly, countries with positive net foreign assets must have trade deficits in equilibrium. Thus, a shock to net foreign assets has a long-run effect on the exchange rate as long as goods produced in different countries are not perfect substitutes. In addition, it is also important to recognize that exchange rate dynamics may be the mechanism by which shocks to desired net foreign assets are equilibrated. Thus, an increase in desired net foreign assets may cause an immediate depreciation of the exchange rate in order to generate a trade surplus, followed by a long-run real appreciation of the exchange rate above its asset stock that is achieved. However, in a more general framework, both net foreign assets and the real exchange rate should be viewed as endogenous variables that influence each other and are determined simultaneously.

We apply this model to four Asian countries, namely Indonesia, South Korea, Malaysia and the Philippines since they have displayed rapid structural changes in the supply side in the early 1980s and experienced turbulence in 1990s, characterized by frequent changes in the real exchange rate and speculative attacks. The surge in structural changes can generate considerable changes in the relative price structure between traded goods and non-traded goods in individual countries and eventually the equilibrium real exchange rate will adjust in response to these structural changes. Meanwhile, during the financial crisis of 1997/98, the real exchange rate has depreciated and appears to be non-stationary. This evidence can not be explained by the benchmark model of real exchange rate determination, PPP, which predicts a constant real exchange rate.

In a recent paper, Arghyrou et al (2004) have argued that the task of extracting the underlying equilibrium real exchange rate is made even more difficult by possible non-linearity in the process of the short-run exchange rate adjustment, cause by market frictions. Market frictions, such as transactions costs, in international trade introduce a neutral range, an "inner regime", or band of inaction, within which deviations from parity are left uncorrected, as they are not large enough to cover transactions costs. Only deviations outside the neutral range are arbitraged away by market forces. In this dynamic equilibrium framework, Benninga and Protopapadakis (1988), Dixit (1989), Dumas (1992), Uppal (1993), Sercu et al (1995), Coleman (1995), Shleifer and Vishny (1997), and O'Connell (1998), show that deviations from equilibrium exchange rate follow a nonlinear stochastic process that is mean-reverting. In particular, the strength of mean reversion increases with the deviation from equilibrium (in the "outer regime"), as the profits from goods arbitrage, which is generally thought to be the ultimate force behind maintaining PPP, do not make up for the costs involved in the necessary transactions for small deviations from the presumed equilibrium real exchange rate. This has recently led to an outburst of empirical studies using nonlinear time series models to model such effects.[52] Sarno (2000b) for instance, found empirical evidence that deviations of PPP revert to a constant equilibrium level in a nonlinear fashion, in the context of the real exchange rate behaviour in Middle Eastern countries. Obstfeld and Taylor (1997), Michael et al (1997), Taylor and Peel (2000), Taylor et al (2001), and Baum et al (2001) have found evidence of nonlinear adjustment in the real exchange rates of the G7 countries. In a study on the exchange rates of transition economies, Sarno and Taylor (2001) arrive at a similar conclusion. Chen and Wu (2000), Baharumshah et al (2002), Liew et al (2003, 2004) also report nonlinear adjustment of Asian nominal exchange rate deviation towards PPP. Their models reveal a typical behaviour of adjustment process for PPP deviations.

[52] See Michael et al (1997), Obstfeld and Taylor (1997), Sarantis (1999), Baum et al (2001), Lo and Zivot (2001), Taylor et al (2001), and O'Connell and Wei (2002). It should be noted that many of these papers consider the relative price of individual goods and therefore actually test the Law of One Price (Micheal et al., 1997; Sarantis, 1999; Baum et al., 2001). An exception is the study of Enders and Falk (1998) who, working within a non-linear unit tests framework, find limited evidence in support of PPP.

However, their findings are based on the assumption that the adjustment of exchange rates to over- and under-valuations of the same magnitude is symmetric. This assumption may not be true. Van Dijk and Franses (2002) draw on the existing model of the threshold autoregressive (TAR) (Tong, 1990), the smooth transition auto regression (STAR) (Chan and Tong 1986, Luukkonen et al 1988, Teräsvirta 1994), and the exponential smooth transition autoregressive (ESTAR) (Granger and Teräsvirta, 1993) to develop a nonlinear model of the Quadratic Logistic Smooth Transition Error Correction Model (QL-STECM). This model examines whether the behaviour of exchange rates in adjusting to the fundamental value is nonlinear with respect to the size and sign of deviations. Their model extends the existing models in that it allows the response of exchange rates to depend not only on the size of the deviation from fundamentals but also on the sign of the deviation from fundamentals.

2.3. Methodology

2.3.1. Modelling equilibrium real exchange rates

We model equilibrium real exchange rates using a general behavioural specification, nesting all the theoretical arguments listed in the literature review above. This is given by equation (2.1) below:

$$q_t = \alpha + \beta_1 (\bar{y} - \bar{y}_{USA})_t + \beta_2 (i - i_{USA})_t + \beta_3 (r - r_{USA})_t + \beta_4\, rnfa_t + \beta_5\, \Delta rnfa_t + \beta_6\, t + u_t \tag{2.1}$$

In (2.1), q denotes the actual (observed) real exchange rate of the domestic currency against the US dollar, calculated using CPI indexes; $\bar{y}$ the level of permanent output; i and r nominal and real interest rates respectively; *rnfa* real net foreign assets, *Δrnfa* the change in real net foreign assets, which serves as a proxy for current account; t a time trend, a catch-all variable capturing the effects of all variables unaccounted for; and u_t a white noise error term. All variables in (2.1), except from nominal and real interest rates are expressed in logs, with the subscript USA denoting variables referring to the USA. Given that negative numbers' logarithms are not defined, when a country's net foreign asset position is recorded by IFS to be negative, an extra variable, real net foreign liabilities (*rnfl*), is added in (2.1). In such cases, real net foreign liabilities (assets) are defined as the maximum of the log of the absolute value of the net liabilities (assets) and zero. In this case, in estimating (2.1) we would expect *rnfa* and *rnfl*, to have identical signs and parameters.

Equation (2.1) can be seen as an equilibrium model of the real exchange rate, a simple version of which is discussed by Taylor (1995, pp. 24-26). Equilibrium real exchange rate models consider two countries under full price flexibility, with $\bar{y}$ and $\bar{y}_{USA}$ representing full-employment output levels. In such models, an increase in domestic productivity, captured by an increase in $(\bar{y} - \bar{y}_{USA})_t$, has two analytically separate effects. The first, defined by Taylor as a relative price effect, results in a reduction in the relative price of domestic output, thus leading to a real depreciation. The second, defined by

Taylor as a money demand effect, results in an increase in demand for money, reducing equilibrium prices and ultimately leading to real exchange rate appreciation. The net effect of an increase in domestic productivity on the real exchange rate is determined by the degree of substitutability between domestic and foreign goods, with real appreciation (depreciation) being more likely the higher (lower) the degree of substitutability.

Typically, a real appreciation of the domestic currency is expected if domestic productivity exceeds that of foreign economy. This is mainly due to higher domestic inflation as a result of faster productivity growth. This transmission is conventionally associated with the Balassa–Samuelson effects (1964). Such effects say that if the productivity growth in the domestic tradable sector (manufacturing) is relatively higher than in the non-tradable sector (services), wages in the tradable sector tend to increase. The assumption of perfect labour mobility equalizes wages in the two sectors and increases the prices of non-tradable goods, thus increasing the overall price level in the domestic economy with respect to the foreign economy. This transmission leads to real exchange rate appreciation.

Equation (2.1) includes another four possible determinants for the real exchange rate. First, the nominal interest rate differential $(i-i_{USA})_t$, which aims to capture the effects of shifting medium-term inflation expectations, reflecting in turn demand conditions. In monetary models of the exchange rate (see e.g. Frankel, 1979), an increase in the nominal interest rate differential results in nominal depreciation and, in the presence of short-run price rigidities, real depreciation too.

Second, the real interest rate differential $(r-r_{USA})_t$ is included to capture the effects of capital inflows following changes in short-term interest rates, as predicted by

Dornbuch's (1976) sticky price overshooting model.[53] Adding this variable is also in line with the Behavioural Equilibrium Exchange Rate (BEER) approach. Given that this approach is developed from the underlying Uncovered Interest Parity (UIP), a negative interest rate differential (the domestic currency has relatively lower interest rate compare to the foreign one) leads domestic currency to depreciate in order to match the yields in domestic and foreign currencies, hence any possible arbitrage opportunity can be abolished. Correspondingly, a positive interest rate differential generates portfolio reallocation and a higher demand for domestic currency, implying a contemporaneous appreciation of the domestic currency.

Third, real net foreign assets $(rnfa)_t$ are included to capture the wealth effects of accumulated current account imbalances. Portfolio balance models of the exchange rate, such as Branson (1983), suggest that a country's debt resulting from current account deficits has to be financed by internationally diversifying investors. Traditionally, given interest rates, these investors want a higher yield in order to adjust their portfolios in the desired way, which can be achieved through an expected appreciation of the debtor country's currency. This may require contemporaneous depreciation of the currency. Similarly, increasing the stock of foreign assets held by domestic agents results in expectations of future capital inflows, leading to a real appreciation of the domestic currency.

However, this negative relationship may be reversed within the context of the balance-of-payments model. Assuming that current account deficits accumulate net foreign liabilities, an improvement in the trade balance is needed to pay dividends and rental payments associated with the accumulated liabilities. This requires the currency to

[53] See also Hallwood and MacDonald (2000, pp. 175-209).

depreciate, thus increasing the international price competitiveness of the country's exports. Faruqee (1995) find a similar adjustment of the real exchange rate when employing stock-flow models. These models predict that the relationship between $(rnfa)_t$ and the real exchange rate may be positive rather than negative in the medium-run, because the higher growth prospects of emerging economies cannot be financed by domestic savings only, but also through increased foreign borrowing leading to an increase in foreign liabilities. Nevertheless, in the long-run, payments on the existing stock of foreign liabilities would restore the negative relationship: the higher the stock of foreign liabilities (i.e. the lower $(rnfa)_t$ is), the higher the need for real exchange rate depreciation to service the debt through an improved current account.

Fourth, the change in the stock of real net foreign assets, $(\Delta rnfa)_t$ serves as a proxy for the movements of the current account. The effects of the latter on the real exchange rate remain unclear and subject to debate. Rogoff (1996, p. 663) has described the literature's agnostic state by stating that, "from a theoretical perspective, virtually any correlation between the current account and the real exchange rate can be easily rationalise. Ultimately, the correlation between the current account and the real exchange rate is an empirical matter, one that remains the subject of debate". Finally, equation (2.1) includes a linear trend, which serves as a proxy for any other variable that may be relevant to the process of real exchange rate determination and not captured by the rest of the terms included in equation (2.1).

Summarizing our discussion, in estimating (2.1), all betas (β_1, β_2, β_3, β_4, β_5 and β_6) can take either positive or negative signs. The fitted values of (2.1), denoted by $\hat{q}*$, provide an estimate for the behavioural equilibrium level of the real exchange rate, in which case the estimated residuals of (2.1), $\hat{u}_t$, is the deviation of the observed real exchange rate from its equilibrium level (the misalignment term).

2.3.2. Linear real exchange rate adjustment models

We model the adjustment of the real exchange rate towards its behavioural equilibrium level described by (2.1) using the linear model given by (2.2) below:

$$\Delta q_t = \beta(L)\,\Delta q_t + \gamma(L)\,\Delta\hat{q}^*_t + \delta(q - \hat{q}^*)_{t-1} + \varepsilon_t \qquad (2.2)$$

In (2.2), $\hat{q}$ is the log of the estimated equilibrium real exchange rate obtained from (2.1), $\beta(L)$ and $\gamma(L)$ are lag-polynomials of order L, ε is a white noise error term and Δ is the first difference operator. The error correction term $(q - \hat{q}^*)$ measures the deviation of the real exchange rate from its equilibrium level, with the coefficient δ measuring the speed of adjustment of the former to the latter. If there is cointegration, the Granger representation theorem suggests that we should expect δ to be in all cases statistically significant with a negative sign.

2.3.3. Testing for non-linear real exchange rate adjustment

We next consider the possibility of non-linear real exchange rate dynamics. To that end, we first test for non-linear dynamics in the process of exchange rate adjustment. We do so using the testing approach suggested by Saikonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993) and Teräsvirta (1994). This involves estimating the auxiliary regression described by (2.3) below:

$$(q-\hat{q}^*)_t = \gamma_{00} + \sum_{j=1}^{\varphi}\{\gamma_{0j}(q-\hat{q}^*)_{t-j} + \gamma_{1j}(q-\hat{q}^*)_{t-j}(q-\hat{q}^*)_{t-d} + \gamma_{2j}(q-\hat{q}^*)_{t-j}(q-\hat{q}^*)^2_{t-d}$$
$$+\gamma_{3j}(q-\hat{q}^*)_{t-j}(q-\hat{q}^*)^3_{t-d}\} + \gamma_4(q-\hat{q}^*)^2_{t-d} + \gamma_5(q-\hat{q}^*)^3_{t-d} + v_t \qquad (2.3)$$

In (2.3), $(q - \hat{q}^*)$ is the deviation of the real exchange rate from its equilibrium level, measured by the estimated residual term obtained from (2.1), and d is the delay parameter. The null hypothesis of linear adjustment to equilibrium is described by H_0: $[\gamma_{1j} = \gamma_{2j} = \gamma_{3j} = \gamma_4 = \gamma_5 = 0]$ for all $j \in$ (1,2...,k), where the autoregressive parameter k is determined through inspection of the partial autocorrelation function of $(q - \hat{q}^*)$; v_t is a white-noise error term.[54] Testing the null of linearity involves estimating (2.3) for all plausible values of the delay parameter d, followed by testing the zero restrictions implied by the null using an LM test. If the null is rejected for more than one values of d, then d is chosen to be the one that which yields the largest value of the test statistic.

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[54] Granger and Teräsvirta (1993) and Teräsvirta (1994) advise against choosing k using an information criteria such as the Akaike since this may induce a downward bias.

2.3.4. Non-linear real exchange rate adjustment models

We model non-linear real exchange rate adjustment using the Quadratic Logistic Smooth Transition Error Correction Model (QL-STECM, see van Dijk et al., 2002). This model, previously used to model non-linear exchange rate dynamics by Arghyrou et al (2005), is described by equations (2.4) to (2.7) below:

$$q_t = \theta_t M_{\mathrm{I}t} + (1-\theta_t)\, M_{\mathrm{O}t} + \varepsilon_t \tag{2.4}$$

$$M_{\mathrm{I}t} = \beta_{\mathrm{I}}(L)\,\Delta q_{t-1} + \gamma_{\mathrm{I}}(L)\,\Delta \hat{q}^* + \delta_{\mathrm{I}}(q-\hat{q}^*)_{t-1} + \varepsilon_{\mathrm{I}t} \tag{2.5}$$

$$M_{\mathrm{O}t} = \beta_{\mathrm{O}}(L)\,\Delta q_{t-1} + \gamma_{\mathrm{O}}(L)\,\Delta \hat{q}^* + \delta_{\mathrm{O}}(q-\hat{q}^*)_{t-1} + \varepsilon_{\mathrm{O}t} \tag{2.6}$$

$$\theta_t = pr\,\{\, \tau^L \le (q-\hat{q}^*)_{t-d} \le \tau^U \,\} = 1 - \frac{1}{1+e^{-\sigma[(q-\hat{q}^*)_{t-d}-\tau^L][(q-\hat{q}^*)_{t-d}-\tau^U]}} \tag{2.7}$$

Equation (2.4) models exchange rate changes as a weighted average of the linear adjustment models M_{I} and M_{O}, where M_{I} represents the inner regime, in which misalignment is small, and M_{O} the outer regime, where misalignment is larger. Equation (2.7) uses the quadratic logistic function to model θ, the probability that the transition variable $(q - \hat{q}^*)_{t-d}$ takes values in the inner regime, with σ affecting the speed of transition between the two regimes. The inner regime is defined by two threshold values, τ^U and τ^L, respectively denoting the upper and lower limit of the inner regime, so that $\tau^L <$ 0 and $\tau^U > 0$. The adjustment of the real exchange rate to its equilibrium is non-linear, subject to size misalignment effects if $\delta_{\mathrm{I}} \neq \delta_{\mathrm{O}}$. In particular, if $\delta_{\mathrm{I}}=0$ and $\delta_{\mathrm{O}} < 0$, the exchange rate follows a random walk in the inner regime, adjusting to equilibrium only in the outer regime. Sign misalignment (asymmetric adjustment) effects exist if $\tau^L + \tau^U \neq 0$. In particular, if $\tau^L + \tau^U > 0$, negative misalignment values are corrected faster than positive ones, which implies that outer-regime undervaluation is more likely than overvaluation. By contrast, if $\tau^L + \tau^U < 0$, fundamental undervaluation is corrected faster than overvaluation. If $\tau^L + \tau^U = 0$, exchange rate adjustment is symmetric, in which case the QL-STECM reduces to an ESTAR type-model.

2.4. DATA

Our data source is the International Financial Statistics (IFS) database of the International Monetary Fund (IMF), provided by Datastream. We work with quarterly data. To avoid mixing periods of fixed and floating exchange rates, we define our samples to cover periods during which the countries examined did not operate a policy of pegging their currencies against the dollar. These are 1978(3)-2003(4) for Indonesia; 1975(3)-1998(3) for Malaysia, 1981(4)-2003(4) for the Philippines; and 1980(1)-2003(4) for South Korea. During these periods all countries followed a managed-floating exchange rate policy against the US dollar, which makes our previous discussion on possible asymmetries in exchange rate adjustment even more relevant.

We define real exchange rates as the product of the nominal exchange rate and the ratio of foreign (USA) to domestic prices. With this definition, an increase (reduction) in real exchange rates denotes a real depreciation (appreciation) of the domestic currency. Real exchange rates are calculated using CPI indexes. To characterize the behaviour of domestic currencies against US dollar, Figure 2.1 presents four important episodes of their movements over our sample periods.

In the case of Indonesia, the first episode is from 1978Q3 to 1979Q1, the second episode is from 1979Q1 to 1983Q1, the third episode is from 1983Q1 to 1998Q1, and the fourth episode is from 1998Q1 to 2003Q4. During these four episodes, the Indonesian rupiah experienced a dramatic up and down rollercoaster ride. From 1978Q3 to 1979Q1, the real exchange rate increased from Rp860/USD to Rp1,258/USD, a depreciation of 46%. Then, from 1979Q1 to 1983Q1, the real exchange rate decreased from Rp1,258/USD to Rp 1,184/USD, an appreciation of 6%. The rupiah experience another depreciation from 1983Q1 to 1998Q1 where the real exchange rate increased from Rp1,184/USD to Rp7,024/USD, a huge depreciation of 493%. Finally, the rupiah real exchange rate appreciated from 1998Q1 to 2003Q4. In this fourth period the rupiah decreased from Rp7,024/USD to Rp3,336/USD, an appreciation of 53%.

In the case of Korea, as shown in figure 2.1, we also notice four important episodes. The first episode is from 1980Q1 to 1985Q4, the second episode is from 1985Q4 to 1989Q3, the third episode is from 1989Q3 to 1998Q1, and the fourth episode is from 1998Q1 to 2003Q4. During these four episodes, the Korean won also experienced a dramatic up and down rollercoaster ride. From 1980Q1 to 1985Q4, the real exchange rate increased from W810/USD to W1,110/USD, a depreciation of 37%. Then, from 1985Q4 to 1989Q3, the real exchange rate decreased from W1,110/USD to W796/USD, an appreciation of 28%. The won experienced another depreciation from 1989Q3 to 1998Q1 where the real exchange rate increased from W796/USD to W1,452/USD, a depreciation of 82%. Finally, the won real exchange rate appreciated from 1998Q1 to

2003Q4. In this fourth episode the won decreased from W1,452/USD to W1,055/USD, an appreciation of 27%.

Meanwhile, in the case of the Philippines, we find three interesting episodes, as shown in figure 2.1. The first episode is from 1981Q4 to 1987Q4, the second episode is from 1987Q4 to 1997Q2, and the third episode is from 1997Q2 to 2003Q4. During these three episodes, as occurred in the other first two countries above, the Philippines peso also experienced volatility. From 1981Q4 to 1987Q4, the peso real exchange rate increased from P23.09/USD to P35.04/USD, a depreciation of 52%. Then, from 1987Q4 to 1997Q2, the peso real exchange rate decreased from P35.04/USD to P24.26/USD, an appreciation of 31%. The peso experienced another depreciation from 1997Q2 to 2003Q4 where the real exchange rate increased from P24.26/USD to P41.70/USD, a depreciation of 72%.

In the case of Malaysia, we find three important episodes during our sample episodes, as occurred in the case of the Philippines previously. As shown in Figure 2.1, the first episode is accounted from 1975Q3 to 1991Q3, the second episode is from 1991Q1 to 1997Q1, and the third episode is from 1997Q1 to 1998Q3. During these three episodes, the Malaysian Ringgit was volatile. From 1975Q3 to 1991Q3, the real exchange rate increased from RM1.82/USD to RM2.89/USD, a depreciation of 59%. Then, from 1991Q3 to 1997Q1, the real exchange rate decreased from RM2.89/USD to RM2.47/USD, an appreciation of 15%. The ringgit experienced another depreciation from 1997Q1 to 1998Q3 where the real exchange rate increased from Rp2.47/USD to Rp3.61/USD, a depreciation of 57%.

To summarize, in all countries we observe the existence of alternating. some upward and downward movements; however for all countries a clear long-term depreciation trend emerges. This is confirmed by the results of the Augmented Dickey-Fuller (ADF) unit root tests applied to these series, as shown in Table 2.1, all of which turn out to be I(1).

As discussed above, our modelling approach models equilibrium real exchange rates using a behavioural specification. This includes relative equilibrium output levels, real and nominal interest rate differentials, current account imbalances and real net foreign assets. GDP data for the countries examined is not available on a quarterly basis, therefore we approximate output using industrial or manufacturing volume indexes.[55] Given the high importance of manufacturing production for these countries, this approximation, also widely used to approximate full-employment output in other applications such as empirical models of monetary policy,[56] can be considered reasonable. To smooth out the effects of demand shocks and thus obtain a measure of the permanent output component, we follow many existing studies by de-trending our output-proxy series. We do so by fitting into the industrial production series a Hodrick-Prescott filter (Hodrick and Prescott, 1997).[57] The extracted series, suggest that relative permanent output against the USA presents a declining trend for Indonesia and an increasing one for

[55] An industrial or manufacturing production series was not available for Indonesia for the whole of the sample period covered by our analysis. Given the high importance of oil production for this country, we approximate output using the crude petroleum production index provided by IFS.

[56] See for example Clarida et al (1998).

[57] To obtain the Hodrick-Prescott trend, we set the value of a smoothing parameter at the recommended value for quarterly data of 1600.

Malaysia, the Philippines and South Korea. [58] The ADF tests applied to all relative permanent output series reject the stationarity hypothesis.

Nominal interest rates are typically included in exchange rate modelling to capture the effects of inflation expectations and, by implication, cyclical demand conditions. For this purpose, our preferred variable is long-term government bond yields, however this series was not always possible. As the best available proxy, we use the long-term lending rate (working-capital loans' rate) for Indonesia; the one-year money market rate for Malaysia, the one-year lending rate for the Philippines; the 10-year government bond yield for South Korea; and the 10-year government bond yield for the USA.

Real interest rates are calculated using the Fischer equation, $r_t = i_t - \pi^e_t$ where r, i and π^e respectively denote real interest rate, nominal interest rate and expected inflation. Real interest rates are used in real exchange rate modelling to capture the Dornbuch (1976) type-effects, based on price rigidities and resulting from expected short-term capital gains created by increases in short-term interest rates. As a result, for all countries real interest rates are calculated using a short-term nominal interest rate, namely the domestic money-market overnight rate (the federal funds rate for the USA). We define π to be CPI inflation over a period of a calendar year, with expected inflation π^e approximated using actual CPI inflation rates after four quarters (i.e. $\pi^e_t = \pi_{t+4}$). The

[58] The medium size of our sample periods implies that in addition to permanent relative supply shocks, ultimately transitory yet relatively persistent demand shocks may also have an effect on the fitted output series. This implies that our relative permanent output series may capture both permanent supply and demand shocks dying out at a slow rate. As a highly persistent positive demand shock would result in real appreciation for the domestic country, this increases the possibility of obtaining a negative coefficient for β_1 in equation (2.1).

applied ADF tests suggest that with two exceptions (nominal interest rate differential in Korea and Malaysia), all interest rate differential series (nominal and real) are stationary.

Finally, regarding real net foreign assets and current account imbalances, as in the previous chapter, we would have liked to include these series into the analysis as percentages in GDP. However, due to the lack of availability of GDP on a quarterly basis, that was not possible. We have therefore used the level of real net foreign assets, calculated by deflating the nominal net foreign assets series provided by IFS using the CPI index. We use the change in the stock of real net foreign assets as a proxy for a country's current account position. All real net foreign series were found to be I(1), with their changes being stationary. Non-stationarity for real exchange rates, relative output and real net foreign assets implies that any econometric analysis aiming to model the real exchange rate using these variables has to be undertaken within a cointegration framework.

2.5. EMPIRICAL RESULTS

2.5.1. Modelling equilibrium real exchange rates

The sample periods on which our analysis is based covers a period of approximately twenty-five years. For the purpose of modelling real exchange rates, such a data span can be classified as medium rather than long-run, in which case the effects of ultimately transitory yet long lasting changes, such as shifts in relative demand and real interest rate differentials, can affect the level of the real exchange rate, as can changes of a more permanent nature, such as productivity gains.

We follow a general-to-specific approach, which involves estimating (2.1) and gradually reducing it to the point where only statistically significant variables are included in the model. The results of our long-run equations appear in Table 2.2 showing in all countries examined, equilibrium real exchange rates are a function of permanent relative output and one or more variables from nominal and real interest rate differentials, the level of and changes in net foreign assets, and a time trend.

Relative permanent output is statistically significant for all four countries, but its' effect on real exchange rates is not uniform: in Indonesia and the Philippines ($\bar{y}-\bar{y}_{USA}$) has a negative sign, which suggests that the Balassa-Samuelson effect is stronger than the relative price effect. By contrast, in Korea and Malaysia, ($\bar{y}-\bar{y}_{USA}$) has a positive sign, suggesting the relative price effect dominates.[59] This is similar to when we model nominal exchange rate determination in the previous chapter.

With one exception (Malaysia) nominal interest rate differentials are in all countries statistically significant, displaying the theoretically-expected positive sign. This is dissimilar to when we model nominal exchange rate determination in the previous chapter in that only in Indonesia and the Philippines cases we find that this variable is statistically significant with the theoretically-expected positive sign.

Real interest rate differentials are significant for Korea and Malaysia, also entering (2.1) with the theoretically-expected negative sign. Our results differ from that

[59] As a robustness check, we estimated the models reported in Table 2.2 changing the value of the smoothing parameter by 10, 20, 30, 40 and 50 per cent upwards and downwards. The results obtained remain unaltered.

of nominal exchange rates model discussed in the previous chapter in that the latter provide evidence that real interest rate differentials are statistically significant with the theoretically-expected negative sign in the case of Malaysia and of the Philippines.

Real net foreign assets are significant with a positive sign for Korea, the Philippines, and Malaysia. This is consistent with the predictions of the stock-flow approach to real exchange rate determination, given the high-growth, emerging nature of the countries considered by our analysis and the medium- rather than long-run character of our samples. However, in the case of Malaysia, we find a distinction between the real exchange rate model and the nominal one as discussed in the previous chapter in that in the latter model the sign for real net foreign assets is negative.

In South Korea and Malaysia, our proxy for the current account, the change in real net foreign assets, is statistically significant with a positive sign. This is dissimilar to when we model nominal exchange rate determination in the previous chapter in that the change in real net foreign assets is statistically significant, displaying a positive sign, in the case of Malaysia and the Philippines. In the case of the change in real net foreign liabilities, we find in the Philippines, these variables enter equation (2.1) with a negative sign, while in the case of South Korea it is positive. Our result for modelling the real exchange rate differ from that of the nominal one as discussed in the previous chapter in that only in the Philippines the change in real net foreign liabilities is statistically significant.

In relation to this, it is interesting to note that in the case of Malaysia, the real exchange rate appears to respond in a statistically significant way only to changes in real net foreign assets but not to changes in real net foreign liabilities, while the opposite holds true for the Philippines. All of this suggests that the ambiguity of the role of the current account in real exchange rate determination, discussed above in the context of Rogoff's statement, may be even more complex, with the nature of the relationship between the two variables (positive or negative) varying not only across countries, but also within the same country, depending on whether the current account is in deficit or surplus. Finding a theoretical explanation for the existence of such a non-monotonic relationship exceeds the scope of an empirical study such as the present one, however, our findings may provide an incentive for future theoretical work.

The trend term is statistically significant for only two countries (Indonesia and the Philippines), and even for these the trend coefficient is very low. This suggests that our equations are unlikely to be subject to the influence of omitted variables, a conclusion also supported by the high explanatory power of all models.

Finally, the reported ADF tests suggest that all equations are clearly cointegrated, which excludes the possibility of spurious correlation among the variables.

2.5.2. Linear real exchange rate adjustment models

We estimate (2.2) using a general-to-specific approach, starting by including sixteen lags for Δq_t and $\Delta \hat{q}^*_t$ and reducing the equation to a parsimonious specification. The results are reported in Table 2.3. All equations have been estimated including intercept dummies for incidences of particular exchange rate turbulence. These are defined at the bottom of Table 2.3. Excluding these dummies does not change the nature of the findings, but results in problems of residual non-normality. In line with our expectations, all error correction coefficients are statistically significant with a negative sign. The speed of adjustment differs across countries, with adjustment to equilibrium in Malaysia and the Philippines being faster than in Indonesia and Korea. This is similar to when we model nominal exchange rate determination in the previous chapter. However, all adjustment to equilibrium of real exchange rate are faster than that of nominal exchange rates. The reported equations are generally well-specified, with their explanatory power being rather mixed. Nonetheless, the nominal exchange rate model fits the data better than that of the real exchange rate one in that the former' coefficient of determinations, with the exception in the case of Indonesia, show relatively higher values. In the case of Indonesia, we find that the R-squares in real and nominal exchange rate models are similar (0.98), indicating that we have accounted for almost all of the variability with the variables specified in these models.

2.5.3. Testing for non-linear real exchange rate adjustment

Table 2.4 presents the results of our non-linearity tests. In all countries we obtain evidence of non-linear adjustment, which we proceed to model formally in the following section.

2.5.4. Non-linear real exchange rate adjustment models

Table 2.5 presents the estimates of our non-linear estimations. The reported equations are parsimonious specifications obtained using a general-to-specific search modelling approach and include statistically significant turbulence dummies similar to those included in their linear counterparts. These dummies ensure that our non-linear findings reflect systematic non-linearity in real exchange rate adjustment and do not simply reflect the influence of isolated, one-off events. For all countries, we obtain strong evidence of size-misalignment. The error correction coefficients are insignificant in the inner regime, suggesting a random walk behaviour when the real exchange rate closes to its equilibrium. On the other hand, for all countries the error correction term is highly significant in the outer regime, suggesting fast reversion to equilibrium when the misalignment term becomes large.

In the case of Indonesia, the error correction coefficients in our non-linear real exchange rate adjustment present a somewhat slower reversion to equilibrium (-0.412) compared to that in modelling non-linear nominal exchange rate adjustment (-0.478). On the other hand, in the case of Malaysia, the error correction coefficients in our non-linear real exchange rate adjustment present a much faster reversion to equilibrium (-0.359) compared to that in modelling non-linear nominal exchange rate adjustment (-0.130). Meanwhile, in the case of the Philippines, the speed of adjustment to equilibrium in our non-linear real exchange rate adjustment (-0.218) is slower than the one obtained when modelling non-linear nominal exchange rate adjustment (-0.387). On the contrary, in the case of Korea, our non-linear real exchange rate adjustment presents a faster reversion to equilibrium (-0.238) compared to that in modelling non-linear nominal exchange rate adjustment (-0.156).

For two countries, Indonesia and Malaysia, we also obtain evidence of sign misalignment effects, with the absolute value of the lower threshold of the inner regime being in all cases higher than that of the upper. This is consistent with the floating-rate exchange rate policy followed by these countries during the larger part of the post-Bretton Woods system, which involved targets for the rate of depreciation against the US dollar. Compare this with the results obtained in the previous chapter when modelling nominal exchange rates, where we find asymmetric nominal exchange rate adjustment only in the case of Indonesia. This asymmetry is a new finding, which previous studies using symmetry-imposing non-linear models such as the TAR or the ESTAR, are not in position to capture. The econometric properties of the models reported in Table 2.5 are generally superior to their linear counterparts in Table 2.3, as they all pass the misspecification tests at the 5 per cent level and produce lower regression standard errors.[60]

Figure 2.2 presents the estimated real exchange rate misalignment term against the estimated thresholds of the inner regime for each of the countries examined. Some interesting observations emerge. First, deviations of the real exchange rates from their equilibrium values have predominantly been taking values within the inner regime. This is similar to the results in previous chapter in that nominal exchange rate misalignment

[60] Note that the estimate of the σ parameter, giving the speed of transition between the inner and outer regime, is high for Korea, moderate for Indonesia and the Philippines and low for Malaysia. With the exception of Korea, these results indicate that using the TAR or MTAR (Momentum Threshold Autoregressive) models (which postulate abrupt change between the two regimes) to model non-linear exchange rate dynamics may result to biased results. Note also that in all cases the σ coefficient is imprecisely estimated, however, this is not surprising as the likelihood function is very insensitive to this parameter (see the detailed discussion on this point in van Dijk et al., 2002).

typically also takes place within the inner regime. However, as found in the case of modelling nominal exchange rates behaviour in the previous chapter, deviations of the real exchange rates from their equilibrium values have also been taking values within the outer regime, particularly for the Philippines and South Korea.

Second, episodes of discrete devaluations were preceded by substantial overvaluation of the currencies involved, with the rate of misalignment taking values in the outer regime. In particular, Figure 2.2 suggests that the crisis of 1997-98 was justified by economic fundamentals. This evidence is also found when modelling nominal exchange rates in the previous chapter. It would appear that the restrictive monetary policy followed by all countries prior to 1997 led to very substantial real exchange rate overvaluation (particularly in the case of the Indonesian Rupiah), creating pressures for a substantial real exchange rate correction, which came in the form of a violent devaluation.

Finally, Figure 2.2 suggests that at the end of our sample periods the real exchange rate of the Indonesian Rupiah and the South Korean Won were significantly overvalued, whereas that of the Malaysian Ringgit was fundamentally undervalued. These results are also discovered in the previous chapter when modelling nominal exchange rates behaviour. To restore equilibrium, Figure 2.2 suggests that the Rupiah and the Won would subsequently depreciate against the US dollar, while the Ringgit would appreciate. In 2004-2005 the Rupiah has indeed depreciated against the US dollar, whereas the recent re-floating of the Ringgit has also led to a slight appreciation of the Malaysian currency. By contrast, during 2004-2005 the Won has appreciated further against the US dollar, suggesting that the Korean currency may be vulnerable to currency turbulence in the future. These results are remarkably consistent with our forecast when modelling nominal exchange rates behaviour in the previous chapter.

2.6. CONCLUSIONS

This chapter has examined real exchange rate behaviour in four fast-growing emerging Asian countries, namely Indonesia, Malaysia, the Philippines and South Korea. Over the past three decades, the currencies of all four countries have experienced a prolonged real depreciation against the US dollar. This renders the benchmark model of real exchange behaviour, Purchasing Power Parity, which predicts a constant real exchange rate, inadequate to explain real exchange rate behaviour in this set of countries.

We modelled equilibrium real exchange rates using a general behavioural equation, consistent with a variety of theoretical approaches to real exchange rate determination. We found equilibrium real exchange rates to be a function of relative permanent output shocks and one or more variables from nominal and real interest rate differentials as well as the level of and change in net foreign assets. However, the behaviour of real exchange rate differs from that of nominal exchange rates in that the former takes into account the deterministic time trend in its long-run model but excludes domestic and foreign prices. We also found that individual countries present significant elements of idiosyncratic behaviour, casting doubt on empirical models using panel-data techniques.

Furthermore, we obtained strong evidence of non-linear dynamics in the process of the adjustment of the real exchange rate to its extracted equilibrium level. More specifically, for all countries examined we found that the speed of reversion to equilibrium is a function of the size and, in two cases, the sign of the misalignment term. Compare this with the results obtained in the previous chapter when modelling nominal exchange rates, where we find asymmetric nominal exchange rate adjustment only in the case of Indonesia.

Finally, similar to the findings when modelling the behaviour of nominal exchange rates, our results in this chapter also suggest that the currency devaluations that took place in 1997-98 were entirely justified by economic fundamentals, as prior to the crisis the real exchange rates of all four countries were significantly overvalued against the US dollar.

Similar to the suggestions we made when modelling the behaviour of nominal exchange rates, our work can be extended in several ways. In the empirical level, we could use our empirical methodology to study the dynamics of real exchange rates in other sets of countries and determine whether the asymmetric, non-linear dynamics identified in the Asian economies examined by our analysis are a common future of exchange rate behaviour. In the theoretical level, we can use the empirical findings of our study first to motivate a theoretical model of non-linear exchange rate behavior based on asymmetric policy preferences and, second, to establish a formal non-monotonic link between the current account and the real exchange rate.

Table 2.1. Unit Root Test

Level	Indonesia		Korea		Philippines		Malaysia	
	1978(3)-2003(4)		1980(1)-2003(4)		1981(4)-2003(4)		1975(3)-1998(3)	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
q	-1.546	-2.084	-1.824	-1.879	-1.955	-1.869	-1.051	-0.510
$y^p - y_{usa}^p$	-0.127	-0.570	-1.575	-1.740	-1.819	-1.885	-1.225	-1.279
$i - i_{usa}$	-3.593***	-3.019**	-1.985	-2.653*	-3.797***	-3.997***	-1.960	-2.088
$r - r_{usa}$	-4.785***	-4.064***	-3.083**	-3.854***	-3.482**	-3.309**	-2.614*	-2.952**
rnfa	-1.709	-2.619***	-1.276	-0.916	-1.434	-1.250	-0.766	-0.551
rnfl			-1.466	-1.419	-0.903	-1.078		
Δ*rnfa*	-4.473***	-11.253***	-4.294***	-8.110***	-5.204***	-8.541***	-4.299***	-8.438***
Δ*rnfl*			-4.386***	-6.887***	-4.349***	-6.974***		

1st Difference

	Indonesia		Korea		Philippines		Malaysia	
	1978(3)-2003(4)		1980(1)-2003(4)		1981(4)-2003(4)		1975(3)-1998(3)	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
q	-4.946***	-8.192***	-3.834***	-7.002***	-5.020***	-7.754***	-4.834***	-6.469***
$y^p - y_{usa}^p$	-5.932***	-14.824***	-4.471***	-7.805***	-4.248***	-10.08***	-4.941***	-10.02***
$i - i_{usa}$	-5.673***	-9.155***	-4.780***	-7.914***	-4.929***	-12.08***	-4.169***	-8.560***
$r - r_{usa}$	-7.126***	-6.613***	-5.334***	-7.394***	-4.826***	-5.751***	-4.377***	-8.454***
rnfa	-4.473*	-11.254***	-4.294***	-8.110***	-5.204***	-8.541***	-4.299***	-8.437***
rnfl			-4.386***	-8.637***	-4.349***	-6.974***		
Δ*rnfa*	-8.081***	-25.987***	-6.869***	-19.296***	-6.394***	-19.715***	-6.048***	-21.72***
Δ*rnfl*			-8.634***	-23.369***	-6.848***	-15.96***		

*Notes: */**/*** denote significance at the 10%/5%/1% level respectively following MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 2.2. Real exchange rate models

	Indonesia	Malaysia	Philippines	South Korea
Sample	1978(3) –2003(4)	1975(3) – 1998(3)	1981(4) – 2003(4)	1980(1) – 2003(4)
constant	3.178 (0.032)	0.931 (0.119)	1.093 (0.027)	2.572 (0.099)
$(\bar{y} - \bar{y}_{USA})$	-0.815 (0.178)	0.506 (0.040)	-0.087 (0.027)	0.286 (0.090)
$(i - i_{USA})$	0.414 (0.061)		0.374 (0.079)	0.248 (0.143)
$(r - r_{USA})$		-0.206 (0.099)		-0.548 (0.157)
rnfa		0.102 (0.026)	0.056 (0.012)	0.090 (0.022)
rnfl			0.109 (0.013)	0.138 (0.020)
$\Delta rnfa$		0.348 (0.072)		0.239 (0.046)
$\Delta rnfl$			-0.102 (0.015)	0.187 (0.045)
t	0.003 (0.001)		0.004 (0.0003)	
R^2	0.895	0.850	0.786	0.740
ADF	-3.723	-3.025	-4.384	-2.998

Notes: Standard errors in parentheses; all variables are significant at 5% level or better; the lag structure of the reported ADF tests has been chosen using the Akaike information criterion.

Table 2.3. Linear Error Correction Models

	Indonesia	Malaysia	Philippines	S. Korea
Sample	1978(3)-2003(4)	1975(3)-1998(3)	1981(4)-2003(4)	1980(1)-2003(4)
constant	-0.002 (0.001)	0.000 (0.001)	0.001 (0.002)	-0.000 (0.001)
Δq_{t-1}	-0.061 (0.023)	0.261 (0.102)		0.408 (0.076)
Δq_{t-4}	0.046 (0.021)			
Δq_{t-9}	0.083 (0.022)			
Δq_{t-10}	0.057 (0.022)			
Δq_{t-11}			0.169 (0.077)	
Δq_{t-13}	0.090 (0.025)			
Δq_{t-14}	0.153 (0.032)			
Δq_{t-15}	0.060 (0.020)			
Δq^*	0.205 (0.044)	0.192 (0.061)	0.320 (0.059)	
Δq^* t-5			-0.202 (0.056)	
$\Delta q^*{}_{t-7}$	-0.144 (0.042)			
$\Delta q^*{}_{t-11}$	0.131 (0.049)			
$(q-q^*)_{t-1}$	-0.051 (0.018)	-0.201 (0.044)	-0.219 (0.052)	-0.098 (0.030)
Regression S.E.	0.00815	0.01103	0.01482	0.00847
R^2	0.98	0.57	0.44	0.85
AR	1.15 [0.34]	2.21 [0.06]	1.71 [0.14]	1.58 [0.17]
ARCH	0.48 [0.75]	0.11 [0.98]	1.51 [0.21]	2.60 [0.04]
Normality	4.63[0.10]	0.39 [0.82]	1.81 [0.40]	3.80 [0.15]
Hetero	0.90[0.61]	1.79 [0.08]	1.65 [0.13]	0.53 [0.81]
RESET	0.08 [0.78]	0.74 [0.39]	2.19[0.14]	3.45 [0.07]

NOTES: Standard errors in parentheses, p-values in square brackets. All models have been estimated including dummy variables for periods of major currency turbulence. These are defined: for Indonesia 1983(2), 1986(4), 1997(4), 1998(1), 1998(4), 2001(3); for South Korea: 1997(4), 1998(1), 1998(2); for Malaysia: 1997(4), 1998(1) and 1998(3). AR is the Lagrange Multiplier F- test for residual serial correlation of up to fifth order. ARCH is an F-test for Autoregressive Conditional Heteroskedasticity and general mispecification. Normality is a Chi-square test for residuals' normality. Hetero is an F-test for residuals heteroskedasticity. RESET is an F-test for functional form.

Table 2.4. Tests for non-linear adjustment

	φ	d	F-test [p-value]
Indonesia	1	2	7.903 [0.00]
Malaysia	1	4	2.264 [0.05]
South Korea	1	4	3.317 [0.00]
Philippines	1	2	4.305 [0.00]

NOTES: φ is the order of the autoregressive component and d the order of the delay parameter in the artificial regression described by (2.3)

Table 2.5. Non-Linear Error Correction Models

	Indonesia	Malaysia	Philippines	South Korea
Sample	1978(3)-2003(4)	1975(3)-1998(3)	1981(4)-2003(4)	1980(1)-2003(4)
M_I				
Constant	0.0009 (0.001)	0.026 (0.009)	0.0012 (0.002)	-0.001 (0.001)
Δq_{t-1}	-0.074 (0.023)			0.366 (0.087)
Δq_{t-4}		0.318 (0.096)		
Δq_{t-11}			0.1929 (0.081)	
Δq_{t-13}	0.077 (0.021)			
Δq_{t-14}	0.141 (0.028)			
Δq_{t-1}				0.130 (0.064)
Δq_{t-2}				0.113 (0.048)
Δq_{t-5}	-0.099 (0.049)			
Δq_{t-7}	-0.170 (0.042)			
$(q-q^*)_{t-1}$	-0.010 (0.018)	-0.035 (0.044)	-0.0515 (0.067)	-0.046 (0.048)
M_O				
Constant	0.0439 (0.008)	-0.021 (0.012)	-0.0002 (0.003)	-0.002 (0.002)
Δq_{t-1}			0.737 (0.167)	
Δq_{t-2}			0.362 (0.146)	
Δq_{t-4}	-2.788 (0.214)			
Δq_{t-9}	-1.566 (0.657)			
Δq_{t-13}	2.242 (0.979)			
Δq_{t-1}				-0.253 (0.077)
Δq_{t-2}	1.709 (0.071)			
Δq_{t-3}		0.9806 (0.499)	0.405 (0.126)	
$(q-q^*)_{t-1}$	-0.412 (0.041)	-0.3591 (0.114)	-0.218 (0.070)	-0.238 (0.044)
σ	15.93 (19.71)	2.25 (0.977)	27.81 (84.31)	68.68 (319.8)
τ^U	0.089 (0.001)	0.032 (0.006)	0.023 (0.002)	0.034 (0.001)
τ^L	-0.104 (0.0004)	-0.058 (0.005)	-0.043 (0.002)	-0.041 (0.001)
Standard error	0.00788	0.00903	0.01324	0.00827916
R^2	0.98	0.75	0.60	0.87
AR	0.39 [0.8531]	0.95 [0.45]	1.01 [0.42]	0.57 [0.72]
ARCH	0.47 [0.7563]	0.26 [0.90]	0.51 [0.73]	0.97 [0.43]
Normality	2.73 [0.2555]	2.68 [0.26]	2.37 [0.31]	1.19 [0.55]
Hetero	1.12 [0.3804]	0.28 [0.99]	0.31 [0.99]	0.62 [0.90]
F-test H_0: $\tau^L + \tau^U = 0$	133.69	11.34	3.17	0.35

NOTES: Standard errors in parentheses, p-values in square brackets. All models have been estimated including dummy variables for periods of major currency crises. These are defined: For Indonesia 1983(2), 1986(4), 1993(1), 2000(2), 2001(3); for Malaysia: 1975(3), 1976(3), 1983(1), 1985(1), 1986(2), 1997(3), 1997(4), 1998(1); for South Korea 1997(4), 1998(1), 2001(1); for the Philippines: 1984(1), 1985(1), 1997(3). AR is the Lagrange Multiplier F- test for residual serial correlation of up to fifth order. ARCH is an F-test for Autoregressive Conditional Heteroskedasticity and general mispecification. Normality is a Chi-square test for residuals' normality. Hetero is an F-test for residuals heteroskedasticity. RESET is an F-test for functional form. The 95 p.c. critical value for the F-test testing H_0: $\tau^L + \tau^U = 0$ is 3.84.

Figure 2.1: Real exchange rates in Asian Economies

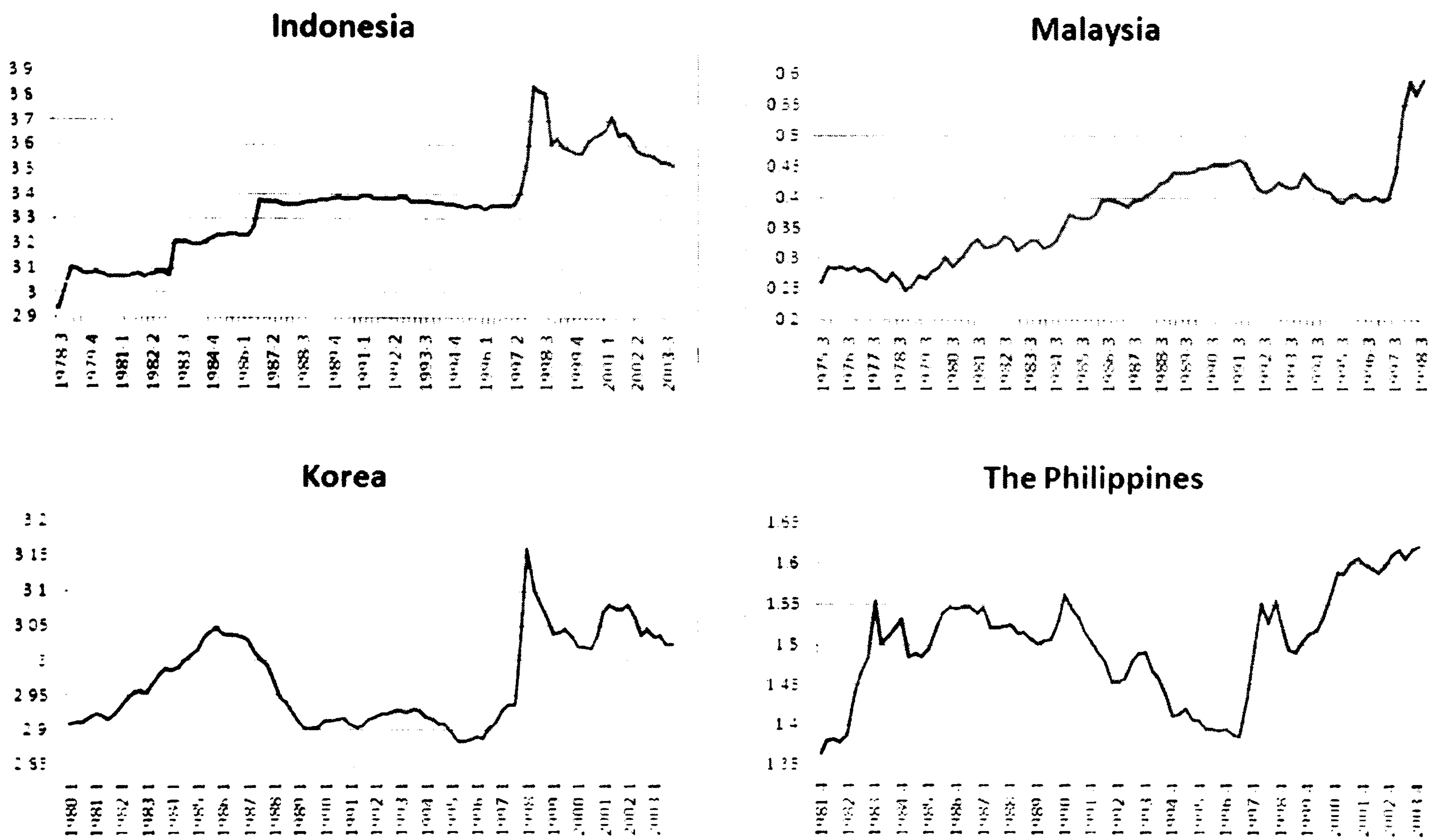
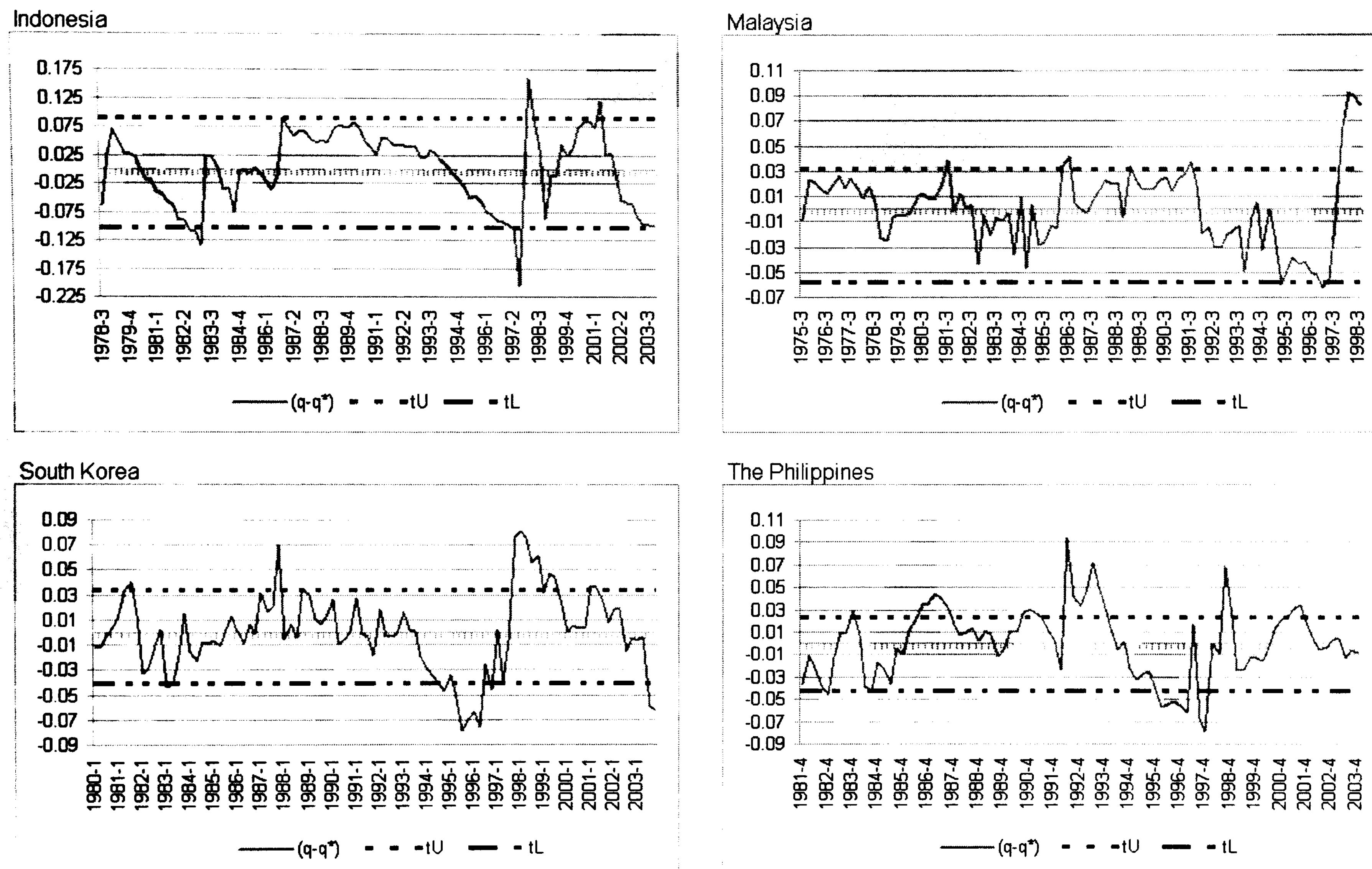


Figure 2.2: Real exchange rates misalignment (q-q*) against the upper (tU) and lower (tL) threshold of the inner regime



PART

II

CHAPTER III

Modelling Monetary Policy Reaction Function: New Evidence from East Asia

3.1. Introduction

It has become standard practice to explain the conduct of monetary policy using reaction functions that associate the interest rate with inflation and output. This reaction function, the Taylor rule that was first proposed by Taylor (1993), suggests that interest rates are changed according to deviations of inflation from a target and to the output gap. However, the Taylor rule has been criticized for being too simple for a smaller and more open economy. Some researchers, such as Svensson (2000), have proposed an augmented Taylor rule with the exchange rate included, in a rule designed for small open economies. Other economists, such as Clarida et al (1998), consider the foreign interest rate to be another variable that should be included in a typical central bank reaction function for these economies.

There are several reasons for including the exchange rate in the central bank reaction function in emerging economies. For example, a high degree of pass-through of the exchange rate into inflation, in which the exchange rate affects the domestic currency prices of imported final goods and, consequently, CPI inflation. As a secondary effect of the exchange rate on inflation, changes in CPI inflation will induce wage setting and eventually affect nominal wages. The impact on both CPI inflation and nominal wages will change the cost of producing domestic goods and eventually lead to inflation in the prices of domestically produced goods (domestic inflation).

Another reason for including the exchange rate in the augmented Taylor rule is the possible effect on aggregate demand. Changes in the exchange rate will alter the relative prices of tradable and non-tradable goods, leading to adjustment in trade balances. For instance, following a depreciation of domestic currency, imported goods become more expensive. If pass-through is high, imports will decline as consumer spending shifts to domestically produced goods and away from imported goods. Indeed, foreign demand for domestic goods will rise if the relative price between domestic and foreign goods becomes larger and may eventually lead to expenditure switching between imports and exports. The shift in domestic and foreign demand for domestically produced goods will ultimately affect aggregate demand in an economy.

For these reasons, it is sensible to presume that an augmented Taylor rule including the exchange rate could lead to an improved macroeconomic performance in terms of stabilizing inflation and output in a small open economy. Accordingly, the inclusion of the exchange rate variable is consistent with all these four Asian Central Banks' objectives of maintaining price and financial stability, as a substantial depreciation of their currency would cause domestic price and wage inflation, eventually hampering its competitiveness. If the domestic currency depreciates beyond a certain point the Central Bank responds by raising the interest rate.

There are also several reasons for including the foreign interest rate in the monetary reaction function of emerging economies. One is interest rate differential parity. Since the advent of financial globalization, any movements in foreign interest rates vis-à-vis domestic rates can no longer be totally ignored in monetary policy implementation. If the foreign interest rate exceeds the domestic interest rate, there is a capital outflow. Therefore, in response to increasing foreign interest rates, the central bank may be forced to raise interest rates. On the other hand, there is a potentially huge capital inflow if domestic interest rate exceeds the interest rate abroad. Hence, the central bank will consider lowering domestic interest rates in response to a decreasing foreign interest rate.

In this chapter, we investigate the monetary policy reaction function of four Asian Central Banks. We attempt to assess whether central banks in these four emerging economies are primarily concerned with fluctuations in inflation and output, or whether they are also concerned with fluctuations in the exchange rate or foreign interest rates. To do this we use a simple model of the augmented Taylor Rule including exchange rates and foreign interest rates. We consider both backward-looking and forward-looking specifications. To the best of our knowledge, there is no research exploring this type of augmented Taylor rule for these four emerging economies.

The evidence in this chapter suggests that all central banks in these emerging market economies pursue the objectives of price and output stability. In all four countries other objectives also play a role, monetary authorities adjusting interest rates systematically in response to foreign interest rates and exchange rates. The response to the foreign interest rate is typically strong in all countries in the sample. Additionally, in Indonesia and the Philippines, the response is found to be even more marked than that to changes in the inflation rate or the output gap. This emphasizes the importance of foreign interest rate fluctuations. Our empirical evidence also suggests that the interest rate is a useful instrument to counter movements in the exchange rate. The augmented Taylor rule including the exchange rate and the foreign interest rate is a better empirical model because it captures how a small open economy attempts to stabilize the exchange rate and the financial market. Finally, we also find evidence that monetary policy reaction functions in Indonesia and Korea were a combination of forward and backward-looking, while in the Philippines were a combination of forward-looking and contemporaneous and in Malaysia were essentially forward-looking. Surprisingly, we do not find any central bank considering purely backward-looking or contemporaneous specifications.

The chapter is organized as follows. Section 3.2 presents the literature review. Section 3.3 presents the methodology we employ and some notes on the estimation of monetary policy reaction functions. Section 3.4 introduces the data used and discusses some preliminary observations. Section 3.5 proceeds with the estimation of the baseline specification and its extensions and then an analysis of the implied monetary policy behaviour over the period studied. Finally, Section 3.6 offers concluding remarks.

3.2. Literature Review

3.2.1. Original Taylor Rule vs. Augmented Taylor Rule

Rudebusch and Svensson (1998) conclude that the Taylor rule framework is useful in summarizing major variables in US monetary policy. Gerlach and Schnabel (2000) conclude that monetary policy in the EMU (European Monetary Union) area has largely been consistent with the Taylor rule. Using quarterly data from 1990 to 1997, with the exception of the period of exchange market turbulence in 1992–93, they show that a Taylor rule accurately portrays the behaviour of interest rates in the EMU area. Implementing such a rule as a policy guideline provides evidence of positive correlations between interest rate and the average of inflation as well as the output gap. Adopting such a rule recognized by the public may ease uncertainty about the future pattern of monetary policy and thus help prevent unnecessary macroeconomic instability. Levin et al (1999), Leitemo and Söderström (2001), and Nyberg (2002) give further support for the robustness of the Taylor rule.

On the other hand, Svensson (2000, 2002) argues that from a theoretical point of view, the importance of the Taylor rule for conducting monetary policy should be questioned. If there are essential variables other than inflation and the output gap, then the original Taylor rule is highly unlikely to explain the monetary authority's action. He suggests that for a small and open economy, other important state variables such as real exchange rate and the foreign interest rate should be included in the rule. His conclusion echoes those of Ball (1999) and Batini et al (2000) who found evidence that such an augmented rule is superior to the original Taylor rule for small open economies, reducing the standard deviation of CPI inflation. Other researchers such as Hsing (2004) also support the use of exchange rates in a Taylor-type rule, in which he shows that between 1975 and 2003 the Bank of Canada raised the call rate in response to a depreciation of the Canadian dollar.

Clarida et al (1998), meanwhile, are among those to have proposed the relevance of a foreign interest rate variable in an augmented Taylor-type rule. According to their results for the period 1979 to 1994, central banks in the E3 countries (U.K., France, and Italy) reacted to the German interest rate and kept interest rates higher than the domestic economic conditions required. They also find central banks in the G3 countries (Japan, U.S., and Germany) pursuing inflation targeting implicitly, reacting to expected inflation instead of past inflation figures, and so were forward-looking.

3.2.2. Backward-Looking vs. Forward Looking Augmented Taylor Rule

The forward-looking version of the Taylor rule, according to Huang et al (2001) performs better than a contemporaneous variable specification. This effect, although the differences are minor, is found when studying the Reserves Bank of New Zealand's reaction function. Similarly, other economists such as Ball (1999), Svensson (1999, 2002), Batini et al (2000), Orphanides (2001), and Woodford (2001) support a forward-looking version of the Taylor rule. Orphanides (2001) estimates the Taylor rule for the U.S. during 1987-1992 using ex post and real time data. He finds evidence that forward-looking versions of the Taylor rule can describe policy better than contemporaneous specifications. He also finds that, the Taylor rule seems to give a much more accurate description of policy when ex post data are used than when real time data are used. Eusepi (2005), meanwhile, provides evidence of the superiority of Taylor rules based on current and past information rather than forecasts.

3.2.3. The Monetary Policy Reaction Function in Emerging Economies

During the last decade, the number of empirical studies of the monetary policy reaction function from the perspective of developing countries has increased substantially, suggesting the relevance of Taylor rule as a tool for the analysis of the behaviour of monetary policy. A review of interest rate setting behaviour in emerging market economies gives interesting results. Affandi (2004), when estimating Indonesia's monetary policy reaction function, finds that reaction of the interest rate to expected inflation is positive, in that an increase in expected inflation is responded to by raising nominal rates. He also finds that the central bank is more sensitive with respect to domestic inflation, in the sense that the interest rate response to non-traded goods inflation is greater than that to CPI inflation. This policy response has ensured inflation stability, as the central bank does not allow expected inflation to rise. He suggests that this empirical evidence shows the monetary authority was implicitly employing inflation targeting as a new framework for monetary policy in Indonesia.[61]

In the case of Korea, Hsing and Lee (2004) find that the call rate reacts positively to the lagged call rate, the inflation gap (the deviation of inflation from its target), the output gap (the difference between actual and potential GDP), the exchange rate gap (the deviation of the exchange rate from its fundamental value), and the stock price gap (the deviation of stock prices from its trend), but not to foreign interest rates. They find that the Bank of Korea focuses more on the inflation gap and the exchange rate gap in the short run, whereas the output gap and the stock market gap are more important in the long run.

Salas (2004) finds that the Philippine central bank (BSP) has been stabilizing inflation through its choice of its key policy rate. However, it appears to be accommodative with respect to the output gap, in that changes in the output gap do not provoke a response. Filosa (2001) finds that most central banks of maturing emerging market economies react strongly to the exchange rate, although frequent changes in the monetary policy regime make it difficult to assess the relative importance placed on inflation control and external equilibrium.

[61] Indonesia officially adopts inflation targeting framework in Juli 2005 following the amendment of its Act No. 23 of 1999.

3.3. The Evolution of Monetary Policy in These Economies

Over the decade before the mid 1980s, the Central Banks of Indonesia, Korea, Malaysia and the Philippines generally conducted monetary policy using an intermediate targeting system, such as a broad monetary aggregate, in order to attain price stability.[62] Additionally, in this period, these four central banks conducted monetary policy through a mixture of financial-market operations and direct controls on markets and financial institutions. These incorporated controls on commercial bank interest rates, reserve requirements and various other balance-sheet restrictions. This system of policy management was gradually found to be ineffective. Markets in fact developed ways of avoiding regulation through dealing with unregulated parts of the financial sector.

As in any other countries, the rapid financial innovation and liberalization of the late 1980s blurred the distinction between monetary aggregates and destabilized the relationship between the real sector and monetary aggregates. These developments greatly reduced the effectiveness of existing methods of conducting monetary policy. These countries began demonstrating considerable instability in the demand for money, implying that monetary growth targets had failed because of large-scale shocks to money demand functions.

In the aftermath of the 1997/98 financial crises, the maintenance of exchange rate at a certain level as the anchor for their monetary policy was abandoned. In the face of growing capital flows and the imperfections of financial markets, monetary authorities

[62] Price stability contributes to economic efficiency by reducing the uncertainties, which are likely to slow investment down. It also allows resources to be directed toward productive economic activities that might otherwise be redirected to alleviating the financial effects of inflation.

shifted their fixed-exchange rate system to a floating exchange rate system.[63] Consequently, they needed a new anchor and turned their attentions to controlling inflation.[64] Since then, these central banks, with the exception of Malaysia, have exercised the potential of inflation targeting as a new framework for the operation of monetary policy.

According to Bernanke et al (1999), inflation targeting is a monetary policy framework that exhibits five conditions. Firstly, the bank specifies and officially announces its inflation rate target. Secondly, the bank unambiguously recognizes that the ultimate goal of its monetary policy is stable inflation, while allowing economic growth and employment stability as subordinate goals. Thirdly, the bank takes all economic indicators concerning price stability into account in its forward-looking monetary policy management. Fourthly, the bank transparently explains to the public and market players reasoning behind the contents of monetary policy decisions and the grounds on which the decisions are based. Fifthly, the focus of its monetary policy is placed on achieving inflation targeting objectives in an accountable manner. With the introduction of inflation targeting system, the previous multiple objectives of monetary policy - high economic growth, a low level of unemployment, a tolerable inflation rate, and a sustainable balance of payments position - were abolished and replaced by the single objective of price stability. Additionally, employing the inflation targeting system strengthened the central bank's independence and neutrality.

[63] For example, South Korea, hard hit by the currency and financial crisis in November 1997, abolished its exchange rate band and shifted to a complete floating exchange rate system in December of the same year.
[64] Countries that have been successful in maintaining low inflation have typically enjoyed better economic performance than those that were unable to do so (see Haldane, 1995; Bernanke et al. 1999; Cecchetti and Ehrmann 1999; Allen 2000).

Korea was the first of these countries to introduce inflation targeting, in 1998. About four years later, inflation targeting was introduced in the Philippines as a new method of operating monetary policy. Indonesia followed, introducing inflation targeting implicitly in 1999 and explicitly in 2005. However, Malaysia has not yet introduced this system as its monetary policy.

Because of the short time since these countries adopted inflation targeting framework their performance cannot be reviewed thoroughly at the present time. The experience of these countries, though, generally shows that the effectiveness of monetary policy has improved since the introduction of the system.

3.3.1. The Monetary Policy Framework in Indonesia

Over the past four decades, Indonesia's monetary policy framework has changed steadily. In the late 1970s, Bank Indonesia (BI) shifted its monetary management from direct controls (i.e. credit and interest rate ceilings) to indirect control (open market operations). Monetary policy was conducted mainly by using base money as the operational instrument for controlling other monetary aggregates such as broad money.[65] However, although the use of base money as the operational instrument for monetary policy seemed to have been effective in the 1980s and early 1990s, this approach came under severe pressure thereafter. During the Asian financial crisis of 1997/98, Bank

[65] McLeod (1997a) argued that during this period, the monetary policy anchor was clearly the nominal exchange rate, which was controlled intensely within a relatively narrow band. This allows the exchange rate to depreciate at a fairly steady rate. However, with this type of exchange rate system, the conduct of monetary management was effectively constrained.

Indonesia had to act as lender of last resort in order to prevent bank runs and a collapse of the banking system, backing failing banks with huge liquidity support. Unfortunately, this action cost the authority its monetary control, as base money grew by 115% and broad money by 68% between November 1997 and July 1998.[66] This expanding money supply, along with an erosion of public confidence in the Rupiah, a weakening currency cycle, and mounting prices, plunged the country into hyperinflation. In brief, monetary policy using quantity targets became ineffective.[67]

As a result, the bank considered shifting from quantity targeting to inflation targeting. As a first step the bank united money, interest rate and exchange rate targeting. In the massive financial integration and globalization of the 1990s, the bank found this pragmatic approach loosing ground.[68] The policy of maintaining the exchange rate within a narrow band was challenged by sizeable and volatile capital flows. Beginning in 1992, the bank gradually broadened its intervention band. Alamsyah et al (2001) noted that by July 1997, the band was about 12% from the central parity following mounting

[66] See Alamsyah et al (2001).

[67] Boediono (1998) in Alamsyah et al (2001) argues that there are at least two reasons why base money growth became less effective. The first is a relatively thin and fragmented market for the bank's open market operation (OMO) instruments, namely central bank bills (SBI, Sertifikat Bank Indonesia) and money market securities (SBPU, Surat Berharga Pasar Uang). The OMO procedure allowed leading banks, mostly state banks to hold most outstanding SBI. Consequently, most private banks were exposed to unexpected shocks since they were extremely dependent on the interbank market to cope with their liquid reserves. In such circumstances, the central bank may be forced to push up the interest rate to control liquidity. In September 1984, for instance, the interbank overnight rate soared to 90% per annum after contraction policy. Under the same policy in mid 1987, with the aim of fighting speculative transactions in foreign markets, Bank Indonesia made the state banks buy back SPBU and the state-owned enterprises purchase SBI with their deposits at the state banks. Secondly, base money is endogenous with respect to output in particular times. During an economic upswing for instance, escalating aggregate demand is followed by inflated foreign loans and the selling of SBI back to BI. Given the quasi-fixed exchange rate policy and an unwillingness to increase SBI rates, base money rises. Therefore, managing base money (and through it, aggregate demand) is a complicated task in which hugely high interest rates should occasionally be considered otherwise non-market instruments such as reserve requirements, moral suasion and tighter prudential regulations for the banks might be put in place.

[68] Conflicts between multiple objectives were discussed by McLeod (1997c), although in a slightly different context. In particular, he argued that Indonesia's efforts to limit the current account deficit to 2% of GDP conflicted with its 5% annual inflation target.

speculative transactions in the money and foreign exchange markets. In August 1997, the bank shifted its managed exchange rate system to a flexible exchange rate system and delayed the implementation of inflation targeting framework. Consequently, the bank continued to employ the quantity targeting as its nominal anchor following IMF advice. Iljas (1999) found that in the aftermath of the crisis, the monetary base target was only utilized as a transitory measure to absorb excess liquidity from its emergency action as lender of last resort during the financial crisis.

A major change in the conduct of monetary policy took place in May 1999 when parliament passed a new central banking law[69] that allowed BI to independently formulate and operate monetary policy. Under the new law, multiple objectives such as a low level of unemployment, high economic growth, a sustainable balance of payments position and a tolerable rate of inflation were abolished. The only objective of the new monetary policy is to pursue and maintain the stability of the value of the rupiah. A stable rupiah value has two meanings. Firstly, it refers to its value in terms of another currency unit (e.g. US dollar, the Japanese yen or the Euro). Since the rupiah exchange rate is completely determined by supply and demand forces in the market, all the BI can do is to attempt to limit fluctuation in the exchange rate. Secondly, it refers to maintaining domestic price stability with regard to the purchasing power of the Rupiah to acquire goods and services. Under the new law, there is reasonable room for BI to achieve price stability since it is granted full independence[70] to formulate inflation target (goal

[69] The Law No. 23 of 1999 on Bank Indonesia (BI).

[70] Unlike in the past, the law stipulates that as an independent institution, BI is free from government or other outside intervention. Article 9 of the Law No. 23 of 1999 on Bank Indonesia prescribes that other parties are prohibited to get involved in any form in implementing BI tasks, and BI is obliged to refuse and/or to disregard any form of involvement by any parties in implementing its tasks.

independence) and operate monetary instruments (instrument independence).[71] In addition, article 10 stresses that BI is authorized to implement monetary policy by determining monetary target in consideration of inflation rate target. Typically, price and exchange rate stability are strongly interconnected since exchange rate stability will affect low inflation.

While Bank Indonesia is supposed to have implemented an inflation targeting framework in 1999 following the adoption of a new central banking law, the Law No. 23 of 1999 on Bank Indonesia (BI), it is in July 2005, Bank Indonesia finally launched this framework following the amendment of its Act No. 23 of 1999.[72] This framework has four basic elements. Firstly, it uses the BI rate as a reference rate in monetary control in replacement of the base money operational target. Secondly, it considers a forward looking monetary policymaking process. Thirdly, the bank commits to be more transparent in its communications strategy. Finally, the bank will strengthen its policy coordination and cooperation with the Government. The reason for this is because the bank assumes that inflation cannot be controlled only over monetary policy, but also over other macroeconomic policy such as fiscal policy. These four basic elements are meant to improve the effectiveness in conducting monetary policy in order to achieve the ultimate goal of price stability in support of sustainable economic growth.[73]

[71] There is a conceptual difference between a quantitative definition of price stability and an inflation target in that the latter does not automatically define "price stability", but reckons the objective in connection with price changes that monetary policy intend to pursue. Traditionally, there have been many occasions when inflation targets were set at levels considerably away from "price stability", often in cases where countries experiencing high levels of inflation, eventually set a path of inflation targets in order to bring inflation down to lower levels. A relationship presents only when such inflation targets are aimed explicitly at achieving "price stability". (Duisenberg, 2001)

[72] The Act No. 23 of 1999 concerning Bank Indonesia is amended by Act No. 3 of 2004.

[73] By adopting the inflation targeting framework, it does not mean that the bank pays attention only to inflation and excludes economic growth from its monetary policy. The bank sees that the ITF is not a rigid

Under the amendment of the law concerning Bank Indonesia, the inflation target is set by the Government after considering Bank Indonesia's proposal. The Government set the inflation target for 2005, 2006, and 2007 at 6% ±1%, 5.5%±1%, and 5.0%±1% respectively. The setting of these intermediate targets considers the trade-off with economic growth in the effort to improve the living standards of the population and consistent with the desire to achieve a medium-long term inflation rate of 3%.

3.3.2. The Monetary Policy Framework in Korea

Korea has used various monetary policy frameworks since 1957. In managing its monetary policy, from 1976, the Bank of Korea used the rate of increase in the monetary aggregate as an intermediate target[74] before shifting to a floating exchange rate system and adopting an inflation target in 1998. The Bank of Korea Act of 1997 that came into effect on 1 April 1998 replaced the previous dual objectives of maintaining monetary stability and strengthening the soundness of the banking system with the primary goal of price stability. The law is concerned to establish the neutrality and autonomy of monetary policy. It specifies that the central bank should formulate the annual inflation target in consultation with the government, make that target public and attempt to achieve it. For

rule, but a comprehensive framework for formulating and implementing monetary policy. Thus, the focus on inflation does not mean guiding the economy towards a condition of zero inflation.

[74] Initially the bank used M1 before net domestic assets. Since then, reserve money has been used before turn to domestic credit of financial institutions, net domestic credit, respectively. Again M1, M2, M2 plus certificates of deposit and balances held by investment trust companies, and finally M3 implemented by the bank accordingly.

instance, according to the agreement between the bank and the government, the bank set the 1998 inflation target at a rate of 9%±1%, based on the Consumer Price Index. In addition to that and as a part of conditions impose on IMF credits, the bank also consults the IMF concerning the method of monetary operation in particular in determining and maintaining the appropriate level of M3 growth, serving as a monitoring variable. This twin target system, M3 target and inflation target, is believed to resemble that of the European Central Bank.

Bank of Korea gave three reasons[75] for adopting the twin target system. Firstly, there would be chaos in financial markets if the monetary target that had been used in the last 30 years were to be abandoned suddenly. Secondly, given that inflationary expectations are influenced by monetary indicators, the bank considered it was right and proper to guide them through the announcement of an appropriate growth rate of M3. Finally, the bank intended to employ both systems only during the period of transition until the inflation targeting approach took root in 2001.

The inflation target formulated by the Bank initially referred to average annual consumer price inflation. However, starting in 2000, the bank adopted the core inflation rate as its inflation target, set at 2.5%±1%,[76] since most of the time, consumer price inflation is considered more volatile in particular it is sensitive to certain items, such as non-grain agricultural products whose prices are greatly affected by weather conditions, harvests and so forth, and petroleum products whose prices are likely to fluctuate depending on changes in international oil prices. This decision was taken by the bank because it could not control supply side external shocks.

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[75] See Monetary Policy in Korea by the Bank of Korea

[76] In anticipation of various uncertainties surrounding the economy, the bank allows a one-percent point band around the mid-point of the target range.

Even though the fundamental task is clearly to ensure price stability, the bank still considers other policy goals. For instance, in a situation when future prices are expected to be high but within the target range, the central bank will not necessarily rush to increase interest rates. Conversely, the bank may base its decision on the state of the financial markets or the real economy. These circumstances led the National Assembly in its annual report to argue that the Bank of Korea actually employs flexible inflation targeting,[77] in the sense that the bank moderates the speed of call rate adjustment in response to the percentage deviations of actual from target inflation with respect to the condition of the real economy.

3.3.3. The Monetary Policy Framework in the Philippines

The Central Bank of the Philippines was established in June 1948 and began operation on 3 January 1949. In conducting monetary policy, the bank formulated and operated a variety of intermediate targets to achieve its final objectives. It traditionally conducted monetary policy by targeting monetary aggregates in line with its mandated duty of maintaining price stability that was conducive to the economic growth of the country and was a fundamental component of the Philippine government's loan program with the International Monetary Fund (IMF).

[77] Flexible inflation targeting occurs if the central bank puts some weight on inflation-stabilization, output-stabilization, interest-rate smoothing, or some other goals. This is opposed to strict inflation targeting when the only concern of the central bank is to stabilize inflation.

On 3 July 1993, The Bangko Sentral ng Pilipinas (BSP) took over from the Central Bank of the Philippines as the country's central monetary authority following the implementation of the New Central Bank Act of 1993. Starting in the second semester of 1995, the bank adopted a so-called modified framework combining monetary aggregate targeting with inflation targeting. Facing difficulties in meeting the intermediate monetary targets, the bank chose to focus its interest on price stability. This new framework allowed base money growth to exceed target as long as inflation targets were met, with mopping up operations done if and when inflation eventually overshot the target (Guinigundo, 2000).

The monetary policy framework was changed again on 24 January 2000 when the Monetary Board (MB), the BSP's policy-making body, informally adopted an inflation-targeting framework. However, the bank only formally adopted this framework two years later. Like other banks adopting inflation targeting, the bank annually announces its explicit inflation target, and sets the monetary policy instrument to attain the target based on inflation forecasts and other relevant information.

Nonetheless, the bank differentiates inflation target from inflation forecast. An inflation target, representing policymakers' desired level of the inflation rate, is basically a contract between the government (represented by the central bank) and the public, while an inflation forecast is a tool or indicator used in performing that contract. Because of their institutional nature, inflation targets are more unlikely to be changed —albeit countries with a history of high inflation are likely to adjust their inflation targets across a period of several years. On the other hand, inflation forecasts, because of important new information is incorporated in the assessment of future inflation, normally tend to change over time. Inflation forecast also represents their expectation or prediction of the level of inflation in the future.

The government of the Philippines defines the inflation target in terms of the year-on-year change in the consumer price index (CPI) and expressing it in terms of a range of one percentage point. For example, the target for 2004 was set between 4 and 5 percent. This band is considered to give operational flexibility to the bank in achieving the target. However, the bank has to show a high degree of transparency and accountability, such as explaining its actions and the motivations of its policies publicly. If the BSP fails to meet the inflation target, the BSP Governor is obliged to write an open letter to the President to explain why the target was not achieved along with measures to be adopted to turn inflation towards the target level. The bank has issued Open Letters to the President on 16 January 2004, 18 January 2005, 25 January 2006 and 19 January 2007.

3.3.4. The Monetary Policy Framework in Malaysia

Prior to the mid-1990s, the central Bank of Malaysia, namely the Bank Negara Malaysia (BNM) conducted monetary policy by using a monetary target to achieve the ultimate objective of price stability. This was an internal strategy and was never officially published. The bank controlled the day-to-day volume of liquidity in the money market to guarantee that liquidity was adequate to meet demands and to meet the monetary growth target.

The globalization of financial markets and global economic integration in recent decades undermined monetary targeting. After 1990, in particular, the globalization of financial markets[78] changed the money demand function. The connection between monetary aggregates and output and prices became less stable. For instance, massive capital inflows in 1992-93 and equally massive outflows in the following year contributed to the instability of monetary aggregates. During periods of large capital flows, the annual money supply growth (M3) was highly volatile. Consequently, the value of M3 as an intermediate target was diminished. This lead to deviations of monetary velocities and ratios of nominal GDP to various monetary aggregates from their historical patterns from the early 1990s as discussed by Cheong (2004).

For the above reasons, in the mid-1990s, BNM altered its policy from monetary targeting to interest rate targeting.[79] According to Cheong (2004), four factors lead the Bank to change its intermediate target from monetary aggregates to interest rates. First, since the liberalization of interest rates in 1978, the formulation of the interest rate has been considerably more market-oriented. Second, since financial deregulation and liberalization measures undertaken during the 1970s, the role of interest rates in the monetary transmission mechanism has become stronger. Third, since the mid-1980s and following structural changes in the economy that shifted emphasis from the interest-

[78] Monetary authority became powerless in formulating its monetary policy since the financial globalization took place. This is so, because the bank now should concern about external considerations when formulating its monetary policy.

[79] It is interesting to notice that in implementing the new interest rate targeting, the bank still observes thoroughly the monetary aggregates, credit growth and other economic and monetary indicators including price developments (i.e. asset prices), consumption and investment indicators.

inelastic market for government securities to the more interest sensitive market for bank credit, there had been a marked change in the financing pattern of the economy. Fourth, as a matter of policy, the bank had retained a positive real rate of return on deposits. Interest rate stability is necessary to encourage a stable financial system, which was a factor in a more effective monetary transmission mechanism. These factors, along with increasing numbers of interest-sensitive investors, provided sufficient ground for interest rate targeting to replace monetary targeting as an intermediate target.

During the Asian Financial Crisis of 1997-98, the Bank's ability to control interest rates was challenged by insecure short-term capital flows and by the tremendous fluctuation of the Ringgit. The Bank had no option other than maintaining high interest rates to discourage large capital outflows. This strategy was aimed at defending the value of the Ringgit against further speculative transactions in the financial market. However, this strategy was unable to dampen volatility in the financial market due to growing uncertainty during the crisis. On the first September 1998, the bank introduced selective exchange rate controls in which the domestic currency was predetermined at the established market rate on the following day. This action reduced exchange rate volatility and accordingly protected foreign reserves from further decline in the volume of the currency. It also granted the bank a higher degree of monetary autonomy in controlling interest rates to champion economic recovery. The BNM policy surprised the world, especially when most economists were worried about Malaysia's decision to reject IMF assistance during the Asian Financial crisis. The BNM proved that it was unnecessary to maintain high interest rates to support the currency, to bring back confidence, and to attract capital inflows.

3.4. Methodology

3.4.1. Simple Taylor Rule

The original Taylor (1993) paper argues that U.S monetary policy during the period of 1987-1992 can be explained by movements in the federal funds rate in reaction to deviations of inflation from target and real GDP from capacity levels. According to Taylor, the relationship between the Federal Funds rate, the current output gap and the current rate of inflation can be presented in a number of different formulae. Below, we present two simple versions of the Taylor rule for the United States, which are equivalent to each other:

$$i_t^* = 4 + 1.5(\pi_t - 2) + 0.5(y_t - y_t^*) \qquad (3.1)$$

$$r_t^* = 2 + 0.5(\pi_t - 2) + 0.5(y_t - y_t^*) \qquad (3.2)$$

where i_t^* is the targeted nominal Fed Funds rate in percent per year, r_t^* is the targeted real Fed Funds rate in percent per year,[80] π is the rate of inflation over the past four quarters, y is the log of real GDP and y* is the log of potential GDP, thus (y−y*) is the output gap, i.e. the percentage deviation of output from steady state or trend output.

[80] Defined as $i = r + \pi$.

Taylor assumes both the equilibrium real interest rate in the economy and the desired rate of inflation to be 2%. If everything else in equilibrium the Fed will set the nominal Fed Funds rate at 4% a year. However, if either inflation is above 2% or the output gap becomes positive then the Fed will raise the funds rate i.e. for every 1 percent increase in the output gap the nominal Fed funds rate is raised by half percent. Similarly, a decrease in either inflation or the output gap will lead to lowering of the Fed Funds rate i.e. for every 1 percent decrease in the inflation the nominal Fed funds rate is reduced by 1.5 percent.

In general, a simple version of the Taylor rule can be expressed by the following formula:

$$i_t^* = \bar{i} + \gamma_\pi(\pi_t - \pi^*) + \gamma_y(y_t - y^*) + \varepsilon_t \qquad (3.3)$$

where i_t^* is the targeted nominal interest rate, $\bar{i}$ is the equilibrium nominal interest rate, π_t is the current inflation rate, π^* is the targeted inflation rate, y and y* are the natural logs of output and potential output respectively, ε_t is a white noise error term, γ_π and γ_y are parameters that measure the magnitude of the response of the monetary policy instrument to deviations of inflation from its target and to the output gap, respectively.

Defining $r^* = (i^*-\pi)$, the desired or equilibrium nominal interest rate $\bar{i}$ is equal to the sum of the equilibrium real interest rate $\bar{r}$ and the targeted inflation rate π^*. Subtracting current inflation from both sides, we can write the Taylor rule in term of targeted real interest rate as follows:

$$r_t^* = \bar{r} + (\gamma_\pi - 1)(\pi_t - \pi^*) + \gamma_y(y_t - y^*) + \varepsilon_t \qquad (3.4)$$

Theoretically, γ_π should be greater than 1 ($\gamma_\pi > 1$) to capture the idea that the central bank should raise or decrease the nominal interest rate by more than the movement in inflation. Defining $\beta = (\gamma_\pi - 1)$ and $\gamma = \gamma_y$, we can write our Taylor rule as follow:

$$r_t^* = \bar{r} + \beta(\pi_t - \pi^*) + \gamma(y_t - y^*) + \varepsilon_t \qquad (3.5)$$

This equation gives a central bank advice on how to set interest rates whenever economic conditions change, in order to achieve both its short-run goal of stabilizing the economy and its long-run goal of stabilizing inflation. It also portrays the preferences of the central bank as reflected by β and γ. In a situation where inflation is above its target and $\beta > 0$, the central bank may pursue a tight monetary policy by raising nominal interest rates (i^*_t) sufficiently to increase the real interest rate (r^*_t). This behaviour enables the bank to keep inflation on target by shrinking aggregate demand. If $\beta < 0$, the rule recommends an easing of monetary policy by lowering the interest rate. The central bank is less sensitive to the ongoing inflationary pressure, which may result in a higher actual inflation. Assuming expected inflation is constant, if $\gamma > 0$ monetary authorities take measures to stabilize output around its steady state level. If $\gamma = 0$ output stabilization is not a matter of concern for the central bank.

If both parameters β and γ are greater than zero, then monetary policy is stabilizing. The stabilizing properties of monetary policy imply that monetary policy not only operates as a nominal anchor, but also encourages a stable macroeconomic background in which output growth is mainly shaped by technology and other supply-side components (potential output).

Levin et al (1999) suggest that the optimal response for a central bank may be to make slow and smooth, rather than sudden, adjustments of interest rates toward the favoured level. This gradual tendency helps to reduce the disturbance of capital markets and to protect its credibility. In addition, empirical work by Clarida et al (1998, 2000), Gerlach and Schnabel (2000) and Doménech et al (2002) detects such interest rate smoothing. We follow Clarida et al's assumption that the actual interest rate r_t is a weighted average of its lagged value and its target level in formulating the following equation:

$$r_t=(1-\rho)\, r^*_t+\rho\, r_{t-1}+v_t \tag{3.6}$$

where ρ ($0\leq\rho<1$) depicts the partial adjustment (i.e. degree of interest rate smoothing) and v_t is a white noise random policy shock term (an exogenous interest rate shock with zero mean). The coefficient ρ determines the speed at which the central bank adjusts the real interest rate (r_t) gradually towards its target real interest rate (r^*_t). In general, the estimated equation has been highly significant, which has been interpreted as evidence for the hypothesis that central banks adjust the interest rate gradually towards its target rate. The coefficient ρ is often fairly high, which implies a slow adjustment process (Österholm, 2003). By defining $\alpha = \bar{r} - \beta\pi_t^*$ and replacing (3.5) and (3.6), we obtain:

$$r_t = \rho\, r_{t-1} + (1-\rho)\,\alpha + (1-\rho)\,\beta\pi_t + (1-\rho)\,\gamma\,(y-y^*)_t + \eta_t \qquad (3.7)$$

where η_t is a random term, which combines the errors of inflation and output and the random policy shock term v_t. Defining $c=(1-\rho)\alpha$, equation (3.7) can be economically estimated using baseline monetary policy rule as shown in equation (3.8).

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t\} + \eta_t \qquad (3.8)$$

where u_t is a white noise term.

3.4.2. Allowing for external influences on monetary policy

3.4.2.1. A Contemporaneous Model

The base-line specifications described by equations (3.3) to (3.8) can be extended to account for the other variables, which may play a role in the determination of monetary policy. Many variants of this base-line rule have been employed in both theoretical and empirical work. For such an extension, Clarida et al (1998) modify equation (3.8):

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t + \theta z_t\} + u_t \qquad (3.9)$$

In equation (3.9) z_t is a generic variable representing additional variable(s) that could play a role when setting monetary policy. We draw on others' work on the transmission mechanism for an open economy when choosing these additional variables.

Clarida et al (1998) develop a model of monetary policy in countries with exchange rate targets. They employ equation (3.9) to model the pre-1993 interest rates of France, Italy, and the UK, defining z_t to be the short-term interest rate of Germany, to which the monetary authorities of these three countries were anchoring their monetary policy before the end of the ERM. The outcomes they get using equation (3.9) were superior to those obtained by the estimation of the simple Taylor Rule in (3.8).

Adam et al (2005) find something similar when estimating monetary policy reaction functions for the UK over three periods - 1985-90, 1992-97 and 1997-2003 - in order to unravel two effects: the switch from an emphasis on exchange rate stabilization to inflation targeting, and the introduction of instrument-independence in 1997. However, they differ their analysis from Clarida et al (1998) by using not only German interest rates but also the US one.

As barriers to the free movement of capital have gradually been lifted as a result of globalization and financial integration, funds can be easily transferred from one country to another in pursuit of the highest rate of return. For this reason, we estimate (3.9) defining z_t to include the exchange rate and foreign interest rates. The exchange rate is particularly important for emerging economies for several reasons discussed previously. However, it is not clear which measure of exchange rate should be considered. Consequently, we develop different versions of equation (3.9) to include the nominal exchange rate, real exchange rate, the deviation of actual nominal exchange rate from its trend (we then call this as the nominal exchange rate gap), and the deviation of actual real exchange rate from its trend (we then call this as the real exchange rate gap), in equation (3.10) to (3.13) respectively.

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t + \phi\, s_t + \lambda\, i^f_t\} + u_t \qquad (3.10)$$

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t + \phi\, q_t + \lambda\, i^f_t\} + u_t \qquad (3.11)$$

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma\,(y-y^*)_t + \phi\,(s-s^*)_t + \lambda\, i^f_t\} + u_t \qquad (3.12)$$

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t + \phi\,(q-q^*)_t + \lambda\, i^f_t\} + u_t \qquad (3.13)$$

where r is the real interest rate, π is the rate of inflation over the past four quarters, $(y-y^*)$ is the deviation of actual from potential output, i^f is the nominal foreign interest rate, s is the nominal exchange rate, q is the real exchange rate (in log term $q=s+p^*-p$, where p^* is foreign national price level and p is domestic price level), $(s-s^*)$ is the deviation of actual nominal exchange rate from its trend, and $(q-q^*)$ is the deviation of actual real exchange rate from its trend. With respect to $(s-s^*)$ and $(q-q^*)$, an increase means a depreciation and vice versa.

Equations (3.10) through (3.13) describe a situation in which the pass-through of exchange rate changes to consumer prices is quick, so in a situation where the exchange rate has depreciated and, in anticipation of increasing inflation, the central bank may raise interest rates to stimulate an appreciation in the exchange rate and so fall in the price of tradable goods. The central bank may subsequently lower the interest rate and allow the exchange rate to depreciate again after dissolving the inflationary pressure. However, we should be aware that reducing inflation fluctuations might raise exchange rate volatility and also note that manipulating the exchange rate has proved to be very difficult to achieve in practice as the previous sections discuss in the case of these four countries. Commonly, the monetary authority tends to intervene in the foreign exchange market through sterilization policy in order to reduce the volatility of exchange rate.

As we stated previously, it is not clear which measure of the exchange rate should be considered. In the same way as with the exchange rate measure discussion above, then again, it is not clear which foreign interest rate the central bank is more sensitive to. For this reason, we extend the Taylor-type rule in equation (3.9), in addition to all equations (3.10) through (3.13), to examine whether the central bank is sensitive to the real foreign interest rate as follow:

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t + \phi\, s_t + \lambda\, r^f_{\ t}\} + u_t \qquad (3.14)$$

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t + \phi\, q_t + \lambda\, r^f_{\ t}\} + u_t \qquad (3.15)$$

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t + \phi\,(s-s^*)_t + \lambda\, r^f_{\ t}\} + u_t \qquad (3.16)$$

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta\pi_t + \gamma(y-y^*)_t + \phi\,(q-q^*)_t + \lambda\, r^f_{\ t}\} + u_t \qquad (3.17)$$

where all variables are similar to equation (3.10) to (3.13) with the exception of real foreign interest rates $r^f{}_t$ replaces nominal foreign interest rate of $i^f{}_t$. Real foreign interest rates are calculated using the Fischer equation, $r^f{}_t = i^f{}_t - \pi^f{}_t$, where $r^f{}_t$, $i^f{}_t$ and $\pi^f{}_t$ respectively denote foreign real interest rate, foreign nominal interest rate and foreign inflation rate.

The theoretical signs of the parameters in equation (3.10) through (3.17) for ρ, β, γ, ϕ and λ are positive (ρ, β, γ, ϕ and $\lambda>0$). According to the Taylor rule, the interest rate is expected to react positively to changes in the inflation gap and the output gap. If the main objective of monetary policy is to keep the inflation rate low or close to its target level, the real interest rate should be raised when inflation becomes positive. In other words, the central bank should raise nominal interest rates by more than the increase in inflation in order to bring up real interest rates. In a standard transmission mechanism from aggregate demand to price dynamics, it is through an increase in the real interest rate that observed inflation is brought back to its target level when the former exceeds the latter. Thus, in the above model, the value of β should be positive.

Similarly, the value of γ should be positive. If output is above its steady state level (i.e. the output gap is greater than zero) and $\gamma > 0$, the rule recommends that the central bank may raise nominal (i^*_t) and real (r^*_t) interest rates in order to shrink aggregate demand, encourage output to converge to its steady state level and prevent pressures on future inflation. In these circumstances, monetary policy is said to be an automatic stabilizer of output around its trend level. This policy is consistent with inflation targeting, in view of the fact that it abolishes sources of persistent pressure on inflation. On the other hand, if $\gamma < 0$ and the central bank reduces nominal (i^*_t) and real (r^*_t)

interest rates, this will enhance aggregate demand and boost output up its trend level. which ultimately will cause inflation to rise.

Our model follows and differs from Taylor's to the extent that we assume that central banks may respond to changes in the foreign interest rate and exchange rate. With near perfect capital mobility, there is a vast capital outflow if the total return on foreign lending exceeds the total return on domestic lending. The central bank will raise interest rates in response to increasing foreign interest rates. Conversely, there is a capital inflow if the return on domestic lending exceeds the return on lending abroad. The central bank lowers interest rates in response to decreasing foreign interest rates. The total returns on temporarily lending in foreign currency is the interest rate paid on assets in that currency plus any capital gain (or minus any capital loss) arising from depreciation (appreciation) of the domestic currency during the period.[81] Accordingly, the central bank will raise interest rates in response to currency depreciations and vice versa.

3.4.2.2. Backward-looking Policy Rules

The basic Taylor rule assumes that interest rates react contemporaneously to movements in inflation and the output gap. Some researchers, such as McCallum (1999a), argue that this may not be an accurate assumption since GDP data is only available with a lag. In other cases, the data is revised at the end of the year resulting in a different value for GDP than in the quarter released. Hence, the proper policy rule may

[81] The interest parity condition stated that return on domestic loan = return on foreign loan = [foreign interest rate] + [domestic currency depreciation while funds abroad]

have lagged macroeconomic variables rather than contemporaneous variables. For that reason, we consider a backward looking equation in which policy responds to a lagged inflation rate, output gap, exchange rate and foreign interest rate:

$$r_t = c + \beta_1 r_{t-1} + (1-\rho)\{\beta \pi_{t-j} + \gamma (y-y^*)_{t-k} + \phi F_{t-l} + \lambda G^f_{t-m}\} + u_t \quad (3.18)$$

where all variables and parameters in equation (3.18) are the same as those in equations (3.10) through (3.17) with the exception of F and G where F is the (nominal s, or real q, or nominal gap $(s-s^*)$, or real gap $(q-q^*)$) exchange rate and G^f is the nominal i^f or the real r^f foreign interest rate, and j, k, l, and m are lags with the values of 1,2,...,8.

3.4.2.3. Forward- looking Policy Rules

As discussed previously, some researchers, such as Ball (1999), Svensson (1997a, 1999, 2002), Clarida et al (1999), Batini et al (2000), Huang et al (2001), Orphanides (2001), and Woodford (2001) use a forward-looking version of the Taylor-rule because it attempts to capture the explicit forward looking behaviour of some central banks. They suggested that forward-looking versions of the Taylor rule describe policy better than contemporaneous specifications. One among other reasons is that current inflation is essentially predetermined by previous decisions and contracts, which means that central banks can only affect future inflation. In this section, we analyze alternative specifications in which we extend a simple augmented Taylor-type rule to use forecasts of the variables in the reaction function. The interest rate is now set in accordance with the following forward-looking reaction function:

$$r_t = c + \rho\, r_{t-1} + (1-\rho)\{\beta \pi_{t+j} + \gamma (y-y^*)_{t+k} + \phi\, F_{t+l} + \lambda\, G^f_{t+m}\} + u_t \quad (3.19)$$

Equation (3.19) differs from equations (3.10) to (3.18) in which real interest rates are assumed to react to the expected inflation, output gap, exchange rate and foreign interest rates, rather than to the past or present values of these variables. All variables and parameters are the same as those in equations (3.10) to (3.18) with the exception of j, k, l, and m where they are leads with the value of 1,2,...,8.

3.4.2.4. Composite model

There is a debate in the area whether central bank should stick to specific rule or may be flexible. We exercise a discretionary Taylor-type rule to analyze the instrumentation of monetary policy through constructing various composite Taylor-type rules. In this section, we focus on policies that respond to a combination of contemporaneous, backward and forward-looking specifications to determine the real interest rate. Building on our previous analysis that allows for foreign interest rates and exchange rates to influence monetary policy in Indonesia, Korea, the Philippines, and Malaysia, we suggested the following models:

$$r_t = c+\rho\, r_{t-1} + (1-\rho)\{\beta_1\, \pi_{t\pm j} + \gamma\, (y-y^*)_{t\pm k} + \phi\, F_{t\pm l} + \lambda\, G^f_{t\pm m}\} + u_t \quad (3.20)$$

where all variables and parameters in equation (3.20) are the same as those in equations (3.10) through (3.19) with the exception of j, k, l, and m where they are lags or leads with the value of 0, 1,...,8 (i.e. $j \in (-8,\ldots,-1, 0, +1, \ldots, +8)$).

3.5. Data and preliminary observations

We use quarterly data for Indonesia, Korea, Malaysia and the Philippines for different time periods, based on their availability. The sample for the estimation of the Korea model runs from 1984(1) to 2005(2). The estimation sample runs from 1988(1) to 2005(2) for both the Philippines and Malaysia, and from 1993(1) to 2005(2) for Indonesia.

However, we face a dilemma in choosing our variables. Even though the literature agrees that inflation and the output gap must be taken into account in the policy rule, it is not obvious what measure of inflation should be used, whether for example, CPI, core CPI, or the GDP deflator. For instance, in the early stage of inflation targeting in Korea, i.e. during 1998 and 1999, the rate of increase in the Consumer Price Index (CPI) was used, while from 2000 onwards, the core inflation was adopted as the target indicator. On the other hand, the government of the Philippines defines inflation target in terms of the average year-on-year change in the consumer price index (CPI) over the calendar year. With respect to output, it is not instantly obvious how to measure potential output. As suggested by earlier papers, such as Clarida et al. (2000) and Nelson (2000), potential output can be computed using a linear trend, a quadratic trend, a split linear trend as well as a Hodrick-Prescott (1997) filter.

Thus, during the period of our observations, we use all available data related to all variables involved in our equations, as stated in section (3.4), in order to uncover the parsimonious model from each country in our analysis. All the data used in this analysis were obtained from the International Financial Statistics published by the International Monetary Fund provided by Datastream. We define r_t as the discount rate,[82] deposit rate,[83] and money market rate/federal funds/call money rate[84] for Indonesia;[85] the discount rate, deposit rate, and money market rate/federal funds/call money rate for Korea[86]; the discount rate, deposit rate, and treasury bill[87] rate for the Philippines;[88] the

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[82] Discount rate or Bank rate is the rate at which the central banks lend or discount eligible paper for deposit money banks, typically shown on an end-of-period basis (International Financial Statistics, 2002).

[83] Deposit rate usually refers to rates offered to resident customers for demand, time, or savings deposits. Frequently, rates for time and savings deposits are classified according to maturity and amounts deposited; in addition, deposit money banks and similar deposit-taking institutions may offer short- and medium-term instruments at specified rates for specific amounts and maturities; these are frequently termed "certificates of deposit.' (International Financial Statistics, 2002)

[84] Money market rate is the rate on short-term lending between financial institutions (International Financial Statistics, 2002).

[85] Bank Indonesia conducts Open Market Operation (OMO) through offering Bank Indonesia Certificates (SBI) to influence the liquidity of the Rupiah in the money market, which in turn will influence interest rate. This conducted through auction so that discount rate achieved truly reflects the liquidity condition of the money market. However, since SBI rate is not available during our period of observations, thus, we suggest to use either money market rates or discount rates as our interest rates. We also take into account the deposit rate for comparison.

[86] Since Korea has only recently approved the call rate as a policy instrument (Overnight call rate began to be suggested as a target from May 1999 onwards), term structure information is not available for empirical analysis. As an alternative, we use typical interest rates in the present Korean market which is the money market rate/federal funds.

[87] Treasury bill rate is the rate at which short-term securities are issued or traded in the market (International Financial Statistics, 2002)

real deposit rate, real money market rate, and real treasury bill rate for Malaysia. Inflation π is defined as the percentage increase of the price level relative to its value in the same quarter of the previous year. We calculate π using the consumer price index (CPI).[89] Real interest rates are calculated using $r= i-\pi$, where r, i, and π respectively denote real interest rate, nominal interest rate and inflation.

The output gap $(y-y^*)$ is a measure of the difference between actual output (y) and the potential output (y^*).[90] We estimate potential output and hence the output gap since it cannot be observed. Theoretically, productivity growth, labour force developments and other conditions affecting productive capacity in the economy may change (raise) the potential output. In this study, we use the Hodrick-Prescott filter since it is the most commonly accepted way of measuring potential output. We fit Hodrick-Prescott (HP) filter into y using the suggested smoothing parameter for quarterly data in order to obtain an estimate of potential output (y^*). We then measure the output gap as the difference between y_t and y^*_t. The output gap in these four countries represents the overall assessment of resource utilization in their economy. The basis for the assessment is as follow. First, we collect data of variable GDP Volume Index (1995=100)[91] for Indonesia; GDP Volume Index (2000=100) and calculated real GDP (= GDP current/GDP deflator) For Korea;[92] GDP Volume Index and GDP Volume Index (1995=100) for the Philippines; and GDP Volume Index (2000=100) for Malaysia, to measure actual output

[88] The current Bank Ng Pilipinas's primary monetary policy instruments are its overnight reverse repurchase (borrowing) rate and overnight repurchase (lending) rate. However, during this period of observation, unfortunately, this data set is not available.

[89] Therefore, the rate of inflation $p_t = p_t - p_{t-1}$, where p is the log of the consumer price index.

[90] Potential output is a level of output that over time is consistent with stable inflation.

[91] GDP volume indices that are presented on a standard 1995 reference year and are derived from the GDP volume series reported by national compilers (International Financial Statistics, 2002)

[92] We find that the value of GDP Volume Index (2000=100) and calculated real GDP (= GDP current/GDP deflator) are different.

y_t and to ensure our findings are robust. Next, we choose a parameter to measure the degree of variability in trend output, i.e. how smooth the trend should be. In this case, we specify the smoothing parameter to be 1600.

The nominal exchange rate s is expressed as units of the domestic currency per U.S. dollar. The real exchange rate q is defined as nominal exchange rates adjusted for differences in national price p levels or defined in log terms as $q=s+p^*-p$, where p^* is foreign national price level and p is domestic price level. The HP filtering process is used to estimate trend values for the nominal and real exchange rates. The nominal exchange rate gap $(s-s^*)$ is determined as the deviation of the nominal exchange rate from its trend value. Similarly, the real exchange rate gap $(q-q^*)$ is then determined as the deviation of the real exchange rate from its trend value. The nominal foreign interest rate (i^f) is the U.S Treasury bill rate. The real foreign interest rate (r^f) is calculated using the Fischer equation, $r^f = i^f - \pi^*$, where r^f, i^f and π^* respectively denote real interest rate, nominal interest rate and CPI inflation in the US.

3.5.1. Statistical Description

As a first step, it is useful to review the data. Tables 3.1 through 3.5 summary the main statistical properties of the four countries' short-term nominal interest rates (i), real interest rates (r), inflation rates (π), output gap $(y-y^*)$, nominal (s) and real exchange rates *(q)*, nominal *(s-s*)* and real exchange rate gaps *(q-q*)*, as well as nominal (i^f) and real foreign interest rates (r^f).

According to the Taylor rule, the relationship between short-term real interest rates and inflation is expected to be positive, an increase in inflation being followed by an increase in the short-term real interest rate (a decrease being followed by a decrease in the short-term real interest rate). We begin our data analysis by looking at the correlation coefficient defining a measure of linear association between two variables. In particular, we would like to see how strong the relationship between the dependent variable of real interest rates and each of the independent variables under discussion is.

As shown in Table 3.1, in the case of Indonesia, there is a positive relationship between the real money market rate and inflation, albeit a weak one (0.09).[93] However, the degree of association between the real discount rate and inflation, and between the real deposit rate and inflation are stronger but negative.

Similarly, in Korea (Table 3.2), only the correlation between the real money market rate and inflation fits the Taylor rule. However, while the correlation coefficient in Indonesia is nearly zero, that in Korea is larger.

In the case of the Philippines (Table 3.3), none of the correlation coefficients between the three short-term real interest rates of real discount rate, real deposit rate and real treasury bill rate, and inflation are found to be positive, while, in Malaysia (Table 3.4), all three short-term interest rates of real deposit rate, real money market rate, and real treasury bill rate show a positive correlation to the inflation rate.

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[93] Although zero correlation does not necessarily imply independence, we may suspect that the real money market rate and inflation are statistically independent. In this research, we are not primarily interested in such a measure. Instead, we try to estimate or predict the average value of short-term interest rates on the basis of the fixed values of inflation or other variables in our augmented Taylor rule.

As with inflation the Taylor rule suggests a positive relationship between short-term real interest rates and the output gap, an increase in output gap being followed by an increase in the short-term real interest rate (a decrease being followed by a decrease in the short-term real interest rate).

In general, the relationship between the real interest rate and the output gap in all four countries can be represented by the correlation coefficient ranging from -0.11 to +0.52. As shown in Table 3.1, in Indonesia, the degree of association between, firstly, the discount rate and secondly, the money market rate and the output gap is positive and moderate to strong, giving the impression of non-accommodative monetary policy. The degree of association between deposit rate and output gap is also positive but relatively weaker.

As shown in Table 3.2, in the case of Korea, there is a positive relationship between the real discount rate and firstly, the output gap based on the GDP Volume Index (2000=100), and secondly, the output gap based on the real GDP (=GDP current/GDP deflator), albeit a weak one (0.11). However, the degree of association between the real deposit rate and both these measures of the output gap is negative and weak, implying that movements in these output gaps tend to be in the opposite direction to movements in the real deposit rate. With respect to the correlation between the real money market rate and these measures of the output gap, we may suspect that they are statistically independent as the correlation coefficient between these variables is nearly zero.[94]

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[94] If two variables are (statistically) independent, their covariance is zero. Therefore, the correlation coefficient will be zero. The converse, however, is not true. That is, if the correlation coefficient between two variables is zero, it does not mean that the two variables are independent. This is because the correlation coefficient is a measure of ***linear association or linear relationship*** between two variables. For example, if $Y=X^2$, the correlation between the two variables may be zero, but by no means are the two variables independent. Here Y is nonlinear function of X.(Gujarati, 2006, pp 61)

In the case of the Philippines (Table 3.3), there is a positive relationship between the real deposit rate and firstly, the output gap based on the GDP Volume Index, and secondly, the output gap based on the GDP Volume Index (1995=100). Similarly, there is a positive relationship between the real treasury bill rate and these measures of the output gap. However, we may suspect that the real discount rate is statistically independent of these measures.

In the case of Malaysia, we find the relationship between all real short-term interest rates and the output gap is positive. As shown in Table 3.4, the relationship between all three short-term interest rates of real deposit rate, real money market rate, and real treasury bill rate and the output gap based on the GDP volume index is reflected in a correlation coefficient of 0.35.

With respect to the relationship between the real interest rate and the exchange rate, the relationship between them is expected to be positive, a depreciation of domestic currency being followed by an increase in the short-term real interest rate (an appreciation being followed by a decrease in the short-term real interest rate).

Tables 3.1 through 3.4 show interesting results. The correlation coefficients range from -0.68 to 0.43. In the case of Indonesia, as shown in Table 3.1, our augmented Taylor rule works when we define the real interest rate as the discount rate and the money market rate, and the exchange rate as real exchange rate, nominal or real exchange rate differential. However, it does not work when we consider the real deposit rate, which shows a negative and moderate to strong correlation with all exchange rate measures.

The table also shows that all three real interest rates are negatively correlated with the nominal exchange rate, implying, contrary to our rule that a currency depreciation is associated with a decrease in the real interest rate and vice versa. Additionally, we may suspect that the relationship between the real discount rate and nominal exchange rate differential is statistically insignificant.

In the case of Korea (Table 3.2), on the other hand, the real deposit rate is positively, albeit weakly, correlated with all exchange rate measures, with the exception of nominal exchange rate. We may suspect that the real deposit rate and nominal exchange rate are (statistically) independent. We may also suspect that the real discount rates and real exchange rates are independent as the correlation coefficient between these variables is zero.

Similar to the case in Indonesia, in the Philippines, as shown in Table 3.3, all real interest rates have a negative correlation with the nominal exchange rate, implying, a currency depreciation is associated with a decrease in the real interest rate and vice versa. Table 3.3 also shows that the real discount rate is negatively correlated with all measures of exchange rate under observation, with the exception of real exchange rate differential, where the correlation coefficient is +0.09.

In the case of Malaysia (Table 3.4), all correlation coefficients, surprisingly, are negative, implying that an appreciation of the Ringgit leads to a tightening of monetary policy. In terms of magnitude, table 3.4 shows that the degree of association between the real treasury bill rate and the nominal exchange rate as well as that between the bill rate and the real exchange rate is moderately high with a coefficient correlation of about 54%.

Our augmented Taylor rule suggests that the relationship between short-term real interest rates and foreign interest rates will be positive, an increase in foreign interest rates being followed by an increase in the short-term real interest rate (a decrease being followed by a decrease in the short-term real interest rate).

Tables 3.1 through 3.4 show that the conduct of monetary policy in all countries under research relied on the conduct of monetary policy at the Federal Reserve. In the case of Indonesia (Table 3.1), the strongest relationship between the real interest rate and the foreign interest rate is found using the real money market rate and the real U.S Treasury bill rate where the coefficient of correlation is +0.53.

In the case of Korea (Table 3.2), the relationship between the real interest rate and the foreign interest rate is moderate to strong, the strongest relationship being between the real deposit rate and the real U.S Treasury bill rate with a correlation coefficient of +0.74. This is also the highest coefficient of correlation among four economies. As with Indonesia, there is a moderate relationship between the real money market rate and the real U.S Treasury bill rate, with the coefficient of correlation at +0.56 (the second highest coefficient among the four economies).

As shown in Table 3.3, in the case of the Philippines, the strongest relationship between the real interest rate and the foreign interest rate is found using the real treasury bill rate and the nominal U.S Treasury bill rate where the coefficient of correlation is +0.52. However, Table 3.3 also shows that the Philippines has the weakest relationship among these four economies, between any measure of the real interest rate and the foreign interest rate. This is found when we use the real discount rate and nominal U.S Treasury bill rate, where the coefficient of correlation is almost zero.

In the case of Malaysia (Table 3.4), monetary policy management in Bank Negara Malaysia was less closely related to the movement of U.S Treasury bill rates as shown by a relatively weak degree of association between these variables. The strongest relationship between Malaysian real interest rates and the foreign interest rate is found using the real treasury bill rate and the nominal U.S Treasury bill rate with the coefficient of correlation of only +0.38.

It is also important to look at the volatility indicators. This is represented by the standard deviation of variables as shown in Table 3.5. Real interest rates are more volatile in countries that have witnessed more volatility in inflation rates and real exchange rates than those with relatively stable financial environments. In particular, mirroring frequent devaluations and high inflation, short-term real interest rates in Indonesia are more volatile than those in the Philippines and Korea. What is also striking in the case of Indonesia is that the output gap is relatively more stable than other domestic variables. We also find that the nominal rupiah-dollar exchange rate is highly volatile.

In the case of Korea, we find that both inflation and real discount rates are relatively more stable than other domestic variables. On the contrary, the nominal exchange rate is found to be the most volatile variable in Korea. Similar to the case of Indonesia, as shown in table 3.5, in the Philippines, the output gap is relatively more stable than other domestic variables. The table also shows that the nominal exchange rate is the most volatile variable in this country.

An interesting result appears in the case of Malaysia. Table 3.5 shows that both real interest rates and inflation are relatively more stable than other domestic variables. These variables provide the least volatile among all variables under research. The standard deviation of output gap is also relatively low.

Although the standard deviation of inflation in the case of Indonesia is higher than in the other three countries, as shown in Figure 3.1, the inflation rate in Indonesia was relatively stable from the beginning of 1994 until the beginning of 1996. Indonesia enjoyed low inflation from 1996(2) to 1997(1), with a low of 4% reached in the first quarter of 1997, before increasing during the Asian financial crisis from 1997(2) to 1998(4), where inflation reached a high of 58% in the last quarter of 1998. Indonesia's post-crisis inflation performance has been relatively poor in comparison to the other three economies under discussion. However, since the beginning of 1999 inflation has fallen, and Indonesia experienced deflation in the first quarter of 2000. Since then there has been a relatively stable inflation of 7%.

Figures 3.2 and 3.3 show that before the financial crisis unfolded in 1997, Indonesia enjoyed the highest economic growth rate in Southeast Asia.[95] However, the financial crisis had a highly destabilizing impact on the economy. Real growth shrank from 13% in 1997(1) to -21% in 1999(1),[96] as a result of widespread banking sector collapse and widespread business failures. The real output gaps, as shown in Figure 3.4, show large negative values from the last semester of 1998 until the first semester of 2000. Since the last semester of 2000, real output has been relatively close to potential output and in some periods have significantly positive values following the turnaround of competitiveness, probably caused by factors such as the depreciation that followed the implementation of a free-floating exchange rate regime in 1997, a more credible central bank, and fiscal reform in the economy that increased international confidence.

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[95] Based on GDP Current measure, growth is 13% in 1997(1).
[96] Based on GDP volume index (1995=100).

In terms of interest rates, soon after floating the currency in August 1997, the government adopted an extremely tight monetary policy, raising interest rates sharply (Figure 3.5) and forcing state enterprises to withdraw funds from the banking system and purchase central bank bills (SBI=Sertifikat Bank Indonesia). Bank Indonesia also suspended the use of several monetary instruments that had an expansionary impact, such as auctions of money market securities (SBPU=Surat Berharga Pasar Uang), the Discount Facility I[97] and repurchases of central bank bills (SBI=Sertifikat Bank Indonesia). Figure 3.6 shows that the real discount rate reached a high of 18% in the second quarter of 1998, before suddenly plunging to a low of -19% two-quarters later. The real money market rate touched 38% in the beginning of the crisis in 1997(3) and reached a low of -5% in 1998(4).

In Korea, as shown in Figure 3.7, the inflation rate rose during the 1980s and reached a high of 11% at the beginning of 1991. After that CPI inflation declined continuously and reached 0.6% in the second quarter of 1999. However, during the turbulent times of the Asian financial crisis, the CPI inflation rate almost doubled within two quarters, from 5% in 1997(4) to 9% in 1998(1). The Korean won plunged by 93.1% as the exchange rate depreciated from a high of 870.98 won per U.S. dollar in 1997(1) to a low of 1,605.72 in 1998(1) (Figure 3.8). Real GDP declined from 1,426 billions won in 1997(4) to 1,127 billions won in 1998(1) (Figure 3.9 shows in log term). During this period the monetary authority in Korea frequently changed the call rate (money market rate) but maintained the discount rate at 5%. As shown by Figure 3.10, the call rate changed dramatically from a low of 11.9% in 1997(1) to a high of 23.9% in 1998(1). The

[97] Bank Indonesia's Discount Facility I is designed to allow banks to cover any shortfall in their required minimum reserves. The maximum maturity of this facility is one month, but borrowings can be extended by a month each time they fall due.

latter figures show that Bank of Korea was more aggressive in bringing inflation down and consequently strengthening the currency although at the price of economic recession. In the aftermath of the financial crisis, inflation started falling before showing another upturn. Conversely, the output gap in Figure 3.11 shows a major jump after the peak of the financial crisis in 1998(1).

Figure 3.12 shows that the interest and inflation rates in the Philippines decreased after 1990. Inflation reached its highest rate of 17.9% in 1991(3), and gradually decreased to an average of 7.5% in 1995. During this period, as opposed to the downward pattern of Inflation and interest rates, the output gap tended to increase as shown in Figure 3.13.

In the second quarter of 1995, the bank adopted a so-called modified framework that endeavoured to balance monetary aggregate targeting with some form of inflation targeting. This novel framework permitted base money growth to surpass target as long as inflation targets were met, with a contraction whenever inflation rose above target. As shown in Figure 3.13, the framework appeared to work as the inflation rate reached a low of 5% just a quarter before the Asian crisis unfolded. The output gap, on the contrary, presents an obvious upward trend, with an exception during the financial crisis. During the crisis, a major increase in inflation and interest rates was accompanied by a major decline in the output gap.

In Malaysia, as shown in Figure 3.14, the inflation rate declined steadily from 1992 to the first quarter of 2004, with the exception of during the Asian crisis in 1998.[98] Government spending cuts along with a tighter monetary policy from mid-1997

[98] As a small open economy, the rise of inflation at this time was practically obvious when the Ringgit came under attack. However, such contractionary macroeconomic policy responses were only a little help to bring back the Ringgit to its desired value or stimulate a rapid deflation.

intensified disinflationary pressure. Accordingly, economic growth declined dramatically from a high of 8% in mid-1997 to a low of -11% in mid-1998.

In contrast with the other three countries, the Malaysian authorities did not ask for IMF assistance. Instead, in September 1998 Malaysia introduced currency and capital controls. This controversial policy was unexpectedly successful in minimizing speculation in the Ringgit, although the policy was implemented too late to stop capital flight, which had already contributed to an 80% collapse in the stock market index since the onset of the financial crisis. While the Republic of Korea and the Philippines began their economic recovery in the first quarter of 1999, Malaysia's unconventional strategies were likely responsible for the delay in its recovery. The bank amended the policy in February 1999 before finally abandoning it in September 1999. Malaysia then embarked on positive growth in the third quarter of 1999. As shown in Figure 3.16, the Malaysian regime claimed that its strategy was efficient in that it brought about stronger recovery than had been achieved by Indonesia and the Philippines, though not the Republic of Korea at the end of 1999.[99]

3.5.2. Unit root test

Given that the time series properties of the data will play an important role in the discussion below, it is worth noting that all series display unit root characteristics.

[99] As Korea's Government did, the Government of Malaysia improved the fiscal policy, performed more rapid bank re-capitalization and corporate restructuring. The pre-Y2K demand for electronics, large budget deficits and enormous government spending to offset the private investments loss, benefited Malaysia more than the others. Malaysia also benefited from soaring petroleum and palm oil prices, whereas the intensity of the 1998 recession in Southeast Asia was partly due to El Nino weather effects on agricultural output, and not just the currency and financial crises.

Figures 3.1 through 3.15 suggest that some variables such as real interest rates and inflation are not stationary within the period covered by our sample. However, to test this more formally we use the Augmented Dickey-Fuller (Said and Dickey, 1984) and Phillips-Perron (PP) tests. The Augmented Dickey-Fuller (ADF) test has been shown to have good size and power properties in a number of studies and is therefore preferred to other tests with a unit root as the null hypothesis.[100] To complement the ADF test, we formally employ the Phillips-Perron (PP) test to determine whether each of the time series have a unit root. The process to estimate orders of integration is essentially an important part to seek more robust results.

The results of the unit root tests for all countries are shown in Table 3.6. The real discount rate *(r_a)* for Indonesia and the Philippines is stationary, whereas in the case of Korea the results are ambiguous. Using ADF tests, the results suggest that the rate is non-stationary. On the other hand, the PP tests suggest it is stationary.

The real deposit rate *(r_b)* is found to be stationary in the case of Indonesia and the Philippines, but non-stationary in the case of Korea and Malaysia. The table also shows that both money market rates *(r_c)* and treasury bill rates *(r_d)* in the countries where data is available are non stationary. Looking at the first difference ADF and PP tests, the results obviously show that the order of integration of the real money market rate and Treasury bill rate is 1 (I(1)).

Our evidences contribute to the debate on the order of integration of interest rates. While most economists believe that the order of integration of interest rates is I(0), authors such as Nelson and Plosser (1982) and Perron (1989) find that interest rates are I(1). Tkacz (2001), using the wavelet OLS estimator of Jensen (1999), finds that all short-

[100] See for instance Schwert (1989) and Pantula (1991)

term interest rates for the United States from 1948 to 1991 are long-run mean-reverting, whereas longer-term rates are more likely to follow unit root processes. These differences occurred probably because of the additional risk captured in the term premia of long-term bonds. In addition, he also finds that Canadian bonds show larger order of integration than their American counterparts for the reason that the former ones are usually riskier than the latter based on political uncertainty and exchange rate movements considerations.

As shown in Table 3.6, the unit root hypothesis for inflation is not rejected in all countries, with the exception of Korea where the tests give ambiguous results. Using ADF tests, we do not reject the existence of a unit root in Korea, while using PP test we do.

The ADF and PP tests show that the nominal exchange rate gap, real exchange rate gap, and all measures of the output gap are stationary variables. An exception is the nominal exchange rate gap in Indonesia, where, according to the ADF test, it is clearly non-stationary. However, the PP test shows it to be stationary at the 90% confidence level.

With respect to the level of the nominal and real exchange rate as well as foreign interest rates, either nominal or real, we found they are non-stationary with an order of integration of one (I(1)). An exception is the real exchange rate in Malaysia, where, according to the ADF test, it is clearly stationary, while the PP test shows it to be non-stationary.

In view of these results, there is a risk of running a spurious regression in estimating the Taylor rule on these data. Clarida et al (2000) encounter the same problem of non-stationary variables but argue that unit root tests have low power. Taylor (1999b) gives no further details apart from parameter estimates, t-values of the estimated coefficients and the multiple coefficient of determination (R^2). Hetzel (2000) states something very similar but with additional information regarding the standard error of regression and the Durbin-Watson statistic.

We follow the same approach. We assume here that all variables such as the inflation and real interest rate series are stationary. The rationale for this assumption is that this is just a sample rather than population property. In this research, we consider have only small to medium sample (from 53 (Malaysia) to 89 (Korea) observations). In addition, the ambiguity related to the integration order of these variables is a well-debated subject in the theoretical literature. However, the predominant opinion holds that inflation, real and nominal interest rates are stationary. For further discussion on this point see Martin and Milas (2004) and the references therein.

3.6. Empirical analysis

3.6.1. The Baseline Model

The empirical analysis begins with the estimation of the baseline specification. Subsequently, we investigate other variables that may enter the reaction function. As discussed earlier we include the movements in foreign interest rates, either in nominal or real terms, and exchange rates in terms of nominal and real exchange rate level and also in their difference from their trend value (nominal and real exchange rate gap).

We estimate a variety of baseline and augmented Taylor-type models using quarterly data, different measures of variables and over several different sample periods for these countries. To accommodate lags and expectation in the operation of monetary policy, we explored different lags and leads for all variables. We investigated the robustness of these findings in several ways and, for efficiency reasons, only the several best results for each country and model of these lengthy experiments are reported here.

Firstly, we used alternative measures of real interest rates. We estimated equation (3.8) where real interest rate was the discount rate, deposit rate, money market rate/federal funds, or Treasury bill rate. We defined output gap as GDP volume index, GDP Volume Index (1995=100), GDP Volume Index (2000=100), or Real GDP (=GDP current/GDP deflator) either in contemporaneous, backward-looking, forward-looking or a combination of these three specifications.

Our best findings on estimation of the baseline specification using Ordinary Least Squares (OLS) are reported in Table 3.7. The table shows that the optimal results are achieved when we define r_t as the three-month-money market rate for both Indonesia and Malaysia, the discount rate for Korea, and the treasury bill rate for the Philippines. The output gap contributes to a most robust model when we use the GDP volume index (1995=100) for Indonesia, the GDP volume index for the Philippines, and the GDP volume index (2000=100) for Korea and Malaysia.

In the case of Indonesia, the Philippines and Malaysia the model suggests a relatively moderate degree of interest rate smoothing, as the coefficients on the lagged interest rate are 0.57, 0.49 and 0.58 respectively. On the other hand, in the case of Korea, the model suggests a relatively high degree of interest rates smoothing as the coefficients on the lagged interest rate is 0.83.

Table 3.7 shows that, the real interest rate responds positively and significantly to inflation. This evidence meets our theoretical expectation and suggests a non-accommodating inflationary pressure. In the case of Indonesia, the movement in inflation leads the monetary authority to respond positively by a factor of 49% of the inflation rate. In Korea, the monetary authority responds to increasing inflation by increasing the real interest rate by 85%. In the case of the Philippines, the coefficient on inflation is 0.73. The result for Malaysia shows that the weight on the inflation is 0.45.

Table 3.7 also shows statistically significant and positive coefficients of output gaps. These results meet our theoretical expectation suggesting a non-accommodating economic growth in each central bank's monetary policy. In the case of Indonesia, the central bank is very sensitive to movement in the output gap as the coefficient of the output gap is about +1.97. In the case of Malaysia, the coefficient is much lower (+0.20), implying a monetary authority only slightly sensitive to the output gap. On the other hand, Bank ng Pilipinas appears to be moderately to highly sensitive to the output gap as the coefficient of the output gap is +0.56. This moderate response to the output gap is also found in the case of Korea in which the coefficient of the output gap is about +0.44.

In general, as shown in Table 3.7, the best model of monetary policy response in Indonesia is backward looking, in Korea is a combination of backward- and forward-looking, and in the Philippines and Malaysia is a combination of forward-looking and contemporaneous. In the case of Indonesia, the model is best when we use a one-year lag of inflation and a three-quarter lag of output gaps. This implies that monetary policy in Indonesia responds to a fourth-quarter behind of inflation and a three-quarter behind of output gaps. In the case of Korea, the best model is obtained when we consider a one-year lag of inflation and a quarter ahead of output gaps. This implies that monetary policy in Korea responds, not only to a first-quarter lag of real money market rates, but also a fourth-quarter behind of inflation and a quarter expectation of output gaps. In the case of the Philippines and Malaysia, the best model is obtained when we combine a one-year expectation of inflation with a contemporaneous value of the output gap.

3.6.2. The augmented Taylor-rule

We resume the analysis by estimating the augmented Taylor rule during 1984-2005 using OLS in equations (3.10) through (3.20), where we also consider, as an alternative specification, a backward and forward-looking version of the augmented Taylor-type rule. We use the current, lag (from the first to the eight) and lead (from the first to the eight) of inflation π, output gap $(y-y^*)$, all exchange rate and foreign interest rate measures. The optimal interest rate rule for all these countries can be seen in Table 3.8. The optimal results are achieved when we use the same definition of real interest rates r_t as in our baseline model.

A quick glance at Table 3.8 reveals that the inflation, output gap, foreign interest rate, and the exchange rate have a significant effect on the domestic real interest rate. However, the timing of the impact differs considerably.

Monetary policy in Indonesia responds to a first-quarter lag of real money market rates, a fourth-quarter lag of inflation, a third-quarter lag of output gap, and the expected real exchange rate gap and nominal foreign interest rate two quarters ahead. The monetary policy reaction functions in Korea responds to a first-quarter lag of real discount rates, a fourth-quarter lag of inflation, a quarter ahead of output gap, a fourth-quarter lag of real exchange rate and the expected real foreign interest rates one quarter ahead.

In the case of the Philippines, the best results are obtained using the current value of output gap, real exchange rate gap and nominal foreign interest rates as well as an expected first-quarter ahead of inflation. Table 3.8 also shows that the central bank of Malaysia reacts to an expected inflation, output gap, real exchange rate gap and nominal foreign interest rates one year ahead. We find consistency between Table 3.7 and 3.8, in particular in Indonesia and Korea, with respect to inflation and output gap, either in the sign of parameters or the timing of the impact.

A more careful examination of the results as shown in this table reveals that the degree of interest rate smoothing is relatively high in all these countries, with the exception of Indonesia, between 53% and 74%. The degree of interest rate smoothing, among these three countries, is particularly high in Korea and the Philippines but smaller in Malaysia. On the other hand, in the case of Indonesia we find that the degree of interest rate smoothing is only 25%. The coefficient on the lagged interest rate of all countries, with the exception of Indonesia, is on average 66%, implying that the initial adjustment in interest rates is on average only 34%. This is considered low if we compare to the one with Indonesia where the initial adjustment in its interest rates is as high as 75%.

The elasticity of the interest rate with respect to inflation is highly significant at the 5% level or better. The estimated coefficient of the inflation rate varies between +0.23 (Indonesia) and +1.21 (Philippines). The results show that the inflation coefficients have the expected positive signs in all countries. An interesting finding can be seen in the Philippines, where the estimated long-run inflation coefficient is high and statistically significant with a magnitude of higher than one. The low coefficient in Indonesia suggests that the inflation has not been the main focus of monetary policy in this country.

As shown in Table 3.8, the conduct of monetary policy is significantly affected by the state of the business cycle. The response of monetary policy to the output gap is statistically significant for all countries and ranges between +0.28 (Malaysia) and +1.27 (Indonesia). The results also show that the monetary policy response to output is stronger in Indonesia than in Korea, the Philippines and Malaysia. In the case of Indonesia, our results suggest that the central bank has indeed been sensitive to the movement of the output gap.

It is also found that the monetary authority of Indonesia put more weight on output rather than inflation. This quantitative evidence runs counter to the view that the central bank's main task is to achieve price stability. On the other hand, the evidence on output in the remaining three countries, Korea, the Philippines, and Malaysia, clearly shows that the monetary authority puts more weight on inflation, as shown by the greater coefficient of inflation than that of output in the estimated reaction function.

With respect to the exchange rate, the coefficient is statistically significant and varies between +0.11 (Malaysia) and +0.26 (the Philippines). As shown in Table 3.8, the coefficient of exchange rates in all countries is lower than the one of inflation rates. The sign of the coefficients of exchange rate adjustment in all countries is comparable to most previous work done on this subject (see Bharucha and Kent (1997), Ball (1999), Svesson (2000), and Leitemo and Söderstrom (2001)).

With respect to the foreign interest rate, we find that, with the exception of Malaysia and Korea, it appears to have had a very significant effect on monetary policy, more so than domestic inflation. This suggests that the foreign interest rate is the pre-dominant factor influencing Asian monetary policy, with an estimated coefficient for the foreign interest rate consistently higher than unity in Indonesia and the Philippines, and almost unity in Korea. Moreover, in Indonesia and the Philippines, the long-run response of the target interest rate to changes in the foreign interest rate is more than or almost double in size than that to changes in inflation.

These results are consistent with the monetary policy in these countries before the crisis. Following the implementation of fixed exchange rate regimes, the initial spread between the domestic and the foreign interest rate -adjusted for the expected rate of devaluation- rose sharply, providing substantial encouragement for capital inflows and credit expansion. Our results show that any increase in foreign interest rates will lead to arise in the domestic rate giving a significant spread between domestic and foreign interest rates.

Theoretically, however, this increase in the spread could also be due to fiscal policy. Our results also support this as shown by a positive and statistically significant output reaction coefficient. Our findings explain implicitly that in all four countries under discussion, a combination of large capital inflows, an expenditure boom, and a sharp real appreciation occurred before the crisis. A sudden reversal of capital flows sensibly leads to a major crisis.

The other evidence that we find is that the introduction of foreign nominal or real interest rates along with exchange rate gaps or exchange rate levels improves the model's fit, as it results in a lower regression standard error in all four countries. Table 3.8 also shows that adding foreign interest rates results in substantially higher estimated coefficients for inflation, especially so in the case of Korea, Malaysia, and the Philippines. These findings confirm a positive correlation between inflation and any measure of foreign interest rate, as shown in Tables 3.1 through 3.4.

Putting the R^2 and the Durbin-Watson (DW) statistics side by side, we find another interesting piece of evidence in which the DW in all cases is larger than the R^2, implying that the sign of the spurious regressions never took place. This statistics ease our previous concern over running a spurious regression in estimating the Taylor rule on these data, given several variables are integrated with the order of one (*I(1)*) or nearly integrated.

3.7. Conclusions

This study examines monetary policy reaction function in four Asian countries, namely Indonesia, Korea, Malaysia and the Philippines, based on an open economy augmented Taylor rule including the real exchange rate (level or difference from its trend) and the foreign interest rate (nominal or real). Using more recent quarterly data, we reach major findings as follows.

Firstly, the real interest rate reacts positively and significantly to inflation, the output gap, the exchange rate, and the foreign interest rate. Secondly, we find that the timing of the impact sometimes differs considerably. According to our findings, monetary policy conducted by central banks of Indonesia and Korea is essentially a combination of forward and backward-looking, while policy of central bank of the Philippines is composite looking between forward and contemporaneous looking. In the case of Malaysia, monetary policy is essentially forward-looking. Surprisingly, we do not find any central bank considering purely backward-looking or contemporaneous specifications.

Thirdly, we find the initial adjustment in interest rates varies between 26% and 75%. Fourthly, we find that it is an aggressive response of monetary policy, which has played a more important role in Asia since the financial crises of 1997-98 rather than, as claimed in the literature, the fiscal policy.

Fifthly, we find that, only in Indonesia, does the central bank appear to be less sensitive to inflation, though it has indeed been stabilizing the output gap by and large through its key policy rate. This quantitative evidence supports the fact that the central bank's main task is not to achieve price stability during period of observations.

Sixthly, with the exception of Korea and Malaysia, the foreign interest rate is more influential in explaining the variance of the interest rate than other endogenous variables, suggesting that the major focus of the monetary policy in these countries is to consider foreign interest rates.

This research can be expanded in numerous approaches. As the results show that the inflation did not justify as much variation in the real interest rate as we had expected, it may be possible to restructure this variable differently. Otherwise, it would also be interesting to take into account other monetary policy variables such as the stock prices and monetary base in empirical work.

Furthermore, it is also more challenging to develop an empirical study of the potential asymmetrical behaviour of central banks' preferences, with respect to inflation and output targets, based on the common assumption that central bank loss function is quadratic. In addition, following the development in the non-linear rules, it would be more useful, to develop an empirical work toward a formal model of non-linear monetary reaction function, which would provide a clearer theoretical grounding for empirical work in this area. We will discuss these in the next chapter.

Table 3.1. Variable Correlations: Indonesia

	r_a	r_b	r_c	π	$(y\text{-}y^*)$	s	$(s\text{-}s^*)$	q	$(q\text{-}q^*)$	i^f	r^f
r_a	1.00	0.44	0.66	-0.34	0.48	-0.06	0.04	0.16	0.23	0.33	0.27
r_b	0.44	1.00	0.30	-0.71	0.22	-0.49	-0.68	-0.45	-0.53	0.35	0.23
r_c	0.66	0.30	1.00	0.09	0.52	-0.06	0.21	0.30	0.43	0.42	0.53
π	-0.34	-0.71	0.09	1.00	-0.24	0.27	0.66	0.45	0.52	0.13	0.34
$(y\text{-}y^*)$	0.48	0.22	0.52	-0.24	1.00	-0.05	-0.01	0.15	0.26	0.15	0.09
s	-0.06	-0.49	-0.06	0.27	-0.05	1.00	0.57	0.88	0.50	-0.47	-0.40
$(s\text{-}s^*)$	0.04	-0.68	0.21	0.66	-0.01	0.57	1.00	0.80	0.95	0.05	0.18
q	0.16	-0.45	0.30	0.45	0.15	0.88	0.80	1.00	0.80	-0.12	-0.02
$(q\text{-}q^*)$	0.23	-0.53	0.43	0.52	0.26	0.50	0.95	0.80	1.00	0.09	0.21
i^f	0.33	0.35	0.42	0.13	0.15	-0.47	0.05	-0.12	0.09	1.00	0.93
r^f	0.27	0.23	0.53	0.34	0.09	-0.40	0.18	-0.02	0.21	0.93	1.00

Notes: r_a, r_b, and r_c denote real discount rates, real deposit rates and real money market rates respectively; π denotes the inflation; (y-y) denotes the output gap based on the GDP (at 2000 prices constant) seasonally adjusted; s, (s-s*), q, and (q-q*) denote nominal exchange rates, real exchange rates, the nominal exchange rate gap and the real exchange rate gap respectively; i^f and r^f denote foreign nominal and real interest rates respectively.*

Table 3.2. Variable Correlations: Korea

	r_a	r_b	r_c	π	$(y\text{-}y^*)_1$	$(y\text{-}y^*)_2$	s	$(s\text{-}s^*)$	q	$(q\text{-}q^*)$	i^f	r^f
r_a	1.00	0.70	0.24	-0.59	0.10	0.11	-0.30	-0.18	0.00	-0.13	0.39	0.48
r_b	0.70	1.00	0.55	-0.42	-0.11	-0.11	0.00	0.23	0.26	0.25	0.48	0.74
r_c	0.24	0.55	1.00	0.32	-0.03	-0.03	-0.46	0.18	-0.35	0.17	0.48	0.56
π	-0.59	-0.42	0.32	1.00	-0.04	-0.04	-0.45	0.12	-0.46	0.09	0.26	0.00
$(y\text{-}y^*)_1$	0.10	-0.11	-0.03	-0.04	1.00	1.00	-0.20	-0.46	-0.28	-0.44	0.01	-0.08
$(y\text{-}y^*)_2$	0.11	-0.11	-0.03	-0.04	1.00	1.00	-0.21	-0.49	-0.30	-0.46	0.01	-0.08
s	-0.30	0.00	-0.46	-0.45	-0.20	-0.21	1.00	0.46	0.86	0.46	-0.58	-0.30
$(s\text{-}s^*)$	-0.18	0.23	0.18	0.12	-0.46	-0.49	0.46	1.00	0.65	0.99	-0.17	0.05
q	0.00	0.26	-0.35	-0.46	-0.28	-0.30	0.86	0.65	1.00	0.67	-0.28	-0.01
$(q\text{-}q^*)$	-0.13	0.25	0.17	0.09	-0.44	-0.46	0.46	0.99	0.67	1.00	-0.15	0.05
i^f	0.39	0.48	0.48	0.26	0.01	0.01	-0.58	-0.17	-0.28	-0.15	1.00	0.86
r^f	0.48	0.74	0.56	0.00	-0.08	-0.08	-0.30	0.05	-0.01	0.05	0.86	1.00

Notes: r_a, r_b, and r_c denote real discount rates, real deposit rates and real money market rates respectively; π denotes the inflation; (y-y*) and $(y\text{-}y^*)_2$ denote the output gap based on the GDP Volume Index (2000=100) and the real GDP (= GDP current/GDP deflator) respectively; s, (s-s*), q, and (q-q*) denote nominal exchange rates, real exchange rates, the nominal exchange rate gap and the real exchange rate gap respectively; i^f and r^f denote foreign nominal and real interest rates respectively.

Table 3.3. Variable Correlations: the Philippines

	r_a	r_b	r_d	π	$(y\text{-}y^*)_1$	$(y\text{-}y^*)_2$	s	$(s\text{-}s^*)$	q	$(q\text{-}q^*)$	i^f	r^f
r_a	1.00	0.68	0.61	-0.51	-0.01	-0.02	-0.10	-0.05	-0.11	0.09	0.09	0.13
r_b	0.68	1.00	0.94	-0.21	0.23	0.23	-0.28	0.17	0.03	0.33	0.34	0.14
r_d	0.61	0.94	1.00	-0.03	0.32	0.32	-0.46	0.15	-0.13	0.31	0.52	0.32
π	-0.51	-0.21	-0.03	1.00	0.05	0.05	-0.52	0.26	-0.35	0.13	0.47	0.36
$(y\text{-}y^*)_1$	-0.01	0.23	0.32	0.05	1.00	1.00	-0.16	-0.34	-0.12	-0.25	0.36	0.27
$(y\text{-}y^*)_2$	-0.02	0.23	0.32	0.05	1.00	1.00	-0.16	-0.34	-0.09	-0.25	0.38	0.27
s	-0.10	-0.28	-0.46	-0.52	-0.16	-0.16	1.00	0.26	0.84	0.25	-0.69	-0.56
$(s\text{-}s^*)$	-0.05	0.17	0.15	0.26	-0.34	-0.34	0.26	1.00	0.49	0.96	-0.10	-0.10
q	-0.11	0.03	-0.13	-0.35	-0.12	-0.09	0.84	0.49	1.00	0.52	-0.52	-0.60
$(q\text{-}q^*)$	0.09	0.33	0.31	0.13	-0.25	-0.25	0.25	0.96	0.52	1.00	-0.07	-0.12
i^f	0.09	0.34	0.52	0.47	0.36	0.38	-0.69	-0.10	-0.52	-0.07	1.00	0.87
r^f	0.13	0.14	0.32	0.36	0.27	0.27	-0.56	-0.10	-0.60	-0.12	0.87	1.00

Notes: r_a, r_b, and r_d denote real discount rates, real deposit rates and real treasury bill rates respectively; π denotes the inflation; $(y\text{-}y^*)_1$ and $(y\text{-}y^*)_2$ denote the output gap based on the GDP Volume Index and the GDP Volume Index (1995=100) respectively; s, (s-s), q, and (q-q*) denote nominal exchange rates, real exchange rates, the nominal exchange rate gap and the real exchange rate gap respectively; i^f and r^f denote foreign nominal and real interest rates respectively.*

Table 3.4. Variable Correlations: Malaysia

	r_b	r_c	r_d	π	$(y\text{-}y^*)$	s	$(s\text{-}s^*)$	q	$(q\text{-}q^*)$	i^f	r^f
r_b	1.00	0.95	0.83	0.30	0.38	-0.39	-0.08	-0.40	-0.03	0.20	0.27
r_c	0.95	1.00	0.89	0.36	0.36	-0.48	-0.13	-0.48	-0.08	0.26	0.27
r_d	0.83	0.89	1.00	0.24	0.35	-0.55	-0.21	-0.53	-0.15	0.38	0.25
π	0.30	0.36	0.24	1.00	-0.27	-0.50	0.27	-0.52	0.24	0.31	0.38
$(y\text{-}y^*)$	0.38	0.36	0.35	-0.27	1.00	-0.32	-0.64	-0.32	-0.60	0.12	0.07
s	-0.39	-0.48	-0.55	-0.50	-0.32	1.00	0.47	0.99	0.45	-0.45	-0.28
$(s\text{-}s^*)$	-0.08	-0.13	-0.21	0.27	-0.64	0.47	1.00	0.47	0.99	0.10	0.19
q	-0.40	-0.48	-0.53	-0.52	-0.32	0.99	0.47	1.00	0.47	-0.46	-0.33
$(q\text{-}q^*)$	-0.03	-0.08	-0.15	0.24	-0.60	0.45	0.99	0.47	1.00	0.12	0.17
i^f	0.20	0.26	0.38	0.31	0.12	-0.45	0.10	-0.46	0.12	1.00	0.86
r^f	0.27	0.27	0.25	0.38	0.07	-0.28	0.19	-0.33	0.17	0.86	1.00

Notes: r_b, r_c, and r_d denote real deposit rates, real money market rates, and real treasury bill rates respectively; π denotes the inflation; (y-y*) denotes the output gap based on the GDP Volume Index (2000=100); s, (s-s*), q, and (q-q*) denote nominal exchange rates, real exchange rates, the nominal exchange rate gap and the real exchange rate gap respectively; i^f and r^f denote foreign nominal and real interest rates respectively.

Table 3.5. Standard Deviations

	Indonesia	Korea	Philippines	Malaysia
	1993(1)-2005(2)	1984(1)-2005(2)	1988(1)-2005(2)	1988(1)-2005(2)
r_a	0.0574	0.0202	0.0301	0.0126
r_b	0.0574	0.0248	0.0341	
r_c	0.0936	0.0338		0.0143
r_d			0.0397	0.0124
π	0.1289	0.0219	0.0371	0.0123
$(y\text{-}y^*)_a$			0.0188	
$(y\text{-}y^*)_b$	0.0556		0.0191	
$(y\text{-}y^*)_c$		0.0344		0.0290
$(y\text{-}y^*)_d$		0.0329		
s	0.6534	0.2267	0.3327	0.1918
$(s\text{-}s^*)$	0.2555	0.0841	0.0717	0.0685
q	0.3314	0.1564	0.1756	0.1755
$(q\text{-}q^*)$	0.2166	0.0773	0.0685	0.0648
i^f	0.0172	0.0202	0.0208	0.0200
r^f	0.0162	0.0161	0.0159	0.0153

Notes: r_a, r_b, r_c and r_d denote real discount rate, real deposit rate, real money market rate, and real treasury bill rate respectively; π denotes inflation; $(y\text{-}y^*)_a$, $(y\text{-}y^*)_b$, $(y\text{-}y^*)_c$ and $(y\text{-}y^*)_d$ denote the output gap based on GDP Volume Index, GDP Volume Index (1995=100), GDP Volume Index (2000=100), and real GDP (= GDP current GDP deflator) respectively; s, (s-s), q, and (q-q*) denote nominal exchange rates, real exchange rates, nominal exchange rates gap and real exchange rates gap respectively; i^f and r^f denote foreign nominal and real interest rates respectively.*

Table 3.6. Unit Root Tests

Level	Indonesia		Korea		Philippines		Malaysia	
	1993(1)-2005(2)		1984(1)-2005(2)		1988(1)-2005(2)		1988(1)-2005(2)	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
r_a	-3.25**)	-4.24***)	-2.47	-3.24**)	-3.51**)	-3.90***)		
r_b	-2.77*)	-2.61*)	-1.98	-2.24	-2.62*)	-2.92**)	-2.00	-2.29
r_c	-2.22	-2.53	-1.27	-2.06			-2.11	-2.15
r_d					-2.35	-2.48	-1.64	-2.27
π	-2.02	-2.39	-1.93	-2.62*)	-1.40	-2.56	-1.71	-2.12
$(y\text{-}y^*)_a$	-2.81*)	-2.94**)	-4.29***)	-11.13***)	-3.81***)	-12.75***)		
$(y\text{-}y^*)_b$					-3.62***)	-12.55***)		
$(y\text{-}y^*)_c$	-4.18***)	-2.93**)			-3.64***)	-12.54***)		
$(y\text{-}y^*)_d$			-6.26***)	-12.95***)			-5.45***)	-5.38***)
$(y\text{-}y^*)_e$	-3.36**)	-2.91*)						
$(y\text{-}y^*)_f$			-6.31***)	-12.94***)				
s	-1.25	-1.27	-1.27	-1.38	-0.66	-0.60	-0.93	-1.06
$(s\text{-}s^*)$	-2.55	-2.69*)	-3.63***)	-3.38**)	-3.68***)	-3.02**)	-3.09**)	-2.88*)
q	-1.60	-1.93	-1.82	-1.81	-0.95	-1.10	-0.85**)	-1.08
$(q\text{-}q^*)$	-2.66*)	-2.90*)	-3.59***)	-3.42**)	-3.73***)	-3.09**)	-3.02**)	-2.96**)
if	-1.21	-1.42	-1.76	-1.76	-2.53	-1.47	-2.53	-1.47
rf	-0.51	-1.04	-1.44	-2.01	-1.30	-1.75	-1.30	-1.75

1st Difference

	Indonesia		Korea		Philippines		Malaysia	
	1993(1)-2005(2)		1984(1)-2005(2)		1988(1)-2005(2)		1988(1)-2005(2)	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
r_a	-4.31***)	-8.80***)	-6.10***)	-7.76***)	-5.37***)	-8.65***)		
r_b	-4.21***)	-5.00***)	-4.51***)	-8.76***)	-5.01***)	-6.57***)	-3.47**)	-6.00***)
r_c	-4.67***)	-6.18***)	-5.51***)	-8.08***)			-3.69***)	-6.73***)
r_d					-4.89***)	-6.53***)	-3.78***)	-9.13***)
π	-2.58	-2.86*)	-5.39***)	-7.58***)	-3.49**)	-6.01***)	-3.63***)	-5.32***)
$(y\text{-}y^*)_a$	-3.45*)	-8.36***)	-4.52***)	-27.18***)	-3.41**)	-27.76***)		
$(y\text{-}y^*)_b$					-3.12**)	-28.44***)		
$(y\text{-}y^*)_c$	-2.96**)	-7.16***)			-3.11**)	-28.42***)		
$(y\text{-}y^*)_d$			-4.43***)	-28.23***)			-4.15***)	-10.24***)
$(y\text{-}y^*)_e$	-3.24**)	-7.68***)						
$(y\text{-}y^*)_f$			-4.47***)	-28.24***)				
s	-3.02**)	-5.07***)	-3.71***)	-6.57***)	-4.62***)	-5.08***)	-3.63***)	-5.07***)
$(s\text{-}s^*)$	-3.39*)	-5.27***)	-4.43***)	-6.96***)	-5.40***)	-5.34***)	-4.34***)	-5.39***)
q	-3.24	-5.60***)	-3.65***)	-6.56***)	-4.30***)	-5.69***)	-3.72***)	-5.17***)
$(q\text{-}q^*)$	-3.49	-5.74***)	-4.38***)	-6.98***)	-5.15***)	-6.01***)	-4.41***)	-5.46***)
if	-3.42**)	-3.40**)	-2.93**)	-5.55***)	-3.12**)	-3.86***)	-3.12**)	-3.86***)
rf	-2.69*)	-5.95***)	-3.86***)	-7.92***)	-2.92**)	-6.69***)	-2.92**)	-6.69***)

*Notes: */**/*** denote significance at the 10%/5%/1% level respectively following MacKinnon critical values for rejection of hypothesis of a unit root.*

Table 3.7. Baseline Model

	Indonesia	Korea	Philippines	Malaysia
Sample	1993(1)-2005(2)	1984(1)-2005(2)	1988(1)-2005(2)	1988(1)-2005(2)
c	-0.001321 (0.014534)	-0.006862 (0.002844)**	0.003763 (0.006256)	0.003410 (0.002385)
ρ	0.574780 (0.120537)***	0.827520 (0.064317)***	0.487918 (0.094906)***	0.584885 (0.098457)***
β	0.489844 (0.210227)**	0.849954 (0.488482)*	0.733705 (0.155245)***	0.448284 (0.182200)**
γ	1.973352 (0.562975)***	0.443781 (0.252591)*	0.557594 (0.317309)*	0.199550 (0.088409)**
R^2	0.668579	0.712568	0.696011	0.666597
$S.E.R$	0.057938	0.010449	0.021447	0.006906
DW	1.725262	1.667056	1.392900	1.983897

Notes: Numbers in parentheses are standard errors. The model for Indonesia: $r_t = c + \rho r_{t-1} + (1-\rho)\{\beta \pi_{t-4} + \gamma (y-y^*)_{t-3}\} + u_t$; The model for Korea: $r_t = c + \rho r_{t-1} + (1-\rho)\{\beta \pi_{t-4} + \gamma (y-y^*)_{t-1}\} + u_t$; The model for Philippines: $r_t = c + \rho r_{t-1} + (1-\rho)\{\beta \pi_{t-4} + \gamma (y-y^*)_t\} + u_t$; The model for Malaysia: $r_t = c + \rho r_{t-1} + (1-\rho)\{\beta \pi_{t-4} + \gamma (y-y^*)_t\} + u_t$; R^2 is the coefficient of determination. S.E.R stands for standard error regression and DW represents Durbin Watson statistic.

Table 3.8. Augmented Taylor Rule: OLS

	Indonesia	Korea	Philippines	Malaysia
Sample	1993(1)-2005(2)	1984(1)-2005(2)	1988(1)-2005(2)	1988(1)-2005(2)
c	-0.012312 (0.017615)	-0.275364 (0.054428)***	0.009405 (0.006857)	0.000862 (0.002259)
ρ	0.250728 (0.121679)**	0.742655 (0.060261)***	0.710543 (0.090485)***	0.528407 (0.099126)***
β	0.233399 (0.102969)**	0.993854 (0.327058)***	1.211702 (0.493788)**	0.812772 (0.172701)***
γ	1.267558 (0.272812)***	0.346493 (0.138137)**	0.392789 (0.205370)*	0.282745 (0.097390)***
ϕ	0.223000 (0.047490)***	0.145848 (0.041178)***	0.261129 (0.144378)*	0.107188 (0.037475)***
λ	1.394008 (0.636476)**	0.851355 (0.281603)**	2.380589 (0.713363)***	-0.340633 (0.149584)**
R^2	0.677241	0.791175	0.737755	0.705462
S.E.R	0.057842	0.009031	0.020916	0.006608
DW	1.760793	1.854717	1.882978	1.867237

Notes: Numbers in parentheses are standard errors. The model for Indonesia: $r_t = c + \rho r_{t-1} + (1-\rho)\{\beta \pi_{t-4} + \gamma (y-y^*)_{t-3} + \phi (q-q^*)_{t-2} + \lambda i^f_{t-2}\} + u_t$*; The model for Korea:* $r_t = c + \rho r_{t-1} + (1-\rho)\{\beta \pi_{t-4} + \gamma (y-y^*)_{t-1} + \phi q_{t-4} + \lambda r^f_{t-1}\} + u_t$*; The model for the Philippines:* $r_t = c + \rho r_{t-1} + (1-\rho)\{\beta \pi_{t-1} + \gamma (y-y^*)_t + \phi (q-q^*)_t + \lambda i^f_t\} + u_t$*; The model for Malaysia:* $r_t = c + \rho r_{t-1} + (1-\rho)\{\beta \pi_{t-4} + \gamma (y-y^*)_{t-4} + \phi (q-q^*)_{t-4} + \lambda r^f_{t-4}\} + u_t$*;* R^2 *is the coefficient of determination, S.E.R stands for standard error regression and DW represents Durbin Watson statistic.*

Figure 3.1. Inflation

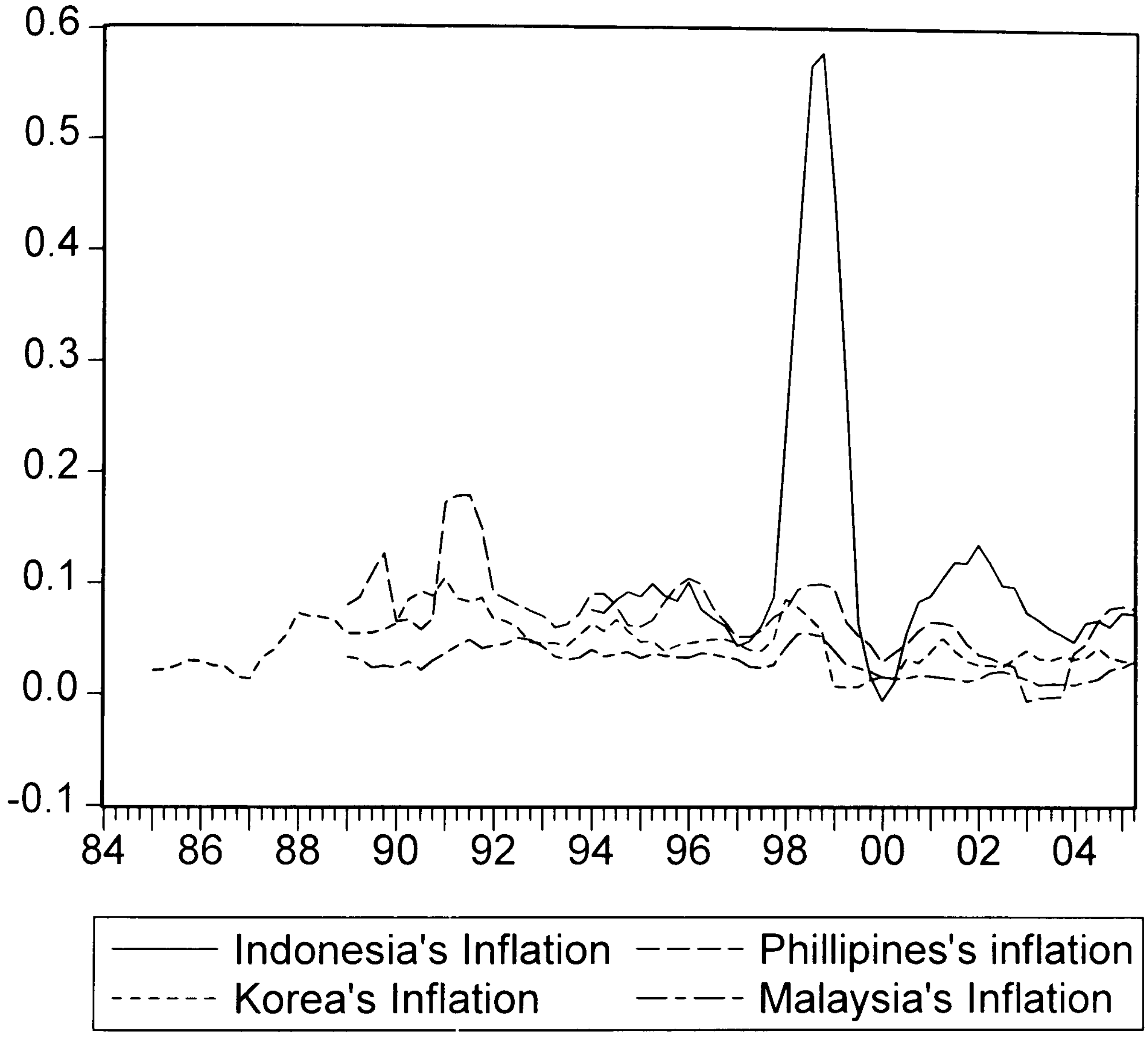


Figure 3.2. Asia's Economic Growth

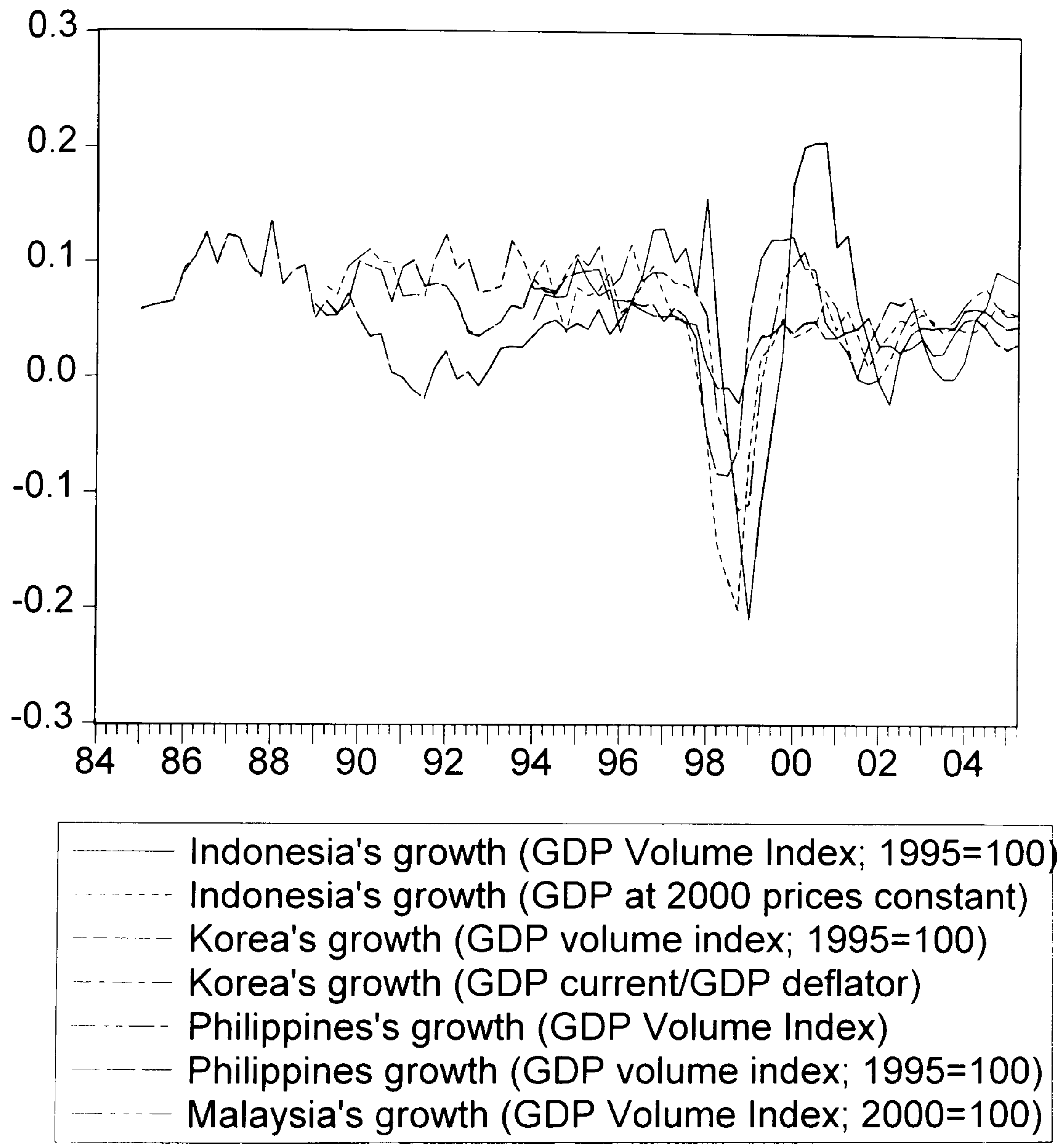


Figure 3.3. Indonesian Growth

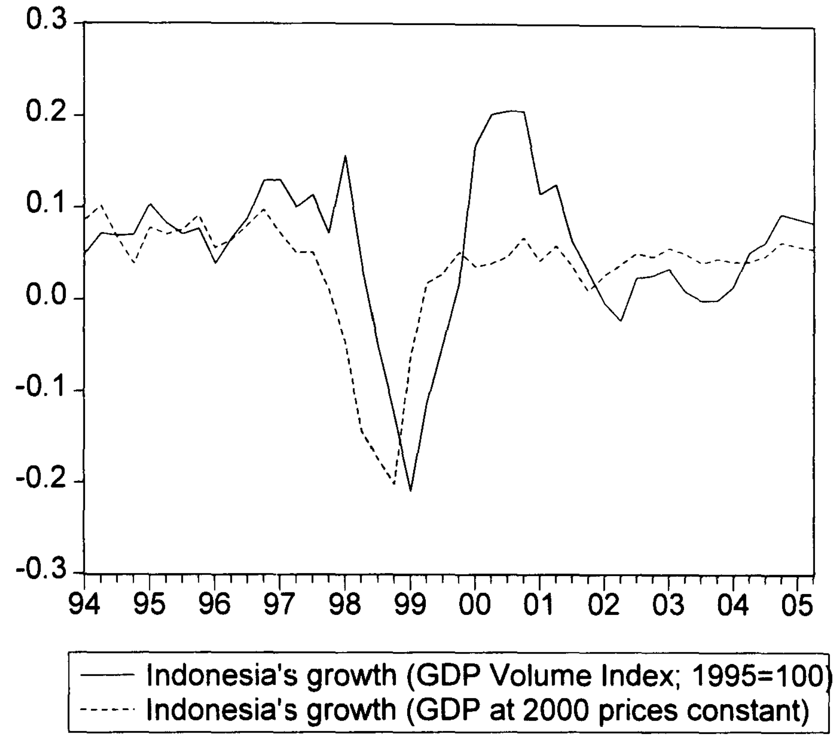


Figure 3.4. Indonesia's Output Gap

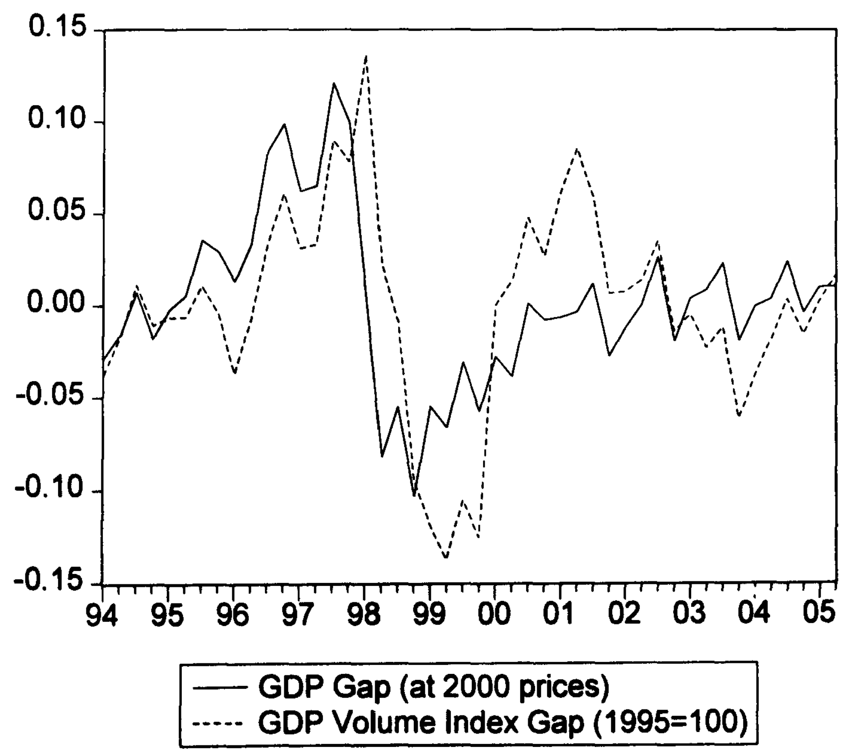


Figure 3.5. Indonesia's Interest Rates

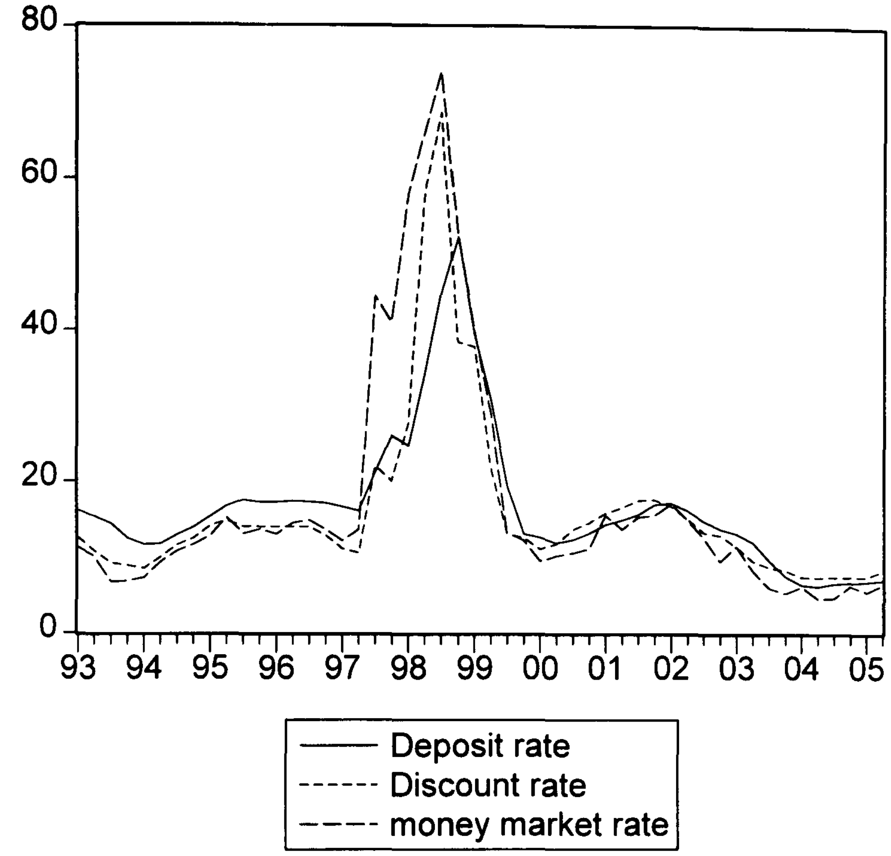


Figure 3.6. Indonesia's Real Interest Rates

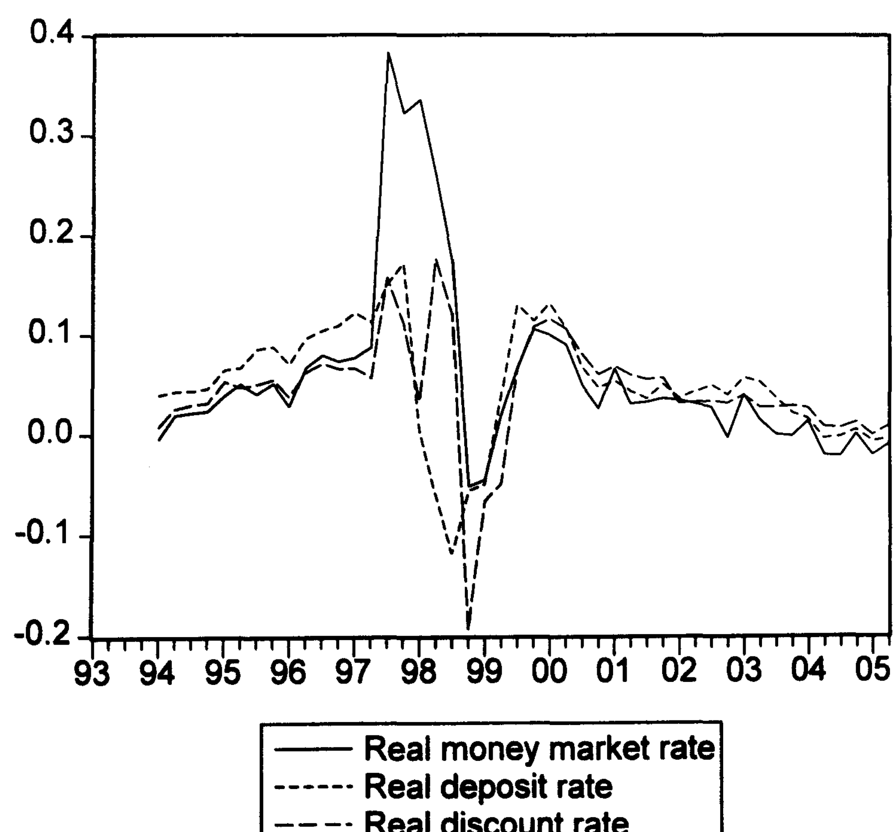


Figure 3.7. Korea's Inflation

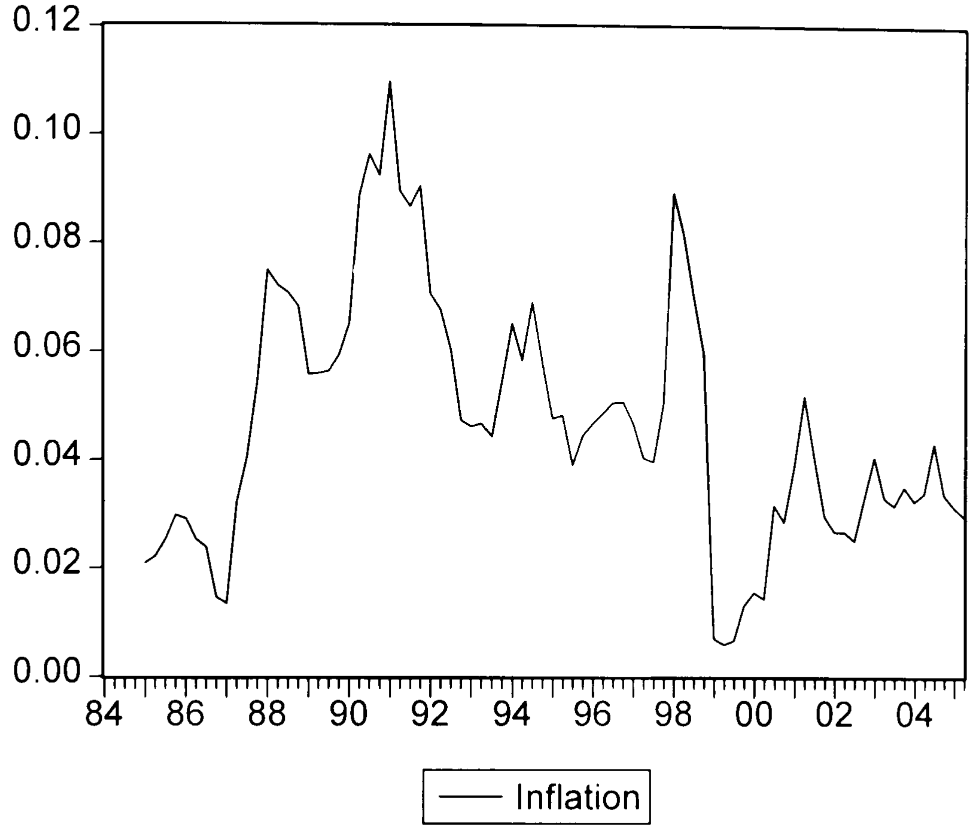


Figure 3.8. Korea's Exchange Rate

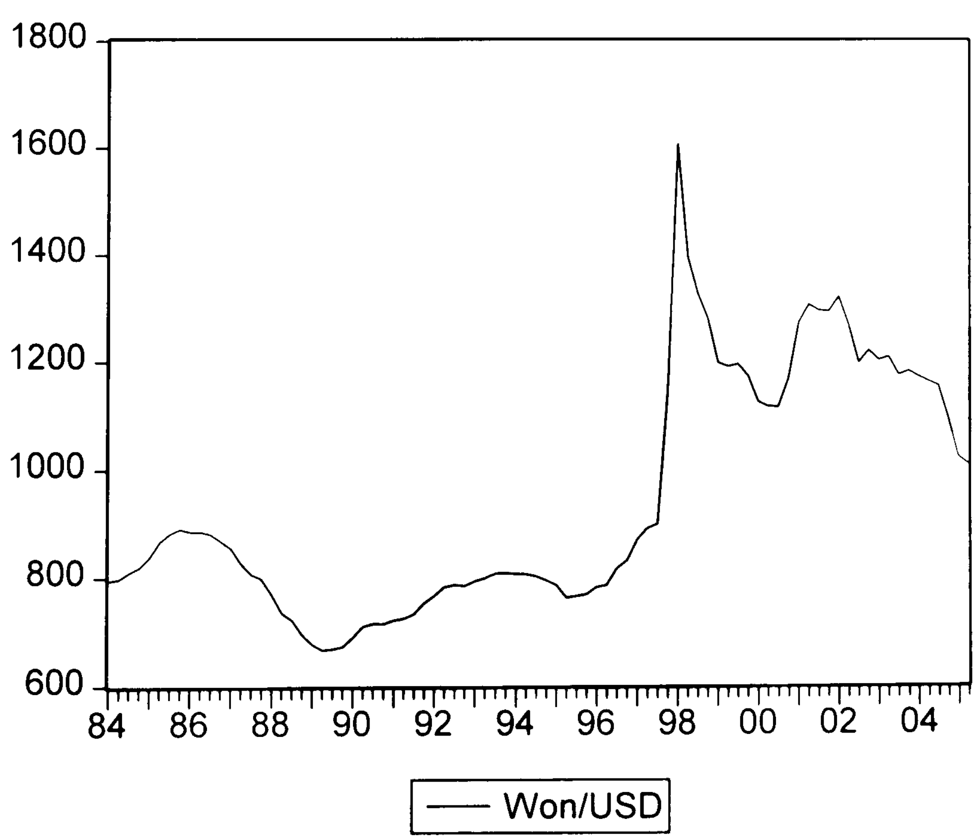


Figure 3.9. Korea's Real Output

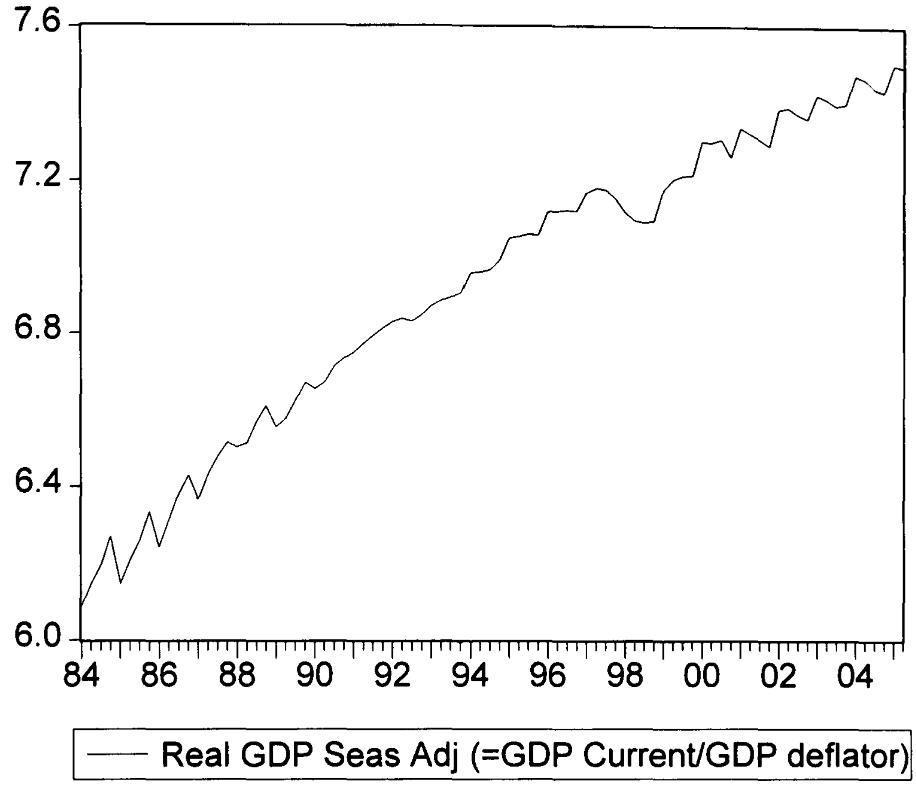


Figure 3.10. Korea's Interest Rates

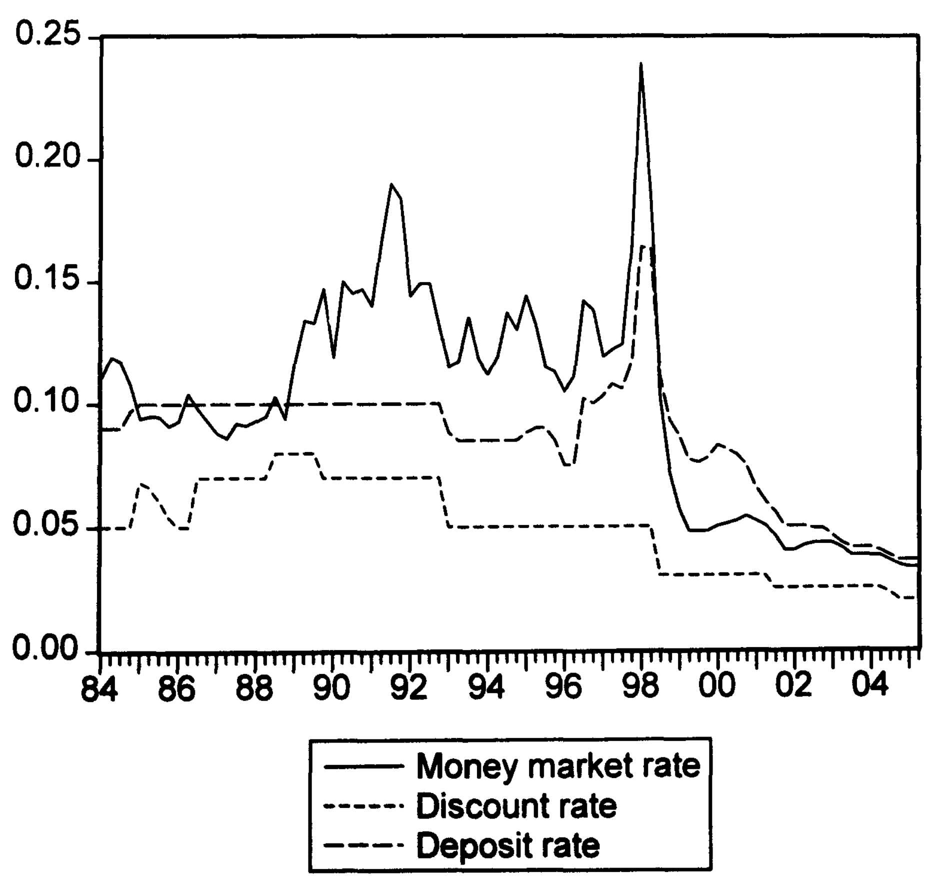


Figure 3.11. Korea's Output Gap

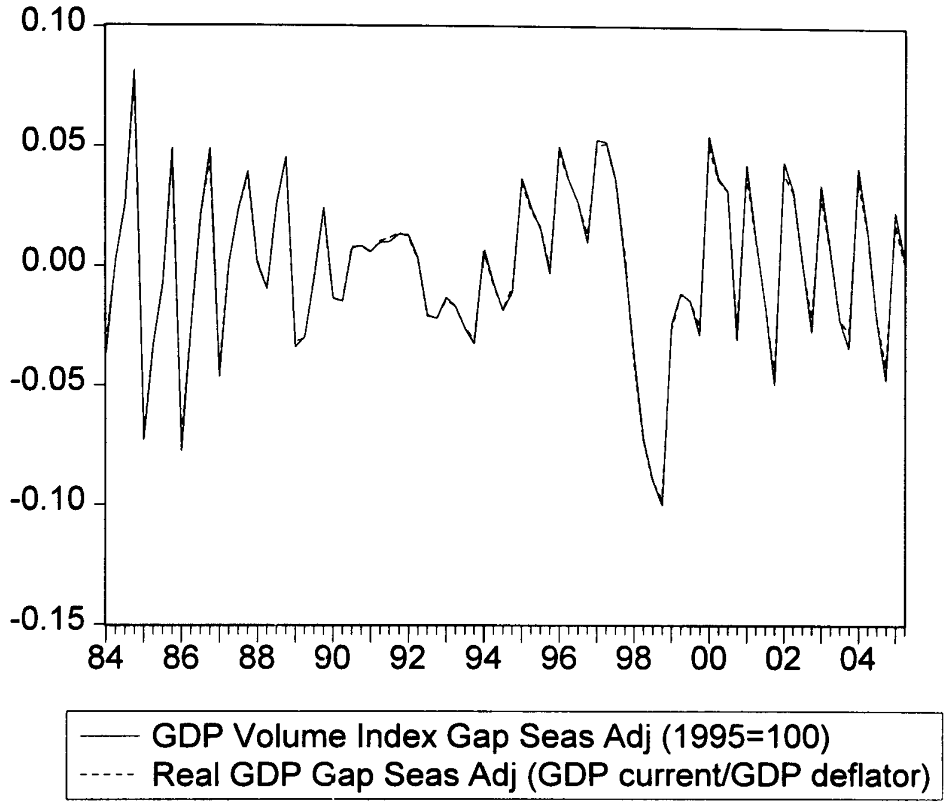


Figure 3.12. Philippine's Interest rates and Inflation rates

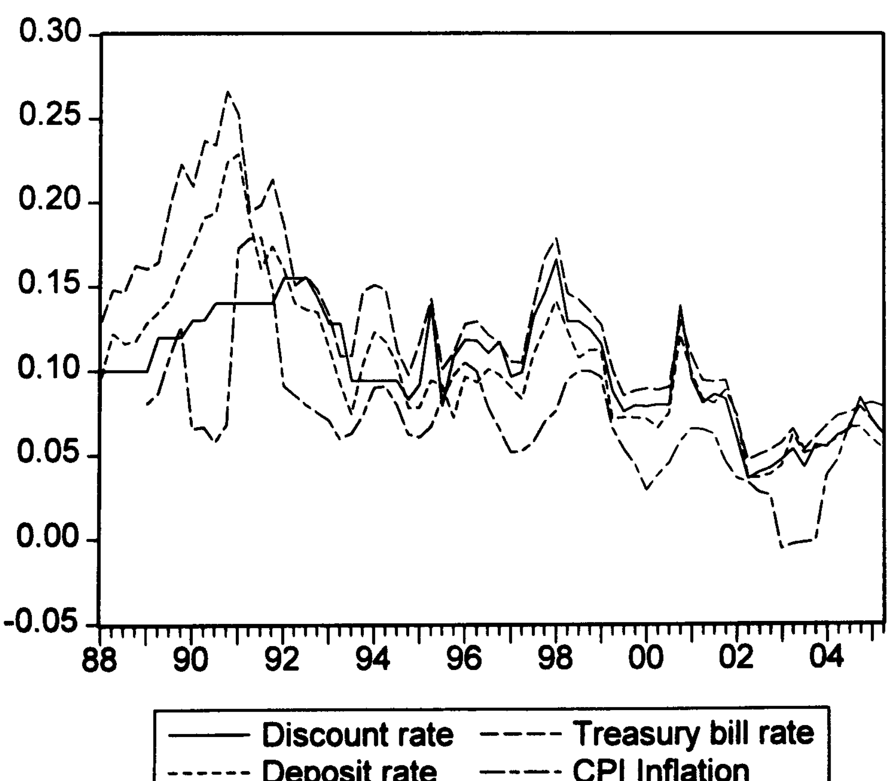


Figure 3.13. Philippine's Inflation and output gap

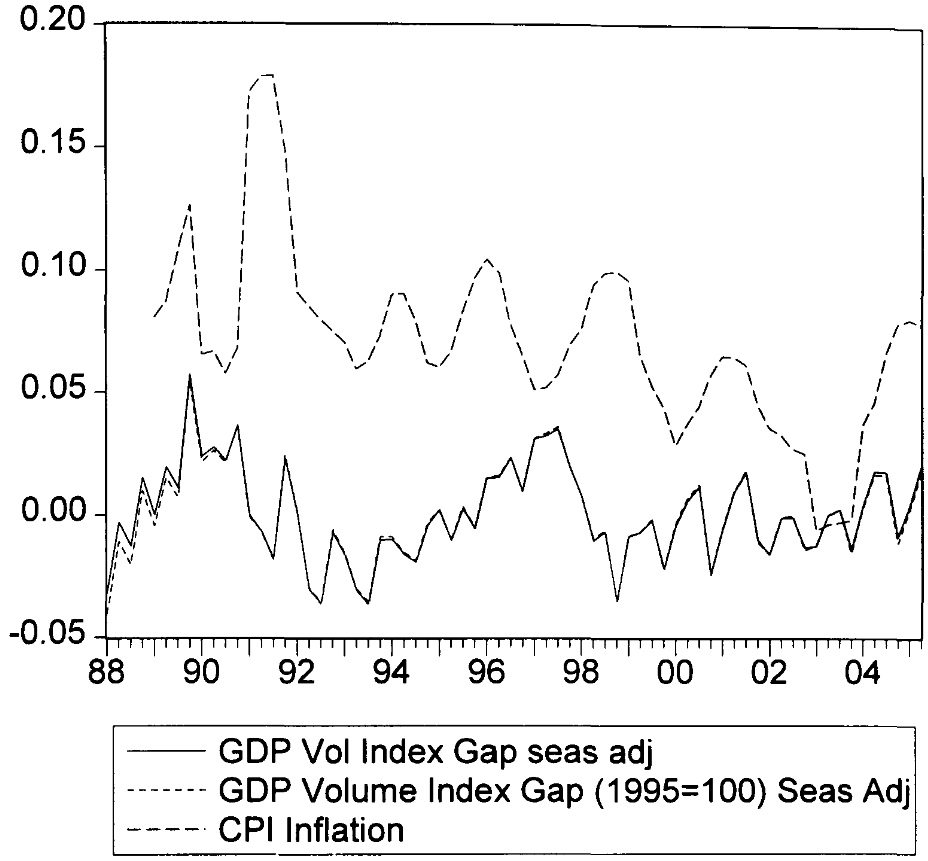


Figure 3.14. The Malaysia's Interest Rates, Inflation, and Growth

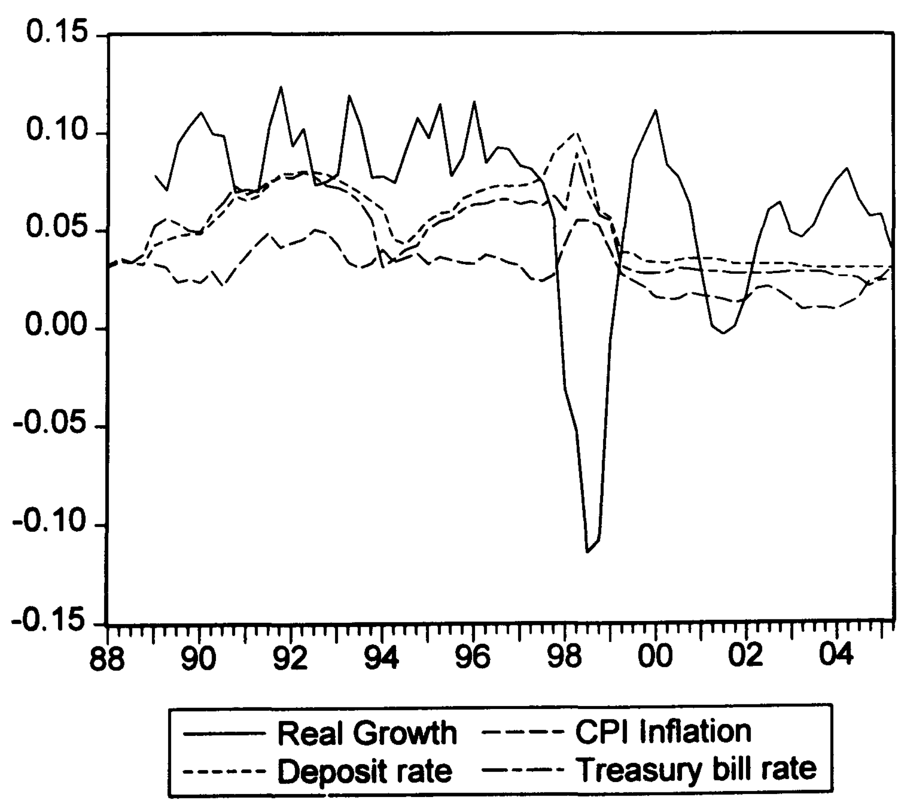
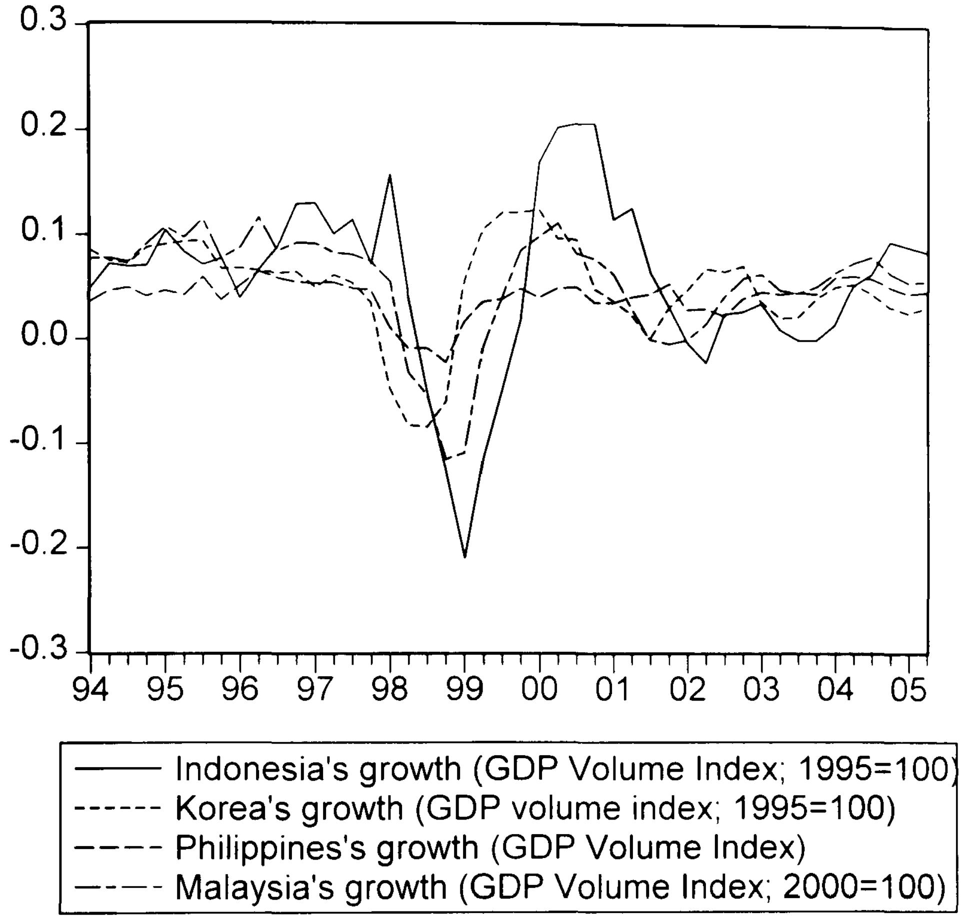


Figure 3.15. The Real Growth



CHAPTER IV

ASYMMETRY AND NON LINEAR MONETARY POLICY REACTION FUNCTIONS:

Inflation Effect

4.1. INTRODUCTION

Recently, there have been a number of studies challenging the assumption that the central bank responds in a linear fashion to inflation and output. These studies suggest that monetary authorities give different weights to positive and negative price pressures as well as economic upswings and downswings. They also imply that their response coefficients vary with the size of the shocks. If so, the linear monetary policy reaction functions based on the assumption that the loss function of the Central Bank is quadratic no longer appropriate.

Researchers identify two possible sources of non-linear monetary policy response. Firstly, the source of asymmetric monetary reaction is the bank's preferences, which may be non-quadratic. Nobay and Peel (1998), Gerlach (1999), and Ruge-Murcia (2000) assume different weights for positive and negative inflation and output deviations from the target. Dolado et al (2004) develop a model that integrates a nonlinear aggregate supply curve and asymmetric preferences of the central bank. They find that the source of the asymmetry derives from the Federal Reserves responding differently to positive and negative inflation gaps. This implies that US monetary policy can be distinguished by a nonlinear policy rule as a result of asymmetric inflation preferences of the Federal Reserve after 1983.[101] Independent monetary authorities tend to be biased towards undershooting rather than overshooting their inflation targets.

Goodhart (1998) supports this argument saying that, in order to maintain price stability and policy credibility, monetary authorities would prefer to have inflation below rather than above the target. Orphanides and Wieland (2000) analyze a Taylor rule in which the Central Bank prefers to increase interest rates by a larger amount when inflation is above the target than it will reduce them by when inflation is below the target. On the other hand, Martin and Milas (2004) argue that the response of the Bank of England to expected inflation differs according to the size of deviation from the inflation target. The bank does not react as long as inflation remains within set thresholds. This response is seen to be asymmetric as the bank's upper and lower thresholds are different.

Secondly, a non-linear association between inflation and output may also generate asymmetry in the optimal monetary policy rule. For instance, nominal wages may be sticky downwards but flexible upwards. This situation will create a non-linear Phillips

[101] The rule was found to be linear prior to 1979.

curve. Dolado et al (2002) suggest that an optimal monetary policy requires an asymmetric policy response to offset a non-linear Phillips curve. Accordingly, the central bank may deal more severely with positive deviations in inflation than with negative deviations. If the Phillips curve is convex, inflation is more responsive to higher output than to lower output.

In summary, existing empirical evidence on non-linear monetary policy reaction functions suggests the presence of a non-linear Phillips curve and/or non-quadratic preferences. Consequently, conclusions drawn from linear policy rules may be misleading.

In this chapter we test for the presence of non-linear and asymmetric policymaking behaviour at the Bank Indonesia, Bank of Korea, Bank ng Pilipinas, and Bank Negara Malaysia. Non-linearity is a hypothesis which we can test formally using the testing approach proposed by Saikonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993) and Teräsvirta (1994). In the presence of such non-linear and asymmetric responses, we then estimate a model of non-linear interest rate behaviour in these four countries.

We model monetary policy by allowing the behaviour of policy makers to differ between an inner regime, when inflation is close to the desired level and an outer regime. We do not assume that the boundaries between these regimes are symmetric.

We obtain a number of novel and interesting findings. Firstly, using a formal testing approach proposed by Saikkonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993), Teräsvirta (1994) we reject linearity.

Secondly, we find that within the inner regime, the sole determinant of Indonesia's monetary policy is inflation, whereas in Malaysia, the determinants are output gap and foreign interest rates. In the case of Korea and the Philippines, we find none of the variables - inflation, output gap, exchange rates, and foreign interest rates - are statistically significant. Policy makers are passive in the inner regime.

Thirdly, in the outer regime, we find that the major determinant of all countries' monetary policy is inflation, although other variables such as output also play a role in the determination of monetary policy in Indonesia and Korea. The U.S interest rate is important in all countries, with the exception of Indonesia, while the exchange rate plays a significant role in Indonesia and the Philippines.

Finally, our results also lead us to speculate that policymakers may have been attempting to keep inflation within the range of 1.2% to 8.7% in Korea, 5.7% to 9.2% in the Philippines, and 2.7% to 3.5% in Malaysia, rather than pursuing a point inflation target as we find in Indonesia.

The remainder of this chapter is structured as follows: section 4.2 presents literature review; section 4.3 discusses our methodology. In particular, section 4.3.1 presents formal tests for non-linear interest rate behaviour; section 4.3.2 presents the estimates of the non-linear monetary policy models; section 4.4 presents data and preliminary observation; section 4.5 discusses our empirical results; Finally, section 4.6 summarizes and offers some concluding remarks.

4.2. Literature Review

In this section we survey recent studies and major empirical results on the asymmetric loss function. Traditionally, the preferences of monetary authorities have been modelled using quadratic loss functions, which imply that the monetary authorities respond proportionately to any and all deviations of inflation and output from desired values. Svensson (1997, 1999), Rotemberg and Woodford (1998), and Clarida et al (1999) demonstrate that a linear monetary policy rule can be derived from the optimizing behaviour of a central bank seeking to minimize a quadratic loss function with respect to the deviations of inflation and output from their target and trend values, and assuming that the Aggregate Demand and Aggregate Supply curves are linear. In summary, the theoretical foundations of linear monetary policy reaction functions of this nature rest on two main assumptions. Firstly, the monetary authority employs a quadratic loss function and secondly, the Phillips curve, i.e. the aggregate supply relation, is linear.[102]

However, there have been a number of recent studies which have challenged these two assumptions. The argument that the preferences of decision makers at monetary authority may be asymmetric has received a lot of interest in recent literature. Promising strands in the literature have recently emphasized that political pressures, labour market frictions and heterogeneity in portfolio holdings can lead to the costs of business fluctuations and inflation variation being asymmetric. We discuss two recent strands in the literature on monetary policy rules that seek to extend the traditional linear-quadratic model. Firstly, the monetary authority has asymmetric preferences regarding inflation

[102] See Clarida et al (1999).

and/or output. Secondly, the Phillips curve, i.e. the aggregate supply relation, is non-linear.

4.2.1. Asymmetric Preferences

Kydland and Prescott (1977) and Barro and Gordon (1983) suggest an inflation bias in which the monetary authority is assumed to have a twin objective of price stability and higher desired level of employment. With respect to the latter objective, the authority prefers to have a level of employment above its natural level. As a result, the authority is tempted to generate inflation shocks so as to drive employment up above its natural level.

However, the relevance of inflation bias' presumption that policymakers aim at achieving a level of employment above potential outlined by Kydland-Prescott and Barro-Gordon has recently been challenged by several economists. McCallum (1995) argues that monetary authorities are typically reluctant to do what Kydland-Prescott and Barro-Gordon suggest because they recognize that increasing output by an expansionary monetary policy is ineffective. Rational economic agents will respond to such an expansionary policy by calculating the true level of inflation as they realize the monetary authority's strategy. Their actions will considerably reduce the effects of inflation on employment and, as a result, in the medium run, employment persists at its natural level. Additionally, Blinder (1998) claims that in fact the Federal Reserve always attempts to keep employment at the natural level rather than above it.

Cukierman (2000, 2002), and Cukierman and Gerlach (2003) argue that an inflation bias remains possible even if central banks are assumed to target the natural level of employment if central bankers are more worried about under- rather than over-employment. For instance, imagine an event where there is the possibility of an adverse supply shock, pushing employment below its natural rate. Economic agents would expect the monetary authority to implement an expansionary policy so as to bring employment back to its target value, leading to upward pressure on prices.

On the contrary, if a positive supply shock pushes employment above the natural level, central banks may take no action. For a given level of inflation, they have no interest in offsetting positive output gaps. The suggestion is that the political authority is vulnerable to the social costs of recession and that in democratic societies even independent central banks are not entirely immune to social and political concerns. In addition, Blinder (1998) states that monetary authorities will take more political heat when they tighten monetary policy to prevent higher inflation than when they ease policy to prevent higher unemployment. Therefore, this asymmetry will possibly emerge in the monetary authority's loss function.

Gerlach (2000) supports Cukierman (2000)'s arguments, finding that the Fed has a greater aversion to contraction than to expansion, which suggests that the bank has asymmetric preferences. Nobay and Peel (2003) follow Cukierman (2000) in seeking asymmetric preferences with regard to output and finding the same inflation bias. By way of contrast, they also investigate asymmetric preferences with respect to inflation. They demonstrate that an asymmetric preference with regard to the inflation target tends to stimulate a 'deflationary bias' if policy makers are less concerned about a policy that results in undershoots rather than overshoots of the inflation target. This is consistent with Mishkin and Posen (1997) who find that the Bank of Canada and the Bank of

England have an asymmetric reaction to positive and negative deviations of inflation from its target.

Dolado et al (2000) investigate the behaviour of policy makers at the central banks of France, Germany, Spain, and the US using data after 1980 in order to assess an asymmetric policy rule that depends on the sign of the inflation gap. The results suggest that the monetary authorities, with the exception of the central bank of Spain, respond more robustly to positive than negative deviation of inflation. Policy makers increase interest rates by a larger amount when inflation is above target than the amount it will reduce them by when it is below target.

Surico (2004) also provides empirical support for asymmetric preferences. He examines the empirical relevance of a model of monetary policy in which central bankers are permitted to response in different ways to positive and negative deviations of inflation and output from the target values. His paper shows that US monetary policy can be characterized by a nonlinear policy rule only during the pre-Volcker regime, with an interest rate response to the state of the business cycle being the dominant type of nonlinearity. Reduced-form and structural estimates of the central bank first order condition point out that preferences of the Fed are extremely asymmetric, with the response to output contractions being larger than the response to output expansions of the same magnitude. This asymmetry is revealed to generate an average inflation bias that played an important role during the great inflation of the 1960s and 1970s.

In contrast to Cukierman's precautionary demand for expansions, Goodhart (1998) introduces a precautionary demand for price stability. Goodhart (1998) observes that a central bank wishing to prove its credibility as an inflation combatant would respond to uncertainty favouring negative instead of positive deviation from the inflation target. In these circumstances, the monetary authority would have a precautionary demand for price stability, from which a deflationary bias would rise.[103] If inflation is a pro-cyclical variable, Goodhart (1998) argues that this precautionary demand for price stability may offset Cukierman's precautionary demand for expansions.

4.2.2. Non-Linear Phillips Curves

Given these two alternative premises with regard to the source of the asymmetric preferences, some economists attempt a different methodology. They concentrate their interest on the estimation of non-linear policy reaction functions, concluding that if central bank preferences are asymmetric, then the optimal policy rule is non-linear.[104]

Schaling (1999, 2004) and Dolado et al (2002, 2005) analyze the implication of convexity of the Phillips curve for optimal monetary policy. They find that the disparity between the actual and expected inflation is a convex function of the output gap, implying a nonlinear aggregate supply (Phillips) curve. Once the nonlinear aggregate supply (Phillips) curve is combined with a standard quadratic loss function, the optimal interest rate rule is also nonlinear and implies that the central bank will boost the interest rate more strongly when inflation is above the target than when inflation is below.

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[103] See also Fischer (1994) regarding a new commitment to low inflation by developed countries during the 1980s and its relation to deflationary bias.
[104] See Bec et al (2002), Kim et al (2002), Cukierman and Muscatelli (2002), Martin and Milas (2004), Karagedikli and Lees (2004), and Bruinshoofd and Candelon (2005).

Dolado et al (2003, 2005) argue that during the 1980s and 1990s, policy makers at the central banks of France, Germany and Spain, but not the USA, showed nonlinearities when setting the short-term interest rate as an instrument of monetary policy. Previously, however, Dolado et al (2004) analysed a model that integrates asymmetric preferences of the central bank and a specific nonlinear aggregate supply curve. Applying this model to US data, they find that asymmetry stems from the Fed's different reactions to positive and negative inflation gaps. These findings show that, after 1983, US monetary policy can be described by a nonlinear policy rule due to the asymmetric inflation preferences of the Federal Reserve, while prior to 1979 the rule is found to be linear.[105]

4.3. Methodology

In this section, we examine the possible existence of asymmetries in the behaviour of the central banks of Indonesia, Korea, the Philippines, and Malaysia in response to its determinants. We estimate models to assess whether the reaction function of central banks have presented size and/or sign effects in the response of interest rates to changes in inflation.

We investigate whether central banks respond differently to negative and positive deviations of inflation from their target values as well as attempting to find out whether larger shocks imply a stronger response than smaller shocks. For that purpose, our

[105] We do not have information regarding the behaviour of the USA inflation between 1979 and 1983.

augmented Taylor rules are re-specified so that the coefficients of the predetermined variables are now allowed to depend on the 'sign' and/or 'size' of the changes.

4.3.1. Tests for non-linear interest-rate adjustment

In this section we attempt to improve on the results of the linear models estimated in section 3.6.2 of chapter 3 by capturing the effects of any possible non-linearities in these four countries' monetary policy. For the existence of the latter to be established, formal tests are needed. We use the testing approach proposed by - Saikkonen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993), Teräsvirta (1994), using the artificial regression to test for linearity. In its general form, this regression takes the form of equation (4.1) below:

$$\begin{aligned}(r-\bar{r})_t = \rho_{00} + \sum_{j=1}^{k}\{\gamma_{0j}(r-\bar{r})_{t-j} + \rho_{1j}(r-\bar{r})_{t-j}(r-\bar{r})_{t-d} + \rho_{2j}(r-\bar{r})_{t-j}(r-\bar{r})^2_{t-d} \\ + \rho_{3j}(r-\bar{r})_{t-j}(r-\bar{r})^3_{t-d}\} + \rho_4(r-\bar{r})^2_{t-d} + \rho_5(r-\bar{r})^3_{t-d} + u_t\end{aligned} \tag{4.1}$$

In (4.1), $(r-\bar{r})_t$ is the deviation of the real interest rate from its equilibrium level, measured by the estimated residual term obtained from the augmented Taylor rule using equations (3.10) to (3.20) of chapter 3,[106] and d is the delay parameter of the transition function, and u_t is a white-noise error term ($\sim$ niid $(0,\sigma^2)$).

The null hypothesis of linear real interest rate misalignment $(r-\bar{r})_t$ can be tested using an LM-type test, estimated for all plausible values of d. This is described by H_0: $[\rho_{1j} = \rho_{2j} = \rho_{3j} = \rho_4 = \rho_5 = 0]$ for all $j \in (1,2...,k)$, with the autoregressive parameter k being determined by the partial autocorrelation function of $(r-\bar{r})_t$.[107] The testing procedure involves estimating (4.1) for all plausible values of d, testing in each estimation round the statistical significance of the linearity restrictions. Non-linearity is rejected if any of the resulting LM-statistics is significant. If linearity is rejected for more than one values of d, the latter's optimal value is determined by the test score with the lowest p-value (i.e. the highest value for the test's LM score).

4.3.2. Non-linear reaction function

We estimate models similar to those in Martin and Milas (2004), to model non-linear interest rate behaviour identified above.[108] The model we estimate is described by equation (4.2).

$$r_t = \theta_t\, r_{It} + (1-\theta_t)\, r_{Ot} + \epsilon_t \tag{4.2}$$

[106] The optimal interest rate rule for all these countries can be seen in Table 3.8 of chapter 3.
[107] Granger and Teräsvirta (1993) and Teräsvirta (1994) advise against choosing k using information criteria such as the Akaike on the grounds that this may result in a downward bias, affecting the results of the non-linearity tests.
[108] A thorough discussion of the models which follow can be found in van Dijk et al. (2002)

where r_{1t}, r_{Ot}, and θ_t are defined in equations (4.3), (4.4) and (4.5) respectively.

$$r_{1t} = c_1 + \rho_1 r_{t-1} + (1-\rho_1)\{\beta_1 A_{t\pm j} + \gamma_1 (y-y^*)_{t\pm k} + \phi_1 F_{t\pm l} + \lambda_1 G^f_{t\pm m}\} + u_{1t} \quad (4.3)$$

$$r_{Ot} = c_2 + \rho_2 r_{t-1} + (1-\rho_2)\{\beta_2 A_{t\pm j} + \gamma_2 (y-y^*)_{t\pm k} + \phi_2 F_{t\pm l} + \lambda_2 G^f_{t\pm m}\} + u_{2t} \quad (4.4)$$

$$\theta_t = pr\,\{\tau^L \leq A_{t\pm n} \leq \tau^U\} = 1 - \frac{1}{1 + e^{-\sigma[A_{t\pm n} - \tau^L][A_{t\pm n} - \tau^U]}} \quad (4.5)$$

where r_t is the real interest rate, ρ ($0 \leq \rho < 1$) is the partial adjustment (the degree of interest rate smoothing), A is the level of inflation 'π', or the deviation of inflation from its target value '$(\pi - \pi^*)$', $(y-y^*)$ is the deviation of actual from potential output, G^f is the (nominal 'i^f' or real 'r^f') foreign interest rate, F is the (nominal 's', or real 'q', or nominal gap '$(s-s^*)$', or real gap '$(q-q^*)$') exchange rate, u_t is a white noise term, and $j, k, l, m,$ and n are lags or leads with the value of 0, 1,...,8 (i.e. $j \in (-8,\ldots,-1, 0, +1, \ldots, +8)$).

We define $r^f = i^f - \pi^f$, in which the desired or equilibrium nominal foreign interest rate i^f is equal to the sum of the equilibrium real foreign interest rate r^f and the foreign CPI inflation. The model compares the results using, firstly, real, and, secondly, nominal foreign interest rates and assesses whether the foreign inflation CPI plays a key role in determining domestic real interest rates.

As we are not fully clear which measure of exchange rate should be considered, we include nominal 's', real 'q', nominal gap '$(s-s^*)$', or real gap '$(q-q^*)$') exchange rates alternately in equations (4.3) to (4.5). We define in log term $q=s+p^*-p$, where p^* is foreign national price level and p is domestic price level. Variable $(s\text{-}s^*)$ denotes the deviation of actual nominal exchange rate from its trend. With respect to variable $(s\text{-}s^*)$ and $(q\text{-}q^*)$, an increase means a depreciation and vice versa.

Equations (4.3) and (4.4) are reaction functions similar to linear augmented Taylor rule including exchange rates and foreign interest rates. The only substantive difference here is that our augmented Taylor rules use both inflation and inflation relative to the target with different time of observation either forward or backward looking, or contemporaneous.

The nonlinear monetary policy rule of Quadratic Logistic Function as shown in equation (4.2) distinguishes two different inflation regimes. These are defined as being the inner (r_{It}) and the outer (r_{Ot}) regime, where inflation 'A' (forward or backward looking, or contemporaneous) takes a value inside and outside a band which is defined by an upper and a lower critical threshold value, τ^U and τ^L respectively. Inside the inner regime, when 'A' (the level of inflation 'π' or the deviation of inflation from its target value '$(\pi - \pi^*)$') lie between the bands τ^U ('π^U' or '$(\pi - \pi^*)^U$')) and τ^L ('π^L' or '$(\pi - \pi^*)^L$')), interest rates are determined by (4.3); outside, when 'A' (the level of inflation 'π' or the deviation of inflation from its target value '$(\pi - \pi^*)$') is away from the bands τ^U ('π^U' or '$(\pi - \pi^*)^U$')) and τ^L ('π^L' or '$(\pi - \pi^*)^L$')), they are determined by (4.4). In this way, the Quadratic Logistic Function captures the impact of inflation size effects on monetary policy.[109]

Equation (4.5) models interest rates as a weighted average of the two regimes, with the weight term θ_t modeled in (4.5) denoting the probability of inflation ($A_{t\pm n}$) being

[109] The Quadratic Logistic Function also captures a certain type of sign effects, namely those implied from non-symmetric regime threshold ($\tau^L + \tau^U \neq 0$). This asymmetry, if validated by the data, may imply that monetary policy considers a positive output gap more costly than a negative gap – or vice versa.

in the inner regime. The model simplifies to the linear model in previous chapter if c_1 = c_2, $\rho_1 = \rho_2$, $\beta_1 = \beta_2$, $\gamma_1 = \gamma_2$, $\phi_1 = \phi_2$, and $\lambda_1 = \lambda_2$. It also simplifies to the linear model if θ is either 1 or 0.

The quadratic logistic function used to model the regime weight in equation (4.5) has the properties that (i) θ becomes constant (0.5) as $\sigma \rightarrow 0$ and (ii) as $\sigma \rightarrow \infty$, $\theta=0$ if 'A'$<\tau^L$ or 'A'$>\tau^U$ and $\theta=1$ if $\tau^L <$'A'$< \tau^U$.[110] Referring to Granger and Teräsvirta (1993) and Teräsvirta (1994), we set σ dimension-free by dividing it by the variance of inflation 'A'. Furthermore, van Dijk et al (2002) argue that the likelihood function is very insensitive to σ, suggesting that an accurate estimation of this parameter is unlikely in our relatively short sample. Therefore, we do not try to use estimates of σ to test our model against the alternative of a linear model.

Our model has paralleled with models developed by Granger and Teräsvirta (1993) and van Dijk et al (2002). In their STAR (Smooth Transition Auto-Regressive) models, the endogenous variable is determined by a weighted average of regimes with endogenous regime weights. Our model also has similarities with quadratic logistic function used by Martin and Milas (2004) when modelling UK monetary policy. However, while Martin and Milas (2004) differ their model from STAR models in using a forward-looking variable to determine the regime weights, we distinguish our model from STAR models in using either a forward or backward-looking or contemporaneous variable to determine the regime weights. Arghyrou (2004) also uses a quadratic logistic function to examine the compatibility of European and Greek Monetary Policies.

[110] See Jansen and Teräsvirta (1996).

However, he models the regime weights using a function similar to (4.5) where the regime weight depends on the lagged output gap rather than inflation.

4.3.3. Alternative models to compare

In this section, we compare estimates of our Quadratic Logistic Function discussed in section 4.3.2 to those alternative models developed by Dolado et al (2000) and those optimal models from our augmented Taylor rules discussed in section 3.6.2 of chapter 3. We then investigate which model is better able to explain monetary policy in these four countries.

4.3.3.1. Linear reaction functions modified for size inflation effects

Dolado et al (2000) propose a model to analyse monetary policy where policymakers are more responsive to inflation when it is further from the inflation target. We construct the following model allowing for size inflation effects in our augmented Taylor rule:

$$r_t = c+\rho\, r_{t-1} + (1-\rho)\{\beta_1\, \pi_{t\pm j} + \beta_2 (\pi-\pi^*)^2{}_{t\pm k} + \gamma (y-y^*)_{t\pm l} + \phi\, F_{t\pm m} + \lambda\, G^f{}_{t\pm n}\} + u_t \qquad (4.6)$$

where all variables and parameters in equation (4.6) are the same as those in equations (4.3) through (4.5). This model allows for inflation 'size' effects in monetary policy. For this purpose, a large deviation from target is now represented by a coefficient of β_2. We test the null hypothesis of symmetry, H_0: $\beta_2 = 0$, using a Wald test.

4.3.3.2. Linear reaction functions modified for sign inflation effects

While a distinction between symmetry and asymmetry would apparently enhance understanding about the preferences of central bankers, standard formal asymmetry tests have not been established in the literature. Asymmetry in monetary policy might be analysed using an augmented Taylor rule, including exchange rates and foreign interest rates, in line with the analysis in Martin and Milas (2004), of the form as illustrated by the following equation (4.7), a modification of our augmented Taylor rule, so that the coefficients on the predetermined variables are now allowed to depend on the 'sign' of the changes:

$$r_t = c+\rho\, r_{t-1} +(1-\rho)\{\beta_1 (\pi-\pi^*)^+_{t\pm j}+\beta_2 (\pi-\pi^*)^-_{t\pm k}+\gamma (y-y^*)_{t\pm l}+\phi\, F_{t\pm m}+\lambda\, G^f_{t\pm n}\} + u_t \tag{4.7}$$

where all variables and parameters in equation (4.7) are the same as those in equations (4.3) through (4.5). In equation (4.7) we define $(\pi-\pi^*)^+_{t\pm j} = (\pi-\pi^*)_{t\pm j}$ if $(\pi-\pi^*)_{t\pm j} \geq 0$ and $(\pi-\pi^*)^-_{t\pm k}$ is $(\pi-\pi^*)_{t\pm k}$ if $(\pi-\pi^*)_{t\pm k} \leq 0$. This model includes inflation and deflation rates as separate variables and so allows for differential responses from policymakers. For this purpose, positive and negative changes are now represented by two coefficients on each variable,

β_1 and β_2, respectively. The null hypothesis of symmetry, H_0: $\beta_1 = \beta_2$ is then tested using a Wald test. This type of model has been used by Dolado et al (2000) to analyze monetary policy in Germany, France, Spain and the US in the period before European monetary union.[111]

4.3.4. Sensitivity Analysis

We try to find out whether contemporaneous, backward-looking, forward-looking specifications and a combination of the three show non-linearity and asymmetry in monetary policymaking with respect to inflation shocks described by equations (4.2) to (4.7).

In addition, we use an alternative measure of all variables involve in our estimates in order to obtain an optimum and robust model. We include the level of inflation or inflation from its target value, the deviation of actual from potential output, the nominal or real foreign interest rate, and the (nominal, or real, or nominal gap, or real gap) exchange rate as discussed above.

4.4. Data

We use quarterly data for Indonesia, Korea, Malaysia and the Philippines for different time periods based on their availability. The estimation sample runs from 1984(1) to 2005(2) for the Korea model, 1988(1) to 2005(2) for both Philippines and

[111] See also Gerlach (2000) and Surico (2002).

Malaysia, and from 1993(1) to 2005(2) for Indonesia. All the data used in this analysis were obtained from the International Financial Statistics published by the International Monetary Fund provided by DataStream.

Following the specification of the estimated model in the previous chapter, we define r_t as the real money market rate/federal funds/call money rate for Indonesia; the real discount rate for Korea; the real treasury bill rate for the Philippines; and the real money market rate for Malaysia. Inflation π is defined as the percentage increase of the price level relative to its value in the same quarter of the previous year. We calculate π using the consumer price index (CPI) because we believe CPI to be the most suitable measure for the key anchor of monetary policy operation. It also represents the inflation indicator most familiar to the public. Real interest rates are calculated using $r= i-\pi$, where r, i, and π respectively denote real interest rate, nominal interest rate and inflation. We denote $(\pi-\pi^*)$ as the deviation of the current from (implicit or explicit) target inflation rates in which the target inflation π^* is the sample average of CPI inflation. We make an exception in the case of Indonesia, as the inflation rate in this country during the financial crisis was extremely large. Accordingly, we exclude the inflation rate from 1998(1) to 1999(2) in calculating target inflation rates of Indonesia. The target inflation π^* is 6.5% (11.95% if the inflation rate from 1998(1) to 1999(2) is included) for Indonesia, 4.57% for Korea, 7.08% for the Philippines, and 2.86% for Malaysia.

The output gap $(y-y^*)$ is a measure of the difference between actual output (y) and the potential output (y^*).[112] Since it cannot be observed we estimate potential output. Theoretically, productivity growth, labour force developments and other conditions affecting productive capacity in the economy may change (raise) the potential output. In

[112] Potential output is a level of output that over time is consistent with stable inflation.

this study, we use the Hodrick-Prescott filter since it is the most commonly accepted way of measuring potential output. We fit the Hodrick-Prescott (HP) filter into y using the suggested smoothing parameter for quarterly data in order to obtain an estimate of potential output *(y^*)*. We then construct the output gap as the difference between y_t and y^*_t. The output gap in these four countries represents the overall assessment of resource utilization in their economy.

The nominal exchange rate s is expressed as units of the domestic currency per U.S. dollar. The real exchange rate q is defined as nominal exchange rates adjusted for differences in national price levels p or defined in log terms as $q=s+p^*-p$, where p^* is foreign national price level and p is domestic price level. The HP filtering process is used to estimate trend values for the nominal and real exchange rates. The nominal exchange rate gap $(s-s^*)$ is determined as the deviation of the nominal exchange rate from its trend value. Similarly, the real exchange rate gap $(q-q^*)$ is then determined as the deviation of the real exchange rate from its trend value. According to our optimum findings in previous chapter, for our analysis, we use the real exchange rate gap for all countries, with the exception of Korea and Malaysia, where we consider the level of real exchange rate.

The nominal foreign interest rate i^f is the U.S treasury bill rate. The real foreign interest rate (r^f) is calculated using the equation, $r^f = i^f - \pi^f$, where r^f, i^f and π^f respectively denote real interest rate, nominal interest rate and CPI inflation in the US. Referring to our results in the previous chapter regarding the most robust model of the augmented Taylor rule, we use nominal foreign interest rates for all countries, with the exception of Korea, where we consider real foreign interest rates.

Given that the time series properties of the data will play an important role in the discussion below, it is worth noting that all variables are assumed stationary, for the reasons discussed in section 3.5 of chapter 3.

4.5. Empirical Results

4.5.1. Formal tests for non-linear interest rate adjustment behaviour

This section reports the relevant tests with respect to non-linear interest rate adjustment behaviour as discussed in section 4.3.1, and the results of which are presented in Table 4.1. In the case of Indonesia, we obtain $\phi=1$ and the reported LM-statistics are statistically significant, with the highest test statistic being obtained for d=3. We reject the hypothesis of linear interest rate adjustment at the 1 per cent level or better, which implies that the linear equations reported in column (i) of Table 3.8 in chapter 3 are mispeficied. We therefore conclude that interest rates in Indonesia show non-linear behaviour.

In the case of Korea, as shown in Table 4.1, the formal tests for non-linear interest rate behaviour suggest that $\phi=1$ and the reported LM-statistics are statistically significant, with the highest test statistic being obtained for d=2. We therefore conclude that interest rates in Korea display non-linear behaviour.

The formal tests for non-linear interest rate behaviour in the Philippines suggest that $\phi=2$ and the reported LM-statistics presented in Table 4.1 for this misalignment is statistically significant, with the highest test statistic being obtained for d=4. We therefore conclude that interest rates in the Philippines show non-linear behaviour, implying that the linear equations reported in column (iii) of Table 3.8 in chapter 3 are mispeficied.

The formal tests for non-linear interest rate behaviour in Malaysia suggest that $\phi=1$ and the highest test statistic for this rate is statistically significant at 1% or better which is obtained when d=3. We therefore conclude that interest rates in Malaysia present non-linear behaviour. This implies that the linear equations reported in column (iv) of Table 3.8 in chapter 3 are mispeficied.

4.5.2. The Non-linear reaction function

The quadratic logistic function allows us to investigate the conduct of monetary policy in these four countries to seek evidence whether the behaviour of the monetary authorities differed between regimes. Using a simple non-linear structural framework to analyze Indonesia's monetary policy between 1993 and 2005, as shown in column (i) of Table 4.2, we estimate π^L = -8% and π^U = 26%. Our estimates suggest that the regime boundaries are wide, implying monetary policy is irresponsive to inflation before the adoption of inflation targeting framework in July 2005. This situation is also found in the case of developed countries. For instance, Martin and Milas (2004) find that UK monetary policy is tolerant to high inflation before the adoption of inflation targeting framework in 1992 as they find wider regime boundaries in that the estimate of π^L is 1.9% and π^U is 21.1%.

We reject the hypothesis H_o: $\pi^U + \pi^L = 0$, implying there is evidence of asymmetry in this model. This means that monetary policy makers in Indonesia see deviations of inflation above and below the target unequally bad. We also find there are size effects in this model, since we reject the hypothesis H_o: $\pi^U = \pi^L$. It means that monetary policy makers in Indonesia are more responsive to inflation when it is further from the target. We also find that the estimate of σ is large, implying rapid transitions between the regimes. However, van Dijk et al (2002) argue that this parameter is imprecise in our relatively short sample as the likelihood function is very insensitive to this parameter.[113] For this reason, we follow Martin and Milas (2004) to not use estimates of σ to test our model against the alternative of a linear model.

In the inner regime, we find that all parameters, with the exception of inflation, are statistically insignificant. In the outer regime, with the exception of foreign interest rates, we find that all parameters are statistically significant, suggesting policymakers adjust the interest rate in response to changes in inflation, output, and exchange rates. The long-run response of interest rates to inflation in the outer regime (0.66) exceeds that in the inner regime (0.47), both are positive, suggesting that policymakers do conform to the Taylor principle that monetary policy should not accommodate inflation. Our results also suggest that the central bank pursued a point target rather than a target range. The estimated output gap parameter (1.92) is significantly greater than that of inflation (0.66). This implies that prior to 2005,[114] the influence of output was stronger than that of inflation.

[113] See the detailed discussion in van Dijk et al. (2002).
[114] In July 2005, Bank Indonesia officially adopts the inflation targeting framework.

The exchange rate also plays a significant role. As shown in column (i) of Table 4.2, the estimated exchange rate parameter in the outer regime is significantly greater than zero (1.70), so the monetary policy makers raise the interest rate in response to depreciation of the Rupiah against the US dollar in the outer regime.

Our estimates for Korea are presented in column (ii) of Table 4.2. The quadratic logistic function allows us to estimate separate upper and lower bands with the value of $\pi^L = 1.2\%$ and $\pi^U = 8.7\%$ respectively. In addition, these regime boundaries are smaller than those found in Indonesia.

Our test results show that we reject the hypothesis H_o: $\pi^U + \pi^L = 0$, implying there is evidence of asymmetry in this model. We also find there are size effects in this model, since we reject the hypothesis H_o: $\pi^U - \pi^L = 0$. In addition, the estimate of σ is large, implying rapid transitions between the regimes. However, as we discussed in the case of Indonesia previously, this parameter is imprecise as the likelihood function is very insensitive to this parameter.

In the inner regime, we find that all parameters are statistically insignificant, suggesting that policymakers do not adjust interest rates to move inflation towards the target. In contrast to the results in Indonesia, we find that β_I=0, suggesting policy makers in Korea pursued a target range rather than a point target. On the other hand, in the outer regime, with the exception of exchange rates, we find that all parameters are statistically significant, suggesting policymakers adjust the interest rate in response to changes in inflation, output, and foreign interest rates in order to move inflation towards the target.

The long-run response of interest rates to inflation (1.040) is similar to its response to the output gap (1.042). In contrast to Indonesia, in Korea, the exchange rate does not play a significant role. On the other hand, while in the case of Indonesia the foreign interest rate is not considered as the determinant of our model, in the case of Korea, it is highly significant (2.505). It implies that the monetary policy makers raise the interest rate in response to increasing U.S t-bill rates.

Column (iii) of Table 4.2 presents estimates of the model for the Philippines. We estimate $\pi^L = 5.7\%$ and $\pi^U = 9.2\%$. Our model has narrow regime boundaries implying monetary policy becomes more responsive to inflation. There is evidence of asymmetry effects in this model as we reject the hypothesis H_0: $\pi^U + \pi^L = 0$. There is also evidence of size effects in this model as we reject the hypothesis H_0: $\pi^U - \pi^L = 0$.

In the inner regime, we find that all four parameters included in our study are statistically insignificant, suggesting that policymakers do not adjust interest rates to move inflation towards the target. Similar to the case in Korea, we find that β_l=0, implying policymakers in the Philippines pursued a target range rather than a point target.

In the outer regime, all parameters are statistically significant, with the exception of the output gap, so that monetary policy becomes more responsive to inflation and irresponsive to the output gap. The long-run response of interest rates to exchange rates in the outer regime (0.232) suggests that policymakers do not accommodate depreciation. In other words, Bank ng Pilipinas raises the interest rate in response to depreciations of the Peso against the US dollar. The estimate of the foreign interest rate parameter (0.685) is significantly greater than that of inflation (0.302), so that monetary policy in the outer regime becomes more responsive to foreign interest rates and less responsive to inflation. Our results suggest that increasing U.S t-bill rate is responded to by raising the domestic interest rate.

When we consider Malaysia, as shown in column (iv) of Table 4.7, our model suggests that the estimate of π^L is 2.7% and of π^U is 3.5%. These narrow regime boundaries imply that monetary policy is more responsive to inflation. With respect to the asymmetry test, our results show that we reject the hypothesis H_o: $\pi^U+\pi^L= 0$, implying strong evidence of asymmetry in this model. We also find size effects in this model, since we reject the hypothesis H_o: $\pi^U-\pi^L= 0$.

In the inner regime, we find that monetary policy authority will react to changes in output and foreign interest rates. The long-run response of interest rates to foreign interest rates in the inner regime (0.523) exceeds that to output gap (0.296), suggesting that policymakers are more concerned with changes in US t-bill rates than the output gap. Similar to the case in Korea and the Philippines, we find that β_I=0, suggesting that monetary policy in Malaysia pursued a target range rather than a point target.

In the outer regime, we find that inflation and foreign interest rates parameters are statistically significant, suggesting policymakers adjust the interest rate in response to changes in inflation and foreign interest rates. The estimate of the inflation parameter (0.619) is statistically significant and positive, implying that Bank Negara Malaysia responds to changes in inflation by increasing the interest rates.

The foreign interest rate also plays a significant role in the outer regime. However, the long-run response of interest rates to foreign interest rates in the inner regime (0.523) exceeds that in the outer regime (0.242), suggesting that in the outer regime, monetary policy is less responsive to changes in US t-bill rates compare with its respond in the inner regime. Considering the foreign interest rates parameters are statistically significant in both the inner and the outer regime, we conclude that Bank Negara Malaysia does not accommodate foreign interest rates.

4.5.3. Compare to Alternative Models

4.5.3.1. Linear Augmented Taylor Rule

Comparing our estimates of nonlinear policy rule in Table 4.2 with those of augmented Taylor rule in Table 3.8 of Chapter 3, we find that our nonlinear policy rule dominates a linear augmented Taylor rule over the 1984-2005 periods as it has a substantially lower standard error. In addition, the formal tests for non-linear interest rate behaviour as discussed in section 4.5.1 suggest that interest rates in all four countries under observation present non-linear behaviour. This implies that the linear equations reported in Table 3.8 of chapter 3 are mispeficied.

4.5.3.2. Linear reaction functions modified for size inflation effects

Table 4.3 presents estimates of equation (4.6), where our augmented Taylor rule is extended to include a quadratic inflation effect. In all cases, with the exception of Malaysia, we find that the quadratic inflation term is significant, suggesting that monetary policy responds more strongly when inflation is far from the target. To confirm these findings, we test for non-linear responses using the Wald test on the inflation terms.

where the null hypothesis assumes a linear response to the inflation effects. We find that, with the exception of Malaysia, monetary policy has been non-linear. That is to say, in three of the four countries the monetary authority response differently according to the size of inflation deviations, increasing the interest rate by a larger amount when inflation is far above or below the target than it will reduce it by when inflation is close to its target. However, in the case of Korea the coefficient is considerably larger than what we would expect the central bank to adjust interest rates by.

We also find a medium-sized degree of interest rate smoothing and a statistically significant inflation term. Models in Indonesia and Korea suggest that the pre-dominant factor influencing these two countries' monetary policy in the 1990s was US interest rates with an estimated coefficient higher than unity.

In the case of Korea and the Philippines, as shown in Table 4.3, we find that the output gap is statistically insignificant, suggesting these countries' monetary policy do not response to output changes. This implies that possibly the adoption of inflation targets by Bank of Korea in 1998 and Bank ng Pilipinas in 2002 has lead to significant changes in monetary policy. In the case of Malaysia, as shown in Table 4.3, although the monetary authority has never adopted the inflation targeting framework, the magnitudes of the parameter estimates suggest that the Bank Negara Malaysia reacts more aggressively to large deviations of inflation from its target than other variables involved in our augmented Taylor rule. However, as shown in Table 4.3, we find that the behaviour of Bank Negara Malaysia in conducting monetary policy with respect to inflation is always linear, no matter whether inflation is further from the target.

Given all above findings, however, these augmented Taylor rules cannot be used to address the other issues considered in this chapter, such as asymmetry in monetary policy. In addition the standard errors of these estimates, with the exception of Malaysia, are slightly higher than those of our quadratic logistic functions discussed in section 4.5.2, so this model is dominated by our nonlinear monetary policy rule.

4.5.3.3. Linear reaction functions modified for sign inflation effects

Table 4.4 presents estimates of equation (4.7), where positive and negative deviations from the inflation target are entered as separate explanatory variables. The point estimates suggest that monetary policy in all countries, with the exception of the Philippines, responds more strongly when inflation is below the target, whereas the response is statistically insignificant when inflation is above the target. However, in the case of Korea and Malaysia, we find that the coefficient for sign effect contradicts our expectation as it suggests the monetary authority raises the interest rate when dealing with falling inflation rather than decreasing it. In the case of Indonesia, the coefficient for negative deviations of inflation consistent with the theory, suggesting an asymmetric policy regime where movements of inflation below the target lead to a more sluggish policy response in that Bank Indonesia tends to decrease the interest rate. On the other hand, in the case of the Philippines, we find the central bank deals more severely with positive deviations of inflation, whereas the response to negative deviations is statistically insignificant.

We test for asymmetric responses employing the Wald test on the response of interest rates to inflation, where the null hypothesis assumes a symmetric response to the deviation of inflation from the target. We confirm that the responses of all four countries are asymmetric. This suggests that central banks respond differently depending on whether inflation is above or below the target.

However, these augmented Taylor rules cannot be used to address the other issues considered in this chapter, such as non-linear in monetary policy in that large and small shocks have different importance for monetary policy. In addition, the standard errors of these estimates are higher than those of our Quadratic Logistic functions as discussed in section 4.5.2. We conclude that this model is also dominated by our nonlinear monetary policy rule.

4.6. Conclusions

We estimate a class of models to test the hypothesis of asymmetric monetary policy responses to the inflation rate at Bank Indonesia, Bank of Korea, Bank ng Pilipinas, and Bank Negara Malaysia. In the presence of such asymmetric responses, we then create a model of non-linear interest rate behaviour in these four countries.

We obtain a number of novel and interesting findings. Firstly, using a more formal testing approach proposed by Saikkonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993), Teräsvirta (1994) we reject linearity.

Secondly, our quadratic logistic function suggests that monetary authorities in these four emerging economies are subject to non-linear inflation effects and that they respond more vigorously to inflation when it is further from the target.

Thirdly, we find that within the inner regime, the sole determinant of Indonesia's monetary policy is inflation, whereas in Malaysia, the determinants are output gap and foreign interest rates. In the case of Korea and the Philippines, we find none of the variables - inflation, output gap, exchange rates, and foreign interest rates - are statistically significant. Policy makers are passive in the inner regime.

Fourthly, in the outer regime, we find that the major determinant of all countries' monetary policy is inflation, although other variables such as output also play a role in the determination of monetary policy in Indonesia and Korea. The U.S interest rate is important in all countries, with the exception of Indonesia, while the exchange rate plays a significant role in Indonesia and the Philippines.

Finally, in the case of Indonesia, we find that the long long-run response of interest rates to inflation in the inner and outer regime are statistically significant and positive, suggesting that the central bank pursued a point target rather than a target range, while in the case of the other three countries, we find that the long-run response of interest rates to inflation only statistically significant and positive in the outer regime, suggesting that these central banks pursued a target range rather than a point target. Our results provide evidence that policymakers may have been attempting to keep inflation within the range of 1.2% to 8.7% in Korea, 5.7% to 9.2% in the Philippines, and 2.7% to 3.5% in Malaysia, rather than pursuing a point inflation target.

Table 4.1 : Linearity Test

	ϕ	d	LM [p-value]
Indonesia	1	3	18.4016[.002]***
Korea	1	2	30.1655[.000]***
Philippines	2	4	37.5432[.000]***
Malaysia	1	3	21.1826[.001]***

*Note: The Table reports the F-scores of the LM test in equation (4.1); Numbers in square brackets are the probability values of the test statistics; the superscript ***/**/* denote statistical significance at the 1% 5% 10% level respectively.*

Table 4.2. The Non-Linear Monetary Policy Response Using The Quadratic Logistic Function

	Indonesia		Korea		Philippines		Malaysia	
Sample	1993(1) - 2005(2)		1984(1) - 2005(2)		1988(1) - 2005(2)		1988(1) - 2005(2)	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
	(i)		(ii)		(iii)		(iv)	
Inner regime								
c	0.040	0.0182**	0.306	0.163*	0.008	0.009	-0.012	0.008
r_{t-1}	0.276	0.1463*	0.942	0.107***	1.064	0.090***		
π^e_{t-1}	0.465	0.193**						
$(y-y^*)_{t-1}$							0.296	0.048***
i^f_{t-7}							0.523	0.080***
Outer regime								
c	-1.194	1.532	-1.276	1.376	0.066	0.019***	0.005	0.004
r_{t-1}	-0.734	0.179***						
π^e_{t-2}	0.663	0.210***	1.040	0.497**				
$(\pi-\pi)^e_{t-6}$							0.619	0.168***
$(\pi-\pi)^e_{t-8}$					0.302	0.147**		
$(y-y^*)_{t-4}$	1.919	0.621***						
$(y-y^*)_{t-8}$			1.042	0.612*				
$(q-q^*)_{t-7}$	1.704	0.704**			0.232	0.073***		
i^f_{t-2}					0.685	0.3579*		
i^f_{t-7}							0.242	0.134*
r^f_{t-8}			2.505	1.382*				
σ	2.097	0.841**	4.489	7.084	-95.710	558.100	85.220	1,020.000
π^U	0.255	0.018***	0.087	0.003***	0.092	0.006***	0.035	0.007***
π^L	-0.080	0.026***	0.012	0.004***	0.057	0.001***	0.027	0.001***
R.S.E	0.0180053		0.0057438		0.016585		0.0060413	
DW	2.32		1.72		1.76		1.74	
	F-stat/Chi^2		F-stat/Chi^2		F-stat/Chi^2		F-stat/Chi^2	
AR	1.553	[0.2305]	1.932	[0.1064]	1.028	[0.4053]	1.391	[0.2572]
ARCH	0.490	[0.6935]	0.431	[0.7851]	0.278	[0.8899]	0.987	[0.4293]
Normality	1.285	[0.5260]	1.436	[0.4878]	1.898	[0.3870]	1.788	[0.4091]
Hetero	31.718	[0.2862]	0.732	[0.7862]	0.215	[0.9997]	0.690	[0.7824]
	Chi^2		Chi^2		Chi^2		Chi^2	
Test: $\tau^U+\tau^L$	31.612	[0.0000]	2514.7	[0.0000]	691.25	[0.0000]	14019	[0.0000]
Test: $\tau^U-\tau^L=$	216.12	[0.0000]	113.2	[0.0000]	26.279	[0.0000]	283.29	[0.0000]
Test: $\tau^U+\tau^L=0$ & $\tau^U-\tau^L=0$	216.12	[0.0000]	3,684.50	[0.0000]	4,990.30	[0.0000]	15.513	[0.0000]

*Notes: The F-test and Chi-square statistics for the null hypothesis of valid over identifying restrictions are rejected. The superscript ***/**/* denote the rejection of the null hypothesis that the true coefficient is zero at the 1%/5%/10% significance levels, respectively.*

Table 4.3: Linear Model Modified for Size Effect

	Indonesia		Korea		Philippines		Malaysia	
Sample	1993Q1- 2005Q2		1984Q1- 2005Q2		1988Q1- 2005Q2		1988Q1- 2005Q2	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
c	0.0553	0.0200***	-0.0050	0.0059	0.0060	0.0055	0.0031	0.0029
r_{t-1}	0.4084	0.1736**	0.7515	0.0747***	0.3592	0.0899***	0.7057	0.0803***
$(\pi-\pi^*)$	-0.7663	0.3905*	1.2446	0.5123**	0.6392	0.1248***	1.0370	0.3025***
$(\pi-\pi^*)^2$	1.6383	0.7504**	-37.4199	18.4719**	4.4623	1.7420**	-0.9035	16.6784
$(y-y^*)$	1.1405	0.3867***	0.0868	0.2945	0.2995	0.2286	0.2778	0.1444**
q^*	0.3865	0.0868***	0.1947	0.1199	0.1801	0.0600***	0.1028	0.0500***
r^f	2.3449	0.8818**	1.6859	0.5842***	-11.6100	0.2967	-0.3624	0.2072*
Reg. SE	0.0488		0.0167		0.0192		0.0056	
	Statistic	Probability	Statistic	Probability	Statistic	Probability	Statistic	Probability
F-test for inflation size effects	4.7668	0.0354**	4.1038	0.0466**	6.5618	0.0132**	0.0029	0.9570
Chi-square for inflation size effects	4.7668	0.0290**	4.1038	0.0428**	6.5618	0.0104**	0.0029	0.9568

***Notes**: The F-test and Chi-square statistics for the null hypothesis of valid over identifying restrictions are rejected.*
The superscript ***/**/* denote the rejection of the null hypothesis that the true coefficient is zero at the 1%/5%/10% significance levels, respectively.

Table 4.4: Linear Model Modified for Sign Effect

	Indonesia		Korea		Philippines		Malaysia	
Sample	1993Q1- 2005Q2		1984Q1- 2005Q2		1988Q1- 2005Q2		1988Q1- 2005Q2	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
c	0.0102	0.0113	0.0128	0.0051**	0.0297	0.0102***	0.0129	0.0053***
r_{t-1}	0.3333	0.1968*	0.7263	0.0769***	0.3657	0.0895***	0.7892	0.0846***
$(\pi-\pi^*)+$	0.1385	0.1836	-0.3795	0.6128	1.1231	0.1786***	-0.5783	0.6329
$(\pi-\pi^*)-$	-1.6491	0.7101**	2.4992	0.9865**	0.2140	0.2323	2.2281	1.1845**
$(y-y^*)$	1.3000	0.3669***	0.0805	0.2537	0.2956	0.2404	0.2639	0.2219
q^*	0.3430	0.0729***	0.1874	0.1089*	0.1891	0.0604***	0.1473	0.0824*
r^f	1.7269	0.8369**	1.5464	0.5125***	0.0140	0.2699	-0.5664	0.4223
Reg. SE	0.0492		0.0168		0.0192		0.0062	
	Statistic	Probability	Statistic	Probability	Statistic	Probability	Statistic	Probability
F-test for inflation sign effects	5.4810	0.0247**	4.2284	0.0435**	7.7030	0.0076***	3.1497	0.0818*
Chi-square for inflation sign effects	5.4810	0.0192**	4.2284	0.0398**	7.7030	0.0055***	3.1497	0.0759*

Notes: *The F-test and Chi-square statistics for the null hypothesis of valid over identifying restrictions are rejected.*
The superscript ****/**/* denote the rejection of the null hypothesis that the true coefficient is zero at the 1%/5%/10%* ***significance levels, respectively.***

CHAPTER V

CONCLUSIONS

In this chapter, we conclude the thesis by detailing what has been achieved throughout the course of this research. In our research we studied and modelled exchange rates and monetary policy in four emerging Asian economies, namely Indonesia, Korea, the Philippines, and Malaysia using non-linear econometric approach. We will briefly discuss the results and the implications of our main findings.

In the first part of our thesis, chapter 1 and chapter 2, we examined the US dollar nominal and real exchange rates of these countries, respectively, for the period during which they implemented a policy of managed exchange rate floating. Over the past three decades, the currencies of all four countries have experienced a prolonged nominal and real depreciation against the US dollar. In particular, during the financial crisis of 1997/98, the nominal and the real exchange rate depreciated and appear to be non-stationary. This evidence cannot be explained by the benchmark model of nominal and real exchange rate determination, Purchasing Power Parity (PPP), which predicts a constant real exchange rate or a cointegrated nominal exchange rate with domestic and foreign price levels. We modelled equilibrium exchange rates using a general behavioural specification consistent with a variety of theoretical approaches; and short-run dynamics using a general non-linear adjustment model.

Our econometric analysis yields a number of interesting results. Firstly, in all countries examined, equilibrium exchange rates are a function of permanent relative output and one or more variables from domestic and foreign price levels, nominal and real interest rate differentials, the level of and changes in net foreign assets, and a time trend. These results imply that individual countries present significant elements of idiosyncratic behaviour, casting doubt on empirical models using panel-data techniques. The behaviour of nominal exchange rate differs from that of real exchange rates in that the latter takes into account the deterministic time trend in its long-run model but excludes domestic and foreign prices.

Secondly, we found strong evidence of non-linear exchange rate adjustment, with exchange rates following a random walk pattern when currency misalignment is small, but converging to their equilibrium level fast when misalignment is large. Furthermore, we found in Indonesia and Malaysia that the reversion to real exchange rate equilibrium is a function of the sign of the misalignment term. In contrast to the results in modelling nominal exchange rates in that asymmetric adjustment only in the case of Indonesia. These results suggest that the evidence in favour of sign misalignment effects in exchange rate behaviour is not as strong as that in favour of size effects.

Thirdly, our findings suggest that the currency devaluations that took place in 1997-98 were entirely justified by economic fundamentals, as prior to the financial crisis that hit the region, the exchange rates of all four countries, especially the one of Indonesia, were significantly overvalued against the US dollar.

In the second part of this thesis, we examined monetary policy in these four economies. In Chapter 3, we examined monetary policy reaction function in four Asian countries, namely Indonesia, Korea, Malaysia and the Philippines, based on an open economy augmented Taylor rule including the real exchange rate (level or difference from its trend) and the foreign interest rate (nominal or real). Using more recent quarterly data, we reach major findings as follows.

Firstly, the real interest rate reacts positively and significantly to inflation, the output gap, the exchange rate, and the foreign interest rate. Secondly, we find that the timing of the impact sometimes differs considerably. According to our findings, monetary policy conducted by central banks of Indonesia and Korea is essentially a combination of forward and backward-looking, while policy of central bank of the Philippines is composite looking between forward and contemporaneous looking. In the case of Malaysia, monetary policy is essentially forward-looking. Surprisingly, we do not find any central bank considering purely backward-looking or contemporaneous specifications.

Thirdly, we find the initial adjustment in interest rates varies between 26% and 75%. Fourthly, we find that it is an aggressive response of monetary policy, which has played a more important role in Asia since the financial crises of 1997-98 rather than, as claimed in the literature, the fiscal policy.

Fifthly, we find that, only in Indonesia, does the central bank appear to be less sensitive to inflation, though it has indeed been stabilizing the output gap by and large through its key policy rate. This quantitative evidence supports the fact that the central bank's main task is not to achieve price stability during period of observations.

Sixthly, with the exception of Korea and Malaysia, the foreign interest rate is more influential in explaining the variance of the interest rate than other endogenous variables, suggesting that the major focus of the monetary policy in these countries is to consider foreign interest rates.

However, there have been a number of studies challenging the assumption that the central bank responds in a linear fashion to inflation and output. These studies suggest that monetary authorities give different weights to positive and negative price pressures as well as economic upswings and downswings. They also imply that their response coefficients vary with the size of the shocks. If so, the linear monetary policy reaction functions based on the assumption that the loss function of the Central Bank is quadratic no longer appropriate. Consequently, conclusions drawn from linear policy rules may be misleading. For these reasons, in chapter 4, we estimate the class of models to test the hypothesis of asymmetric monetary policy responses to the inflation rate at Bank

Indonesia, Bank of Korea, Bank ng Pilipinas, and Bank Negara Malaysia. In the presence of such asymmetric responses, we then create a model of non-linear interest rate behaviour.

We obtain a number of novel and interesting findings. Firstly, using a more formal testing approach proposed by Saikkonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993), Teräsvirta (1994) we reject linearity.

Secondly, our quadratic logistic function suggests that monetary authorities in these four emerging economies are subject to non-linear inflation effects and that they respond more vigorously to inflation when it is further from the target.

Thirdly, we find that within the inner regime, the sole determinant of Indonesia's monetary policy is inflation, whereas in Malaysia, the determinants are output gap and foreign interest rates. In the case of Korea and the Philippines, we find none of the variables - inflation, output gap, exchange rates, and foreign interest rates - are statistically significant. Policy makers are passive in the inner regime.

Fourthly, in the outer regime, we find that the major determinant of all countries' monetary policy is inflation, although other variables such as output also play a role in the determination of monetary policy in Indonesia and Korea. The variable of exchange rates is important in models applied by Indonesia and the Philippines, while the other variable, namely U.S t-bill rates, also plays a significant role in the models applied by Korea, the Philippines, and Malaysia.

Finally, in the case of Indonesia, we find that the long long-run response of interest rates to inflation in the inner and outer regime are statistically significant and positive, suggesting that the central bank pursued a point target rather than a target range, while in the case of the other three countries, we find that the long-run response of interest rates to inflation only statistically significant and positive in the outer regime, suggesting that these central banks pursued a target range rather than a point target. Our results provide evidence that policymakers may have been attempting to keep inflation within the range of 1.2% to 8.7% in Korea, 5.7% to 9.2% in the Philippines, and 2.7% to 3.5% in Malaysia, rather than pursuing a point inflation target as found in the case of Indonesia.

In conclusion this thesis provides strong evidence that exchange rates and monetary policy in four emerging Asian economies present non linear behaviour. These studies suggest that these monetary authorities should consider to model exchange rates and monetary policy reaction functions using non-linear approach.

However, there are some more issues need to discuss. These include link between real and nominal exchange rate, possible on reliability on the data we use, the relationship between our non-linear model and earlier analysis such as Miller-Orr SS model and the possibility that our estimation procedure has induced serial correlation in the residuals.

On the first of these, the relationship between the model of nominal and real exchange rate. Our econometric analysis in modeling exchange rate, in particular in the case of Malaysia, yields an interesting result in that all variables determining the nominal exchange rate model discussed in chapter 1 also play similar roles when modelling real exchange rate behaviour discussed in chapter 2. These include permanent relative output, real interest rate differentials, the level of and changes in net foreign assets. The only distinction between the nominal exchange rate model, as shown in Table 1.4, and the real one, as shown in Table 2.2, is the latter' positive sign for real net foreign assets, while we find a negative sign when modelling nominal exchange rate behaviour.

In relation to the above, a new empirical finding, also observed in the case of nominal exchange rates, is that the relationship between real exchange rates on the one hand and real net foreign assets and/or current account balances on the other may be non-monotonic, depending upon the sign of net foreign assets and the current account balance. For instance, in the case of Korea, our robust real exchange rate model presents a positive sign for the changes in real net foreign liabilities, while in the case of the Philippines we find a negative sign.

On the one hand our results seems to support the argument that the results of Table 1.4 show support for the homogeneity of relative prices in the case of Malaysia, which explains why there is no difference in the estimates for the real exchange rate in table 2.2. On the other hand, we differ from that argument in that our nominal exchange rate model, as shown in Table 1.4, gives a negative sign for real net foreign assets, while in the real one, as shown in Table 2.2, gives positive sign. These results suggest that the relationship between exchange rates, nominal and real term, on the one hand and real net foreign assets and/or current account balances on the other may be non-monotonic, depending upon the sign of net foreign assets and the current account balance.

Similar non-monotonic results are obtained in the case of South Korea, where the link is even more complex with the exchange rate depreciating when the change in real net foreign assets increases and appreciating when net foreign liabilities increase. These findings reaffirm the ambiguity of the nature of the link between exchange rates on the one hand and current account/real assets' accumulation on the other, but add an extra element to it, as they suggest that the nature of the link may differ not only across countries, but also within the same country, depending on the sign of the current account balance and the net foreign assets' position (surplus/deficit, net assets/net liabilities). Providing a theoretical explanation for this ambiguity exceeds the scope of an empirical study such as the present one; however our empirical findings can motivate theoretical work rationalizing and formalizing the non-monotonic link identified here.

A possible criticism of our approach is that if the price variable is independent of the error, simply subtracting relative price from the nominal exchange rate will give the real exchange rate and the results of Table 2.2 could be got from simply re-parameterising Table 1.4. In fact, as said above, although all variables determining the nominal exchange rate model discussed in chapter 1 also play similar roles when modelling real exchange rate behaviour discussed in chapter 2, we find distinction between the nominal exchange rate model, as shown in Table 1.4, and the real one, as shown in Table 2.2, in particular the latter' positive sign for real net foreign assets, while we find a negative sign when modelling nominal exchange rate behaviour. Therefore, it is not true to claim that the results of Table 2.2 are obtained simply by re-parameterising Table 1.4.

In addition, the cointegration ADF tests reported at the end of Table 1.4 suggest that three out of four equations are clearly cointegrated at the 5 per cent level or better, which ensures that the findings discussed above are not reflecting spurious correlation among the variables involved. For the remaining equation (Malaysia), the cointegration test is less clear, with the ADF score being significant only at the 10 per cent level. This ambiguity may reflect the low-power of the ADF test and/or the existence of non-linear cointegration. Compare these results with the results in chapter 2, in particular as shown in Table 2.2, in that the reported ADF tests suggest that all equations, including Malaysia, are clearly cointegrated. These empirical results also cast doubt critics upon the potential problem of misspecification of the equilibrium exchange rate and the problems it poses for the identification of a non-linear system.

Moreover, the reported equations are generally well-specified, with their explanatory power being rather mixed. Nonetheless, in the case of Malaysia, the real exchange rate model fits the data better than that of the nominal exchange rate one in that the former' coefficient of determinations show relatively higher values. In the case of Indonesia, we find that the R-squares in real and nominal exchange rate models are similar (0.98), indicating that we have accounted for almost all of the variability with the variables specified in these models.

However, it would be beneficial to have further work that exploring the use of Monte-Carlo to evaluate the potential of type 2 errors conditional on a misspecified model of the equilibrium exchange rate in order to provide robust conclusion and support findings in this thesis.

Secondly, considering the possible reliability on the data, our results are valid and provide no evidence that the data are suspect. Tables 1.7 and 2.5 present estimates of non-linear error correction equations for nominal and real exchange rates, respectively. We report estimates of parsimonious models obtained using a general-to-specific specification starting with 16 lags and gradually reducing the model so that it only includes statistically significant terms and give a more parsimonious representation. Our estimates of exchange rates present relatively long lags. For instance in the inner regime in the case of Indonesia our model for nonlinear real exchange rates depend on the fifteenth lags of dependent variable (the first difference of observed real exchange rates). This situation is also found by Arghyrou, Boinet, and Martin (2004) in the case of five Central European Economies that recently joined the EU in that the linear error correction model in these countries is the function of twelve lags of its explanatory variables. In our case, the results of long lags response in explanatory variables may reflect the long period of time needed to construct and revise the data. This may have affected our results. A source of data other than datastream may be worth considering since datastream data may not be automatically updated when the source data is updated. As a result, in modelling exchange rates, we may have been led to use an improper equilibrium model and the test of linearity may be misleading. However, we do not find this problem as we are sure about the accuracy of our data taken from data stream. In addition, our models include as many lagged differences as was necessary for the elimination of serial correlation. Our models are proved to be generally well-specified.

To summarise, our empirical findings suggest that over the past three decades nominal exchange rates in all four Asian economies examined by our analysis have been influenced by both monetary and output shocks and, at different degrees and ways, by factors such as nominal and real interest rate differentials, foreign assets' accumulation and changes in current account balances. These, combined with the fact that the exchange rate effects of changes in relative output differs across countries, leads us to the conclusion that the exchange rates of the four Asian economies we examine presents similarities but, at the same time, strong elements of idiosyncratic behaviour.

Thirdly, there is an issue considering Miller-Orr SS model as a precursor of the inner and outer non-linear model employed in the thesis. This model deals with cash balance (inflows and outflows) that change on a daily basis because most firms don't use their cash flows uniformly and also cannot predict their daily cash inflows and outflows. The assumption made here is that the net cash flows are normally distributed with a zero value of mean and a constant standard deviation. The Miller-Orr Model helps firms in managing their cash balance by allowing daily cash flow variation within the lower and upper limits.

The Miller-Orr Model provides a formula for determining the optimum/target cash balance or return point, the point at which to sell securities to raise cash (lower control limit) and when to invest excess cash by buying securities and lowering cash holdings (upper control limit). This depends on transaction costs of buying or selling securities, variability of daily cash (incorporates uncertainty), and return on short-term investments.

As long as the cash balance remains within the control limits the firm will make no transaction. The firm allows the cash balance to fluctuate between the upper control limit and the lower control limit, making a purchase and sale of marketable securities only when one of these limits is reached.

The lower control limits for the cash balance can be related to a minimum safety margin or its desired minimum "safety stock" of cash in hand decided by management. It implies that the lower control limit can be set according to the firm's liquidity requirement.

To use the Miller-Orr model, the firm should also determine an interest rate for marketable securities, a fixed transaction cost for buying and selling marketable securities, and the standard deviation of its daily cash flows. To determine the standard deviation of net cash flows the pasty data of the net cash flow behaviour can be used. Managerial attention is needed only if the cash balance deviates from the limits.

The upper control limits and return path are then calculated by the Miller-Orr Model as follows:

The spread/distance between the lower control limits and the upper control limits is computed as:

$$\text{Spread} = 3\left(\sqrt[3]{\frac{3}{4} \times \frac{\text{Transaction cost} \times \text{Variance of cash flow}}{\text{Daily interest rate}}}\right) \qquad (5.1)$$

The return point is computed as:

$$\text{Return point} = \text{Lower limit} + (\text{spread}/3) \qquad (5.2)$$

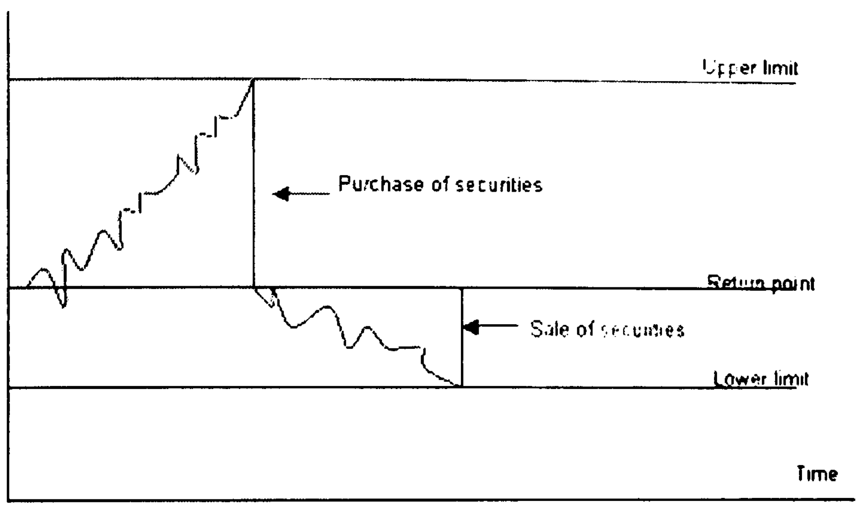
The upper control limit is computed as:

$$\text{Upper Limit} = \text{Lower Limit} + \text{Spread} \qquad (5.3)$$

The upper control limit is specified by Miller-Orr to be three times above the lower control limits and the return point lies between the upper and lower limits.

As shown in the following Figure 5.1, under the model, when the firm's cash in hand fluctuates at random and touches the upper limit, the firm buys sufficient marketable securities to come back to a normal level of cash balance (the return point). In other words, when cash reaches an upper limit, it's invested. Similarly, when the firm's cash flows wander and touch the lower limit. it sells sufficient marketable securities to bring the cash balance back to the normal level (the return point). In other words, when cash reaches a lower limit, investments are sold to raise cash.

Figure 5.1 Miller-Orr Model



Source: TheManageMentor[115]

The upper control limit and lower control limit will be far off from each other whenever the transaction cost increases or cash flows shows greater variation. On the other hand, the limits will come closer whenever the interest rate increases.

However, our QL-STECM model differs from the Miller-Orr model in that the former model allows the speed of adjustment to equilibrium to be a function of both the size and the sign of misalignment term, whereas the Miller-Orr model does not.

Unlike on the Miller-Orr SS model, on the QL-STECM, the lower and upper limits, along with equilibrium, are determined by the data rather than being set by the investigator.

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[115] See http://210.210.18.114/EnlightenmentorAreas/finance/CFA/miller.htm

Our QL-STECM models exchange rate changes as a weighted average of the linear adjustment models of the inner regime, in which misalignment is small, and the outer regime, where misalignment is larger, whereas Miller-Orr SS model considers only fluctuation within the band (inner regime only). This suggests that the QL-STECM regards that fluctuation may not only happen in the inner regime (within the bands) but also in the outer regime (beyond the limits). In other words, In Miller-Orr model, variation can only occur in the inner regime, whereas in QL-STECM model, it can be in the outer regime. This implies that QL-STECM model can estimate what variables are important in the inner regime and/or in the outer regime. The case was not found when using Miller-Orr model.

Fourthly, there is an issue of inducing serial correlation in that sometimes serial correlation may be induced as a result of using actual leading values for expected leading values in econometric estimation. For instance, the expectation of inflation becomes problematic if there is a correlation between this expected price increase and the actual change in prices. The problem of serial correlation in the residuals could also be appeared as a result of using leads and lags in the model. However, our results in chapter 3 provide evidence against these potential problems.

Nonetheless, if there are concerns about whether our residuals have serial correlation because of the use of leads and lags in the model, for further work, we may follow Bardsley and Olekalns (1999) and Becker, Grossman, and Murphy (1994), in applying a two-stage least squares (2SLS) estimator with lags and/or leads of our variables as our instruments. For reference, Bardsley and Olekalns describe the relationship between consumption and price in that, "Prices are suitable instruments in this context since the optimal consumption in any period depends on the past history and expected future course of prices" (p. 233). They suggest adopting a 2SLS model in order to resolve any problems of serial correlation. Although we did not find any problems of serial correlation in chapter 3 and 4, in further work, we might consider using this 2SLS model to extend our augmented Taylor rule analysis.

Finally, we might also discuss the use of calibrated model. It is often implicitly assumed that once a model has been carefully calibrated to reproduce previously observed behaviour, then it will have some level of predictive capability, although this may be limited. In further work, we might use our calibrated linear and non-linear models to generate data and compare these to the properties of real data as an alternative methodology for testing non-linearity. If our model does not have predictive capability, then the model may need to be improved in some way.

Our work can be extended in several ways. In the empirical level, we could use our empirical methodology to study the dynamics of nominal and real exchange rates as well as monetary policy reaction functions in other sets of countries and determine whether the asymmetric or non-linear dynamics identified in the Asian economies examined by our analysis are a common future of exchange rate and accordingly monetary policy reaction functions behaviour. In the theoretical level, we can use the empirical findings of our study such as, firstly, to motivate a theoretical model of non-linear exchange rate behaviour based on asymmetric policy preferences and, secondly, to establish a formal non-monotonic link between the current account and the real exchange rate.

With respect to monetary policy reaction functions, in particular, this research can also be expanded in numerous approaches. As the results show that the inflation did not justify as much variation in the real interest rate as we had expected, it may be possible to restructure this variable differently. Otherwise, it would also be interesting to take into account other monetary policy variables such as the stock prices and monetary base in empirical work.

Furthermore, it is also more challenging to develop an empirical work toward a formal model of non-linear monetary reaction functions relating to the output gap, which allows for size and sign output gap effects, i.e. different monetary policy reaction to small and large deviations from potential output as well as different respond to positive and negative values of the output gap, suggesting different reaction of monetary policy during periods of high and low aggregate demand relative to potential output. If do so, it would provide a clearer theoretical grounding for empirical work in this area.

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