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Essays on International Stock Markets and Real Exchange Rate Dynamics

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Abstract

This thesis aims to examine the long-run determinants of the real exchange rate, and to identify the sources of real exchange rate and relative stock price short-run fluctuations. In chapter 1, I incorporate the relative stock prices into the Dornbusch's Mundell-Fleming Real Exchange Rate Model in order to investigate the long-run relationship between the money, goods and stock markets. In chapter 2, I build on the work of Dornbusch (1976), Clarida and Gali (1994), Malliaropulos (1998) and Hoffmann and MacDonald (2000) in order to form the sticky-price equilibrium solution for identifying the source of real exchange rate fluctuation. In chapter 3, I empirically investigate whether the financial crises, the US monetary policy and the exchange rate regime switching of a country affect the real exchange rate co-moment. In addition to the cross-country real exchange rates correlation, the evolution of the equilibrium real exchange rates equicorrelation and temporary real exchange rates equicorrelation are also examined. In chapter 4, I present a model which builds on the stochastic rational expectations open macro model presented by Obstfeld (1985) and Clarida and Gali (1994) and incorporates Malliaropulos's (1998) theoretical relationship between the real exchange rate and the relative stock differential. The model provides both the short- and long-run flexible price solution for identifying the source of relative stock prices. In chapter 5, I attempt to investigate whether the exchange rate can predict future changes in the stock market return and in the economic performance of a country. I present a model that can be used for analysing whether the real exchange rate or the real exchange rate misalignment would contain an economically significant predictable component on forecasting the future stock price movement and the real output.

Introduction

Over the past two decades, financial markets all over the world have been perceived as highly integrated. Although central banks in various parts of the world began tightening regulations on capital movement following the onset of several financial crises in the last two decades, information technological developments in electronic payment and communication systems have substantially improved the mobility of capital across countries. The remarkable increase in international capital mobility has apparently amplified the importance of the flow of capital on financial markets. International capital funds not only play an important role for the stock price volatility, but also for the exchange rate fluctuation.

In practice, one may often perceive that the changes in the exchange rate affect the performance of the stock market, or, conversely, that the changes in the stock price influence the capital movement. Malliaropulos (1998) proposes a theoretical linkage between the real exchange rate and the relative stock differential and indicates that there is a negative relationship between the expected real stock differential and the transitory component of the real exchange rate. This real exchange rate and relative stock index (RERS) relationship is further supported by many empirical works (for example, Wong and Li, 2009). Figure A shows the relative stock price and the real exchange rate for the nine economies on a log scale. The measures of the real exchange rate and relative stock price are shown on the left axis and right axis, respectively. It is clear that the relative stock price and the real exchange rate are moving to opposite directions in most countries, showing the negative relationship between these two variables by visual inspection, especially during the financial crises periods (1997 Asian financial crisis, 2008 Global financial crisis and the 2011 European sovereign debt crisis).

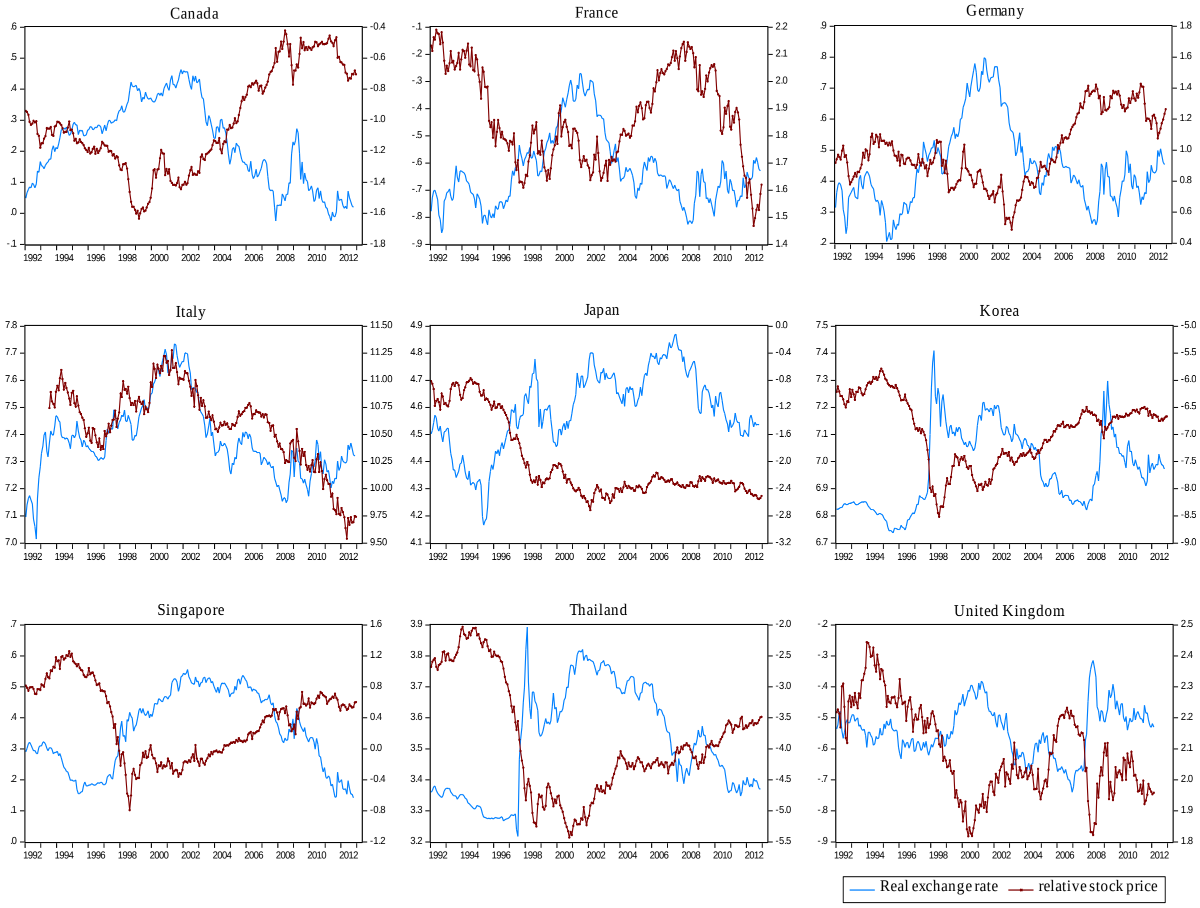

Figure A: Time Series Plots of the Relative Stock Differential and Real Exchange Rate

This thesis aims to examine the long-run determinants of the real exchange rate, and to identify the sources of real exchange rate and relative stock price short-run fluctuations. On the other hand, Blanchard (1981) indicates that if an asset has a higher expected level of future profitability, the international capital funds would move towards the assets, even across countries. The capital movement would initially reflect on the changes in the exchange rate. If so, it is also worth questioning whether the exchange rate can predict future changes in the stock market return and in the economic performance of a country.

Overview of Chapters

Brief overview of chapter 1

The objective of chapter 1 is to determine the long-run relationship between the financial, money and goods markets on the basis of four different variables, namely the real exchange rate, the real interest rate differential, the relative stock differential and the relative output differential for 10 economies from 1992 to 2012. We present a theoretical model which explains the interaction between the four variables. The model suggests that the temporary component of the relative stock differential can be used to explain the evolution of the real exchange rate.

By using the Johansen (1995) procedure, the hypothesis test of the homogeneity restriction and normalised exchange rate are conducted in order to test the relationships between the real exchange rate and the relative stock index (RERS), the real exchange rate and the real interest rate differential (RERI) and the real exchange rate and the real output differential (RERY). On the other hand, we find it of particular interest to test either the sticky-price or the flexible-price version of the exchange rate determination is more appropriate to explain the evolution of exchange rate in the modern economy. The results provide more favourable evidence for supporting the flexible-price approach of the RERI rather than the sticky-price interpretation of the RERI relationship.

In the analysis of real exchange rate determination, the empirical results are consistent with our theoretical model which suggests that relative stock differential is informative to explain the long-run real exchange rate determination. However, we do not find any empirical support for the idea that a single stationary relationship holds in the cointegration vector. This result is informative as it highlights that no particular relationship is sufficient in order to develop a long-run structural relationship between the variables in our system.

Brief overview of chapter 2

Although theoretically the uncovered interest rate parity (UIP) seems to contribute to the determination of the real exchange rate, empirical studies have focused only to a limited extent on investigating how the shocks due to the deviations from the UIP influence the economy. In addition, relatively little is known about the importance of investors' expectation in determining the fluctuation of the real exchange rate.

Following the conceptual framework of Dornbusch (1976), Clarida and Gali (1994), Malliaropulos (1998) and Hoffmann and MacDonald (2000), chapter 2 aims to investigate the sources of real exchange rate fluctuation by developing and estimating a four-equations open macro model, which links up the financial, money and goods markets of advanced and transition economies. According to Malliaropulos (1998), the error term of the relative stock prices equation contains the expected depreciation of the real exchange rate and the expected risk premium of domestic stock prices. We recover the disturbance of relative stock prices by estimating VAR in unrestricted form and term the structural innovations of relative stock price as 'expectation shocks'.

Our model demonstrates that the relative output differential, the real interest rate differential, the real exchange rate and the relative stock price differential are driven by four structural shocks – the supply shock, the monetary shock, the currency risk premium shock and the expectation shock in the short-run when price-stickiness is assumed. The empirical results show the currency risk premium shock plays a dominant role while the expectation shock has apparently outperformed the supply and monetary shocks in explaining the fluctuations of the real exchange rate in most of our sample countries, particularly during the crisis periods.

Brief overview of chapter 3

Understanding what drives the exchange rates co-movement and the evolution of the exchange rate correlations is relevant for various areas in finance, including portfolio diversification, risk management, hedging and pricing of financial derivatives and other structural products, and asset allocation decisions. In chapter 3, we aim to empirically investigate the real exchange rate co-moment among four Asian economies (Korea, Thailand, Malaysia and Indonesia) by using the dynamic equicorrelation (DECO) model.

It has been twenty years since the onset of the Asian financial crisis (AFC). The crisis that began in early July 1997 with the collapse of the fixed exchange rate system in Thailand led to considerable impacts on the Asian economies. Summarising the experience of our sample countries in the AFC, the exchange rate dynamics of these countries provide a good experiment on examining the manner in which the cross-country real exchange rate correlation responds to an official exchange rate regime switching. In addition, our sample period covers at least three other financial crises, the 2000/01 dot-com bubbles (DCB), the 2008/09 global financial crisis (GFC) and the 2011/12 European sovereign debt crisis (ESC), which allows us to observe the manner in which the cross-country real exchange rate (REC) correlation responds to each crisis.

In addition to the cross-country real exchange rates correlation, the evolution of the cross-country equilibrium real exchange rates correlation (BEC) and cross-country temporary real exchange rates correlation (TEC) are also examined in this chapter.

Furthermore, it is also instructive to investigate whether the US monetary variables related to the REC, BEC and TEC movement as market participants in the foreign exchange market and central banks of many countries focus on the US monetary policy changes.

Brief overview of chapter 4

In chapter 4, we present a theoretical model, which highlights the manner in which different types of macroeconomic (demand, supply and nominal) and expectation shocks influence the relative stock prices. Our model builds on the stochastic rational expectations open macro model presented by Obstfeld (1985) and Clarida and Gali (1994) and incorporates Malliaropulos's (1998) theoretical relationship between the real exchange rate and the relative stock differential, which not only exhibits the interaction between the relative stock prices and various macroeconomic shocks when price adjustments are flexible or sluggish, but also includes the results of Dornbusch's dynamic Mundell-Fleming model in the short-run when prices adjust sluggishly to various macroeconomic shocks as well as the longer-run properties that characterise macroeconomic equilibrium in the open economy when prices adjust fully to all shocks.

Similar to chapter 2, we recover the disturbance of relative stock prices by estimating VAR in unrestricted form and term the structural innovations of relative stock price as 'expectation shocks'. An expectation shock is formed when the investors are anticipating an increase in stock prices. We believe that this anticipation might be due to the mean-reverting properties of stock prices (see Fama & French, 1988; Poterba & Summers, 1988) or to other psychological factors or market sentiments, such that investors are willing to pay a higher risk premium in domestic stocks relative to the foreign stocks in return to the expected returns in the future. The model predicts that the expectation shocks generate a permanent impact on the relative stock prices and the demand shocks lead to both short- and long-run changes in the relative stock prices. However, the supply and nominal shock only affect relative stock prices on a temporary basis when prices are sluggish.

Brief overview of chapter 5

Many existing papers in the body of exchange rate literature documented that the changes in exchange rates contain sufficient information to forecast the future changes of their fundamentals (see for example: MacDonald & Taylor, 1993; Engel & West, 2005 and Hoffmann & MacDonald, 2009). In chapter 5, we try to investigate whether the exchange rate can predict future changes in the stock market return and in the economic performance of a country.

As in chapter 4, we argue that if the relative stock prices of a country fall below its permanent level, this would create expectations for a future increase in relative stock prices among international investors, as the temporary component of relative stock prices contains a mean-reverting property, so that it induces the capital inflow. The inflows of speculative capitals might be the shocks that temporarily knock the exchange rate away from its equilibrium level, and would initially reflect on a short-term exchange rate appreciation and push up the stock prices in consequence.

On the basis of a revision that incorporates relative stock price and rational expectation in Dornbusch's dynamic Mundell-Fleming model, we present a simple model that can be used for analysing the forward-looking ability of the real exchange rate. Our model builds on the work of Campbell and Shiller (1987) and MacDonald and

Taylor (1993) which can be used to investigate whether the deviation of the real exchange rate from its fundamental value would contain an economically significant predictable component on forecasting the future stock price movement and output. By introducing a particular assumption and transformation, the DMFS model can be converted into a forward-looking version of the real exchange rate (FLRE) or real exchange rate misalignment (FLM), which makes it possible to test whether the real exchange rate/real exchange rate misalignment is a reasonable approximation of the real output differential and the transitory component of relative stock prices.

Table of Contents

4 Identifying the Source of Relative Stock Prices Fluctuations

5 The Forward-looking Ability of the Real Exchange Rate and its Misalignment to Forecast the Economic Performance and the Transitory Components of Relative Stock Prices

List of Tables

List of Figures

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This thesis is dedicated to all the above and to those of you I have forgotten to mention but who never questioned I would do it.

Dedication

In loving memory of my grandfather and father

And

To my grandma, mother, wife and children

Declaration

I declare that, except where explicit reference is made to the contribution of others, that this Ph.D thesis is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Printed Name: Kai Tim Wong

Signature: ___________________

Chapter 1

Cointegration and the Long-run Real Exchange Rate Determinants

I Introduction

The relationship between the real interest rate differential and the real exchange rate is one of the central issues in macroeconomics. Theoretically, there are two schools of thought that are comprehensively used in order to explain the exchange rate determination. The first interpretation might be referred to as the sticky-price, or the so-called Keynesian approach. Under this interpretation, prices are sticky in terms of domestic currency. The higher interest rate in the domestic country relative to the foreign country will cause capital inflow and hence the domestic currency will appreciate instantaneously. A negative relationship could be found between the exchange rate and the nominal interest rate differential (Dornbusch, 1976).

The second interpretation is also known as the flexible-price approach. Frenkel (1976) and Bilson (1978), for example, argue for a positive relation between the nominal interest rate differentials and the exchange rate, and a change in the nominal interest rate reflects a change in the expected inflation differential or the expected rate of depreciation. Under the assumption that the nominal interest rate equals to the sum of the real interest rate and the expected inflation rate, an increase in the nominal interest rate in the domestic country relative to the foreign nominal interest rate will generate an increase in the expected inflation and thereby cause a decrease in the demand for the domestic currency. Consequently, the domestic currency will depreciate.

The main objective of this chapter is to determine the long-run relationship between the financial, money and goods markets on the basis of four different variables, namely the real exchange rate, the real interest rate differential, the relative stock differential and the relative output differential for 10 economies (Canada, France, Germany, Italy, Japan, Korea, Singapore, Thailand, the United Kingdom and the United States) for the period from 1992 to 2012. By using the Johansen (1995) procedure, co-integration tests are conducted in order to test the relationships between the real exchange rate and the relative stock index (RERS), the real exchange rate and the real interest rate differential (RERI) and the real exchange rate and the real output differential (RERY).

In fact, these three relationships can be described as a forward-looking market mechanism because investors' expectation plays an essential role for the exchange movement, especially for a country which depends heavily on foreign capital. For example, expectations about the future economic growth or the future movement of the stock market price of a country will result in capital flow to the country. Many existing papers (see, for example, Giovanimi & Jorion, 1987; Soenen & Hennigar, 1988 and Roll, 1992) indicate that there is a relationship between the stock price and the exchange rate. Following the conceptual frameworks of Clarida and Gali (1994), Malliaropulos (1998) and Hoffmann and MacDonald (2000), we present a theoretical model which explains the interaction between the real exchange rate, real interest rate differential, relative stock differential and relative output differential. The model suggests that the temporary component of the relative stock differential can be used to explain the evolution of the real exchange rate. The empirical results are consistent with our theoretical model which suggests that stock variable is informative to explain the long-run real exchange rate determination.

On the other hand, we find it of particular interest to test either the sticky-price or the flexible-price version of the exchange rate determination is more appropriate to explain the evolution of exchange rate in the modern economy. Our econometric modelling approach differs from the existing papers, in three important ways. Firstly, reference may be made to the conventional method of studying the RERI relationship in some earlier papers, which imposes an absolute version sticky-price approach of the RERI relationship on the cointegration vector, and strictly assumes that the real interest rate differential is negatively related to the real exchange rate. It is therefore considered that the theoretical interpretation is reasonable from an economic point of view but not always present in empirical works. In our hypothesis tests, in order to investigate whether our empirical works fit the theoretically anticipated sign, we do not impose any restrictions on the sign of the variables in the cointegration vector.

Secondly, many extant research studies estimated a basic variable set of the real exchange rate, real domestic interest rate and real foreign real interest rate. This simple model is likely to be insufficient for explaining the evolution of the real exchange rate. In addition to the exchange rate and interest rate variables, our system also includes financial (stock index) and output variables. This augmented model would provide a more reliable result for the real exchange rate determination.

Thirdly, the earlier papers in the exchange rate literature on exchange rate determination seems to be inconclusive regarding the choice between short- and long-term interest rates as a proxy of the interest rate variable. Many researchers, however, use the long-term interest rate in their studies. It seems that no existing body of literature has claimed that the real exchange rate – real interest rate differential relationship should hold with the short-term interest rate. We use the interest rate determined in the bonds (long-term) and in the money market (short-term) in our empirical study in order to investigate whether the change in the short-term and long-term interest rate would generate any impact on the real exchange rate.

The rest of this chapter is organised as follows. Section II reviews the literature related to the real exchange rate and the real interest rate differential and presents the Dornbusch's dynamic Mundell Fleming exchange rate model with relative stock differential. Section III provides the data description and the statistical results. Section IV reports the empirical results. The final section concludes the paper.

II Literature Review and Dornbusch's Mundell Fleming Exchange Rate Model with Relative Stock Prices

1.2a Literature Review

The uncovered interest rate parity has been universally used as a starting point in order to examine the link between the real interest rate and the real exchange rate in a large number of former studies. Consider the following uncovered interest parity relation:

$$E_t(e_{t+1} - e_t) = i_t - i_t^*, \tag{2.1}$$

where (E_t) is the conditional expectation operator, (e_t) is the log of the spot nominal exchange rate expressed in domestic currency per US dollar, (i_t) is the one period domestic nominal interest rate and an asterisk denotes a foreign magnitude. Equation (2.1) indicates that the expected nominal exchange rate adjustment is equal to the nominal interest rate differential between the domestic and foreign country. All variables below, with the exception of interest rates, are expressed in logarithm.

The domestic real exchange rate (q_t) is constructed from the nominal exchange rate, home and foreign consumer price index:

$$q_t = e_t + p_t^* - p_t, \tag{2.2}$$

where p_t^* (p_t) is the foreign (home) currency price of the goods produced abroad (domestically). The real interest rate (r_t), expressed in the Fisher equation presentation, is equal to the nominal interest rate minus the expected inflation rate:

$$r_t = i_t - (E_t p_{t+1} - p_t) . \tag{2.3}$$

The uncovered interest parity with the real exchange rate and real interest rate can then be expressed as:

$$E_t(q_{t+1} - q_t) = r_t - r_t^* \; . \tag{2.4}$$

Meese and Rogoff (1988) investigate the relationship between the real interest rate differentials and the real exchange rates in the United States, Germany, Japan, and the United Kingdom. The interpretation of the empirical tests in the paper depends on the real versions of the empirical models that have been proposed by Dornbusch (1976) and Frankel (1979) and by Hooper and Morton (1982). Though the empirical results indicate that the real interest rate differentials and real exchange rates have the theoretically anticipated sign, the relationship is not statistically significant and the real interest rate differentials do not display a good performance in forecasting the movement of the real exchange rates.

Edison and Pauls (1993) also apply the Engle-Granger two-step cointegration method in order to test for the cointegration of the real interest rates and real exchange rates of the G10 countries. The risk premium of the exchange rate is considered in the paper. The empirical results suggest that the series of real exchange rates and real interest rates constitute a non-stationary process and mostly fail to reject the null hypothesis of non-cointegration across exchange rates, different time periods and measures of expected inflation. Similar real interest rates - real exchange rates relationship analyses using the Engle-Granger two-step cointegration method can be found in many other research studies (see, for example, Throop (1994), Coughlin & Koedijk (1990)). The empirical works, however, have failed to identify a statistically significant relationship between the real interest rate differential and the real exchange rate.

In fact, the theoretical model with an uncovered interest parity and unit root analysis in modelling the long-run behaviour of the real exchange rate is similar in many research papers. Different results were found when a different econometric method was used. When the Johansen multivariate cointegration approach is used to investigate the relationship between the real exchange rate and the real interest rate differential, clear evidence of cointegration is found. For example, MacDonald (1997) develops a reduced form model of the real exchange rate, and applies the Johansen multivariate cointegration method in order to test for the cointegration of the real interest rates and real exchange rates of the G7 countries. The likelihood ratio and trace test statistics proposed by Johansen (1988, 1991) are used for testing the existence of cointegration amongst the endogenous variables contained in the system. The results provide evidence that there is a significant cointegrating vector between a variety of real exchange rates and real interest rates.

More recent studies apply other econometric methods in order to investigate the link between the real interest rate differential and the real exchange rate. Hoffmann and MacDonald (2009) use the bi-variate VAR model to study the relationship of the real interest rate differentials and the real exchange rate. They suggest that the current real interest differential contains sufficient information for forecasting the expected long-run change in the real exchange rate. Particularly, the past levels of the real interest rate differentials should be included in the forecasting equation for the changes in the real exchange rate. The results provide strong evidence pertaining to the relationship of the real interest rate differentials and the real exchange rate and the analysis suggested that the relationship of the real interest rate differentials and the real exchange rate could be interpreted more broadly as a significant and positive relationship between the expected real exchange rate changes and the real interest rate differential. Other papers, such as

Chortareas and Driver (2001), Sollis and Wohar (2006) and Bautista (2006), have provided evidence of the empirical link. What we can see is that the failure of discovering the link between the real exchange rate and the real interest rate in the literature may be estimation-specific.

In addition to the relationship of the real interest rate differentials and the real exchange rate, many papers attempt to address the relation between the foreign exchange market and the stock market. Franck and Young (1972) published the first paper that tries to study the linkage between stock prices and the exchange rate, but the empirical results suggest that there is no significant relationship between these two variables. After that, many earlier papers re-examined this link and different approaches were presented in order to explain the relation between the stock price movement and the exchange rate. However, there is no consensus with reference to the actual sign between stock prices and the exchange rate. For instance, the money demand-supply approach suggests a positive relation between stock prices and the exchange rate. This is because a positive domestic monetary shock would increase the real interest rate. The changes in the real interest rate differential would lead to capital inflow and real exchange rate appreciation. In an efficient market, a higher real interest rate will reduce the present value of the firm's future cash flow and hence the stock price declines. On the other hand, a higher inflation expectation would cause the exchange rate to depreciate due to a decline in its value in terms of foreign currencies, and lead investors to bear a higher risk premium so that stock prices decrease. The stock price-exchange rate relationship could, therefore, be negative.

The above interpretations give a general theoretical explanation about the relationship between stock prices and the exchange rate. Many other papers attempt to find empirical evidence to support the stock price-exchange rate relationship, but the results are mixed. Empirical works, such as Wu (2000), find a unidirectional short-run causal relationship from the exchange rate to the stock prices using Singapore data. Solnik (1987) tries to detect the impact of the exchange rate on stock prices and concludes that the change in the exchange rate does not generate any significant impact on stock prices. Bahmani-Oskooee and Sohrabian (1992) apply the Granger-causality test and cointegration method to examine the US exchange rate and stock index. The results indicate that a bidirectional relationship can only be found in the short run but there is no long run cointegration between the variables. Nieh and Lee (2001) also apply cointegration in order to study the relationship of the exchange rate and stock prices in the G-7countries and report that there is no significant long-run relationship between these two variables.

Malliaropulos (1998) proposes a theoretical correlation between the real exchange rate and the relative stock differential and indicates that there is a relationship between the expected real stock differential and the transitory component of the real exchange rate. This real exchange rate and relative stock index (RERS) relationship is further supported by the empirical findings of Wong and Li (2009), who examine the dynamic relationship of the relative stock differential and the real exchange rate of 11 economies in the two financial crises of 1997 and 2008.

Hoffmann and MacDonald (2000) seek to explain the relationship between the real exchange rate, the relative output differential and the real interest rate differentials by using the model presented in Clarida and Gali (1994). The model is usually referred to as the augmented Mundell–Fleming–Dornbusch model with sluggish price adjustment and forward looking expectations. Hoffmann and MacDonald use a tri-variate VAR model with the variables of relative output, real exchange rate and real interest rate differentials in order to examine the interaction of the G-7 real exchange rates. The results provide empirical evidence for one cointegrating relationship between the output real interest differentials and the real exchange rate (RERY) and this cointegrating relationship can be restricted between real interest differentials and the real exchange rate alone in some countries.

1.2b Dornbusch's Mundell-Fleming Real Exchange Rate Model with Relative Stock differential

We build on the works of Clarida and Gali (1994), Malliaropulos (1998) and Hoffmann and MacDonald (2000) in order to present a model, which can be considered as an extension of Dornbusch's dynamic Mundell-Fleming model by incorporating the relative stock prices. The model explains the interaction between the real exchange rate, real interest rate differential, relative stock differential and relative output differential.

Consider the following stochastic version of the two-country, rational expectations open macro model developed by Obstfeld (1985). This model is usually referred to as the augmented Mundell–Fleming–Dornbusch model with sluggish price adjustment and forward-looking expectations. All the variables below with the exception of the interest rates are in logarithm and represent home relative to foreign levels. The model consists of the following relations:

IS Equation:

$$y_t^d = \eta q_t - \sigma r_t, \qquad (2.5)$$

$$q_t \equiv e_t + p_t^* - p_t,$$

$$r_t = i_t - (E_t p_{t+1} - p_t).$$

Price Adjustment Equation:

$$p_t = (1-\theta)E_{t-1}\bar{p}_t + \theta\,\bar{p}_t, \qquad (2.6)$$

LM Equation:

$$m_t - p_t = y_t - \lambda i_t, \qquad (2.7)$$

Uncovered Interest Parity:

$$i_t = E_t \Delta e_{t+1} + u_t, \qquad (2.8)$$

Equation (2.5) provides the IS-relation in which the aggregate demand for home output relative to the foreign output (y_t^d) is positively related to the real exchange rate (q_t) and negatively related to the expected real interest rate (r_t). Equation (2.6) is a price adjustment equation where ($\bar{p}_t$) denotes the permanent component of the price level. Equation (2.7) is a standard LM equation, which defines the money market equilibrium condition, while equation (2.8) is a statement of the uncovered interest parity augmented by a catch-all variable (u_t) that captures any deviations from the condition.

The supply side of the model is specified by the following random walks:

$$y_t^s = y_{t-1}^s + z_t, \qquad (2.9)$$

$$m_t = m_{t-1} + v_t, \qquad (2.10)$$

where (y_t^s) is the relative supply of output, and (z_t) and (v_t) represent the supply and money shocks, respectively.

The steady state of this model can be represented by the following three equations:

$$\bar{y}_t = y_t^s, \qquad (2.11)$$

$$\bar{q}_t = \frac{1}{\eta}(\bar{y}_t + \sigma \bar{r}_t), \qquad (2.12)$$

$$\bar{p}_t = m_t - \bar{y}_t + \lambda \bar{i}_t . \tag{2.13}$$

Equation (2.12) gives the long-run solution of the real exchange rate. Deducting q_t on both sides of equation (2.12) and rearranging the equation, the temporary deviation of the real exchange rate is then given as:

$$(q_t - \bar{q}_t) = -\frac{1}{\eta}(\bar{y}_t + \sigma \bar{r}_t) + q_t. \tag{2.14}$$

In order to incorporate the impact of the stock market on the real exchange rate, the stock index variable is included in our model. The relative stock price between the domestic economy and the foreign economy expressed in the domestic currency (ρ_t) is given as:

$$\rho_t = s_t - s_t^* - e_t , \tag{2.15}$$

where s_t (s_t^*) is the domestic (foreign) stock price and e_t is the nominal exchange rate, expressing the domestic currency relative to the US dollar. Porterba and Summer (1988) and Malliaropulos (1998) indicate that the relative stock price contains both the permanent ρ_t^P and temporary ρ_t^T components, and is expressed as:

$$\rho_t \equiv \rho_t^P + \rho_t^T . \tag{2.16}$$

The permanent and temporary components are respectively specified as:

$$\rho_t^P = \rho_{t-1}^P + \eta_t^P , \tag{2.17}$$

and

$$\rho_t^T = \phi \rho_{t-1}^T + \eta_t^T , \tag{2.18}$$

Similarly, Huizinga (1987) and Baxter (1994) suggest that the real exchange rate contains both the permanent q_t^P and transitory q_t^T components:

$$q_t \equiv q_t^P + q_t^T \ . \tag{2.19}$$

The permanent component is specified as a random walk with drift and the error term ε_t^P is a serial uncorrelated innovation:

$$q_t^P = \mu + q_{t-1}^P + \varepsilon_t^P \ . \tag{2.20}$$

The transitory component is assumed to follow a stationary first-order autoregressive process with $0 < \theta < 1$, and ε_t^T is a serial uncorrelated innovation:

$$q_t^T = \theta q_{t-1}^T + \varepsilon_t^T \ . \tag{2.21}$$

Based on the aforementioned conceptual components of the real exchange rate and relative stock differentials, Malliaropulos (1998) constructs a theoretical linkage between the real exchange rate and the relative stock differential. The transitory component of the relative stock differential is expressed as a function of the real exchange rate and of the expected real stock differential $(E_t \Delta rs_t)$:

$$\rho_t^T = \rho_t - \rho_t^p = -\gamma - \frac{\theta - 1}{\phi - 1}(q_t - q_t^P) + \frac{1}{\phi - 1} E_t \Delta rs_t \ . \tag{2.22}$$

Since $0 < \theta$ and $\phi < 1$, equation (2.22) shows that the temporary component of the relative stock price is negatively related to the temporary deviations of the real exchange rate from the purchasing power parity (PPP). A temporary real appreciation of a domestic currency below its permanent component, $(q_t < q_t^P)$, would cause a temporary increase in the domestic stock price relative to the US higher than its permanent component, $(\rho_t > \rho_t^P)$. Malliaropulos (1998) explains this phenomenon in terms of the mean reverting behaviour of the real exchange rate. If the real exchange rate (q_t) contains a mean-reverting component, then a temporary appreciation of the real exchange rate below its trend level generates expectations of future depreciation. Domestic firms would, therefore, enjoy a comparative advantage in exports, which would consequently lead to a higher expected cash flow and increase in stock prices. Another reason, as suggested by Wong and Li (2009), would be the increase in demand for domestic currency. In an emerging market, a high and rapid economic growth leads to higher investor expectations in relation to the future profit earning of domestic firms. The massive capital inflow to the domestic stock market would result in an increase in demand for domestic currency. Therefore, a temporary appreciation of the domestic currency is associated with a temporary increase in domestic stock prices relative to the US.

Since the permanent component of the real exchange rate is always considered to be the measure of equilibrium (Huizinga, 1987; Cumby & Huizinga, 1990; Claida & Gali 1994), the temporary deviation of the real exchange rate (equation (2.14)) can be substituted into equation (2.22):

$$\rho_t^T = -\gamma - \frac{\theta - 1}{\phi - 1}[-\frac{1}{\eta}(\bar{y}_t + \sigma \bar{r}_t) + q_t] + \frac{1}{\phi - 1} E_t \Delta rs_t \tag{2.23}$$

After rearranging the equation, we obtain:

$$q_t = -\gamma + \frac{1}{\eta}(\bar{y}_t + \sigma \bar{r}_t) - \frac{\phi - 1}{\theta - 1}\rho_t^T + \frac{1}{\theta - 1} E_t \Delta rs_t \tag{2.24}$$

Equation (2.24) suggests that the real exchange rate is positively related to the long-run real interest rate and output, and is negatively related to the temporary component of the relative stock differential. Assuming that the permanent component of the relative stock differential and the real exchange rate is a driftless random walk process and the expected real stock differential $(E_t \Delta rs_t)$ is equal to zero, equation (2.24) can be described as a new version of the real exchange rate function, which not only links up the temporary component of the relative stock differential but also includes the permanent equilibrium components of the real exchange rate. In addition, one may note that the temporary component of the relative stock differential can be used to explain the temporary deviation of the real exchange rate.

III Data Description and Empirical Results

1.3a Data Description

In this chapter, we use monthly data for our estimation. Compared to quarterly data, the frequency of monthly data is relatively higher, which makes it possible to capture a close evolution of the data, especially the financial variables, which change rapidly over time. All the monthly data of the 10 economies are obtained from the International Financial Statistics (*IFS*) and DataStream, and are expressed in logarithms with the exception of interest rates. The sample covers the period from January 1991 to December 2012, with the exception of Canada and Italy, whose sample period started from January 1994 and July 1993, respectively.

The objective of this chapter is to examine the validity of the relation of the real exchange rate and the relative stock index (RERS), the real exchange rate and the real interest rate differential (RERI) and the real exchange rate and the real output differential (RERY) of 9 economies (Canada, the United Kingdom, Germany, France, Italy, Japan, Korea, Singapore and Thailand). The US is considered as a 'foreign' country.

For each economy, the estimation is based on a 7-variable system:

$$z_t = (p_t, p_t^* q_t, i_t, i_t^* y_t, y_t^*)$$

(p_t) and (p_t^*) represent the monthly closing price of the domestic stock index and the foreign stock index (US) minus domestic nominal exchange rate. The real exchange rate is calculated by equation: $q_t = e_t + p_t^* - p_t$, which adjusts the end-of-period nominal domestic exchange[1] rate against the US dollar by the home and the US CPI.

Figure 1.1 shows the stock index for the nine economies, together with the real exchange rate on a log scale. The measures of the stock price index and the real exchange rate are shown on the left axis and right axis, respectively. One observation is that although the short-term movement of these two series exhibits a deviation, their overall movement seems to be indicative of a correlation. The stock price index and the real exchange rate moved in the same directions in Canada, the United Kingdom, Germany, France and Italy until 2005, while a negative relation can be seen in the Asian countries, especially over the course of the Asian financial crisis in 1997. Furthermore, a clear negative relationship between the stock price index and the real exchange rate can also be found in the 2008 financial crisis among our sample economies.

The domestic (foreign) real interest rate i_t (i_t^*) is calculated by the nominal interest rate minus the expected inflation rate: $i_t = r_t - (E_t p_{t+1} - p_t)$. Similar to Hoffmann and MacDonald (2009), we constructed an estimate of the inflation expectation over our sample period. This was achieved by implementing the moving window procedure starting with a univariate autoregressive estimation of inflation with 4 lags[2], using the past five years data (60 observations) and in-sample period data to predict the one-step-ahead (month) inflation rate, and then shifting the in-sample estimation period forward by one period for estimation and prediction purposes. This process is repeated *N* times until the last observation of the sample period had been finalised.

[1] The nominal effective exchange rate index is used for the France, Italy and Germany.

[2] The number of lags is based on AIC criteria.

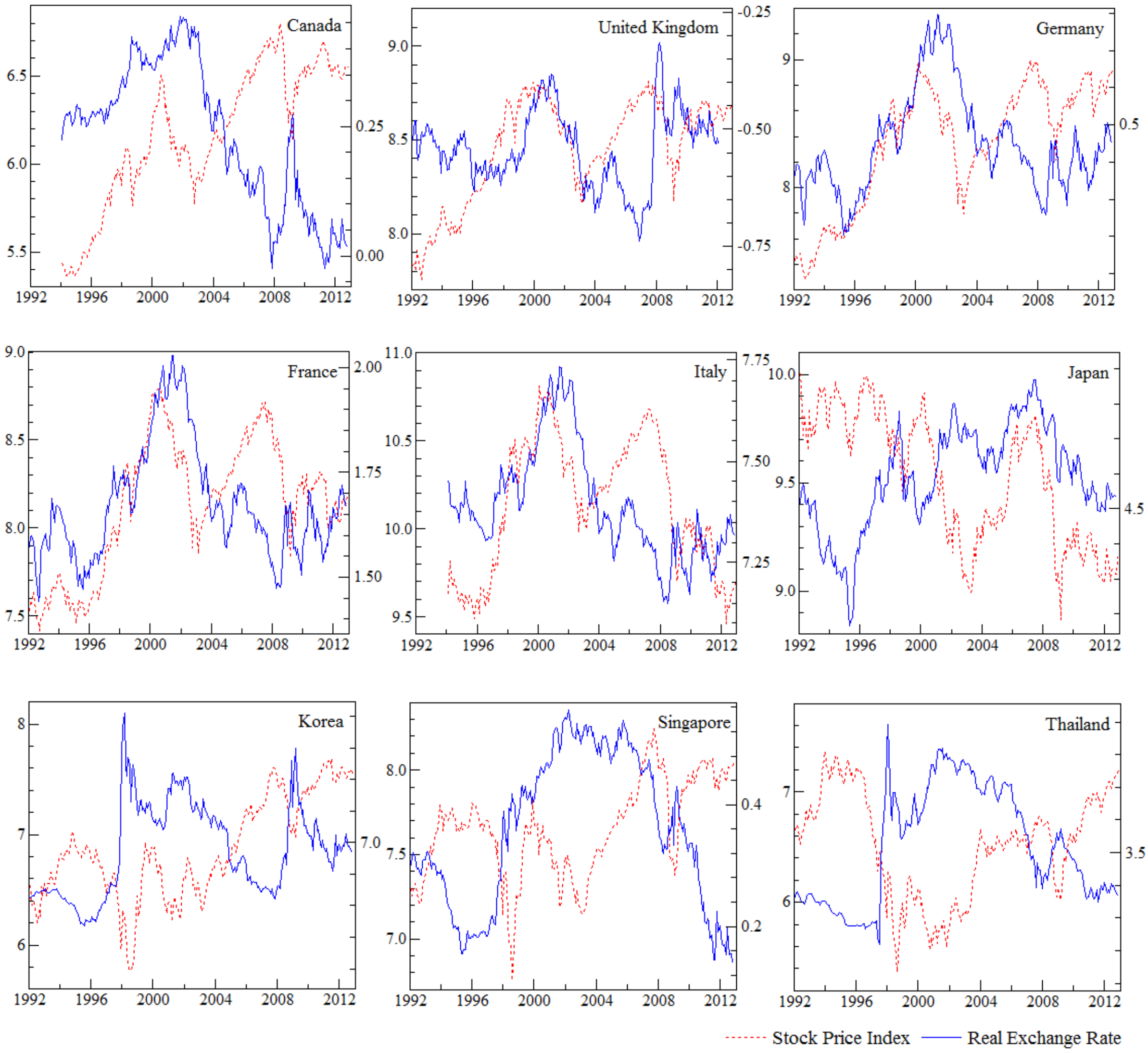

Figure 1.1: Time Series Plots of Stock Price Index and Real Exchange Rate

In order to determine the relationship hold at different stages of maturity, the money market rate, treasury bills rate and government bonds rate are considered as proxies of the nominal interest rate in this chapter. Figure 1.2 illustrates the real interest rates of the 9 economies in a natural scale. Although the real interest rates tend to move in the same direction in the long run, deviations can also be noted in the sample period, and the money market rates seem to be more volatile as opposed to the other two interest rates in most countries.

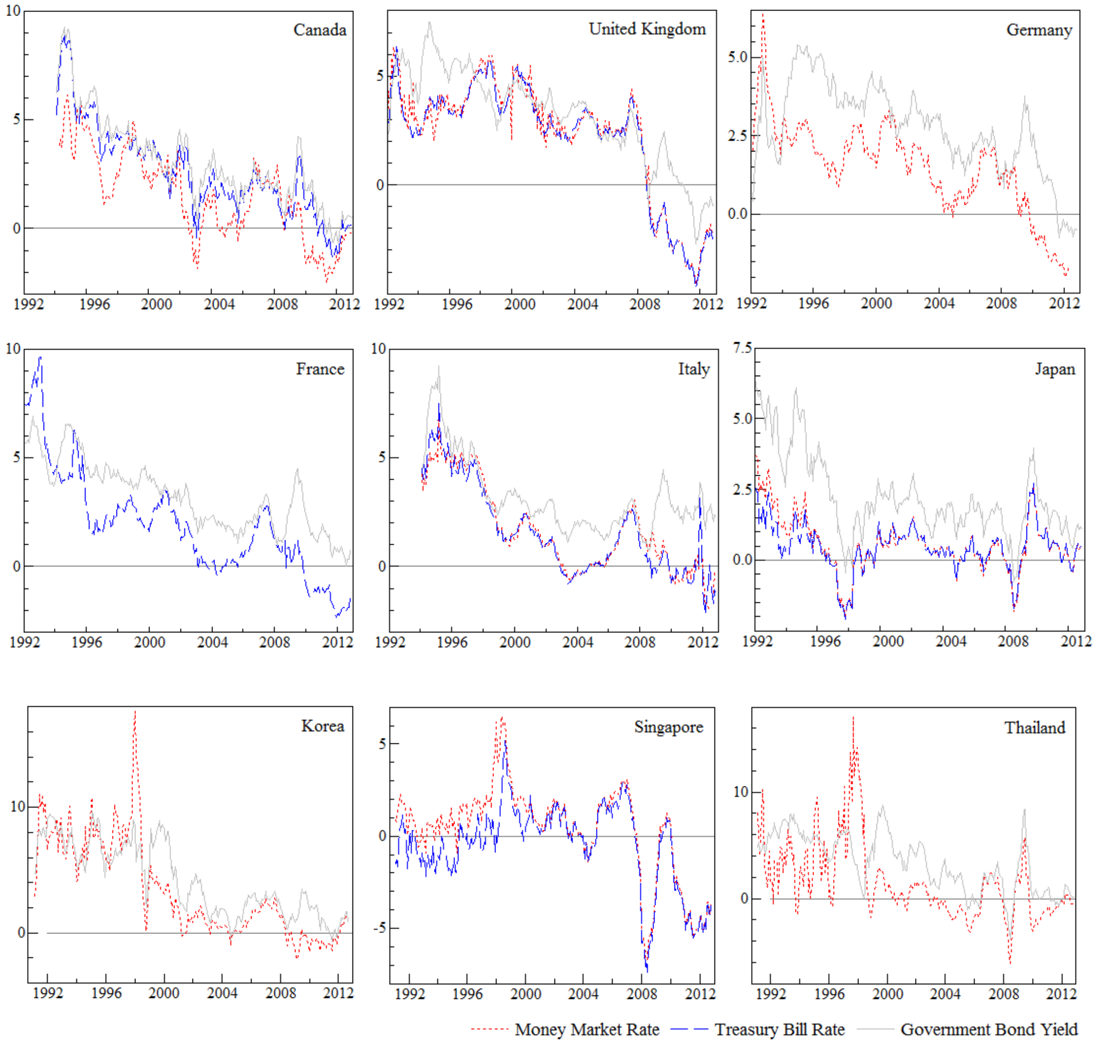

Figure 1.2: Real Interest Rate Comparison

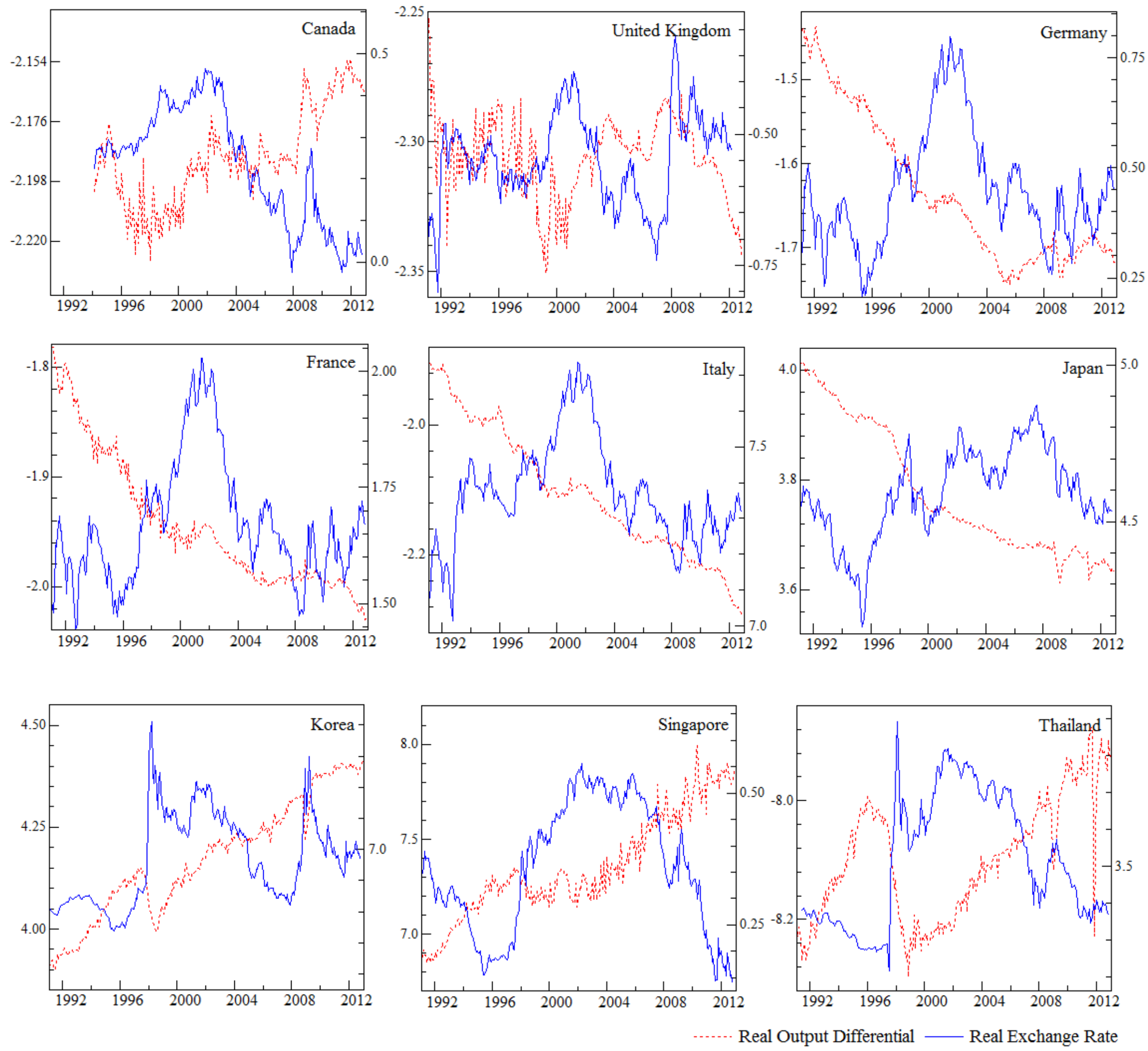

Figure 1.3: Time Series Plots of the Real Output Differential and Real Exchange Rate

y_t and (y_t^*) represent the domestic GDP and (foreign) GDP, respectively. The foreign GDP is converted into home currency. The monthly GDP (y_t) is constructed from the quarterly real GDP by the state-space approach with the monthly industrial production data serving as the related interpolator variable, assuming that the interpolation can be described as an AR(1) process. The relative output differential, as shown in Figure 1.3, is measured by the domestic GDP minus the foreign GDP.

1.3b The ADF test

The statistic results of the Augmented Dickey-Fuller (ADF) test for the presence of unit roots are reported in Table 1.1. In each case, we follow Perron's (1988) testing procedure in order to include additional deterministic components (intercept and trend) in the regression model used for testing the presence of unit roots in each series. The inclusion of deterministic components in the data generating process would result in an increased probability that the null hypothesis of the unit roots will be accepted when in fact the true data generating process is stationary. Referring back to Table 1.1, the ADF results show that the variables in level are non-stationary in all countries except for the treasury bills rate of Japan and the money market rate of Singapore and Thailand, which cannot reject the null of unit roots. In addition, all series become stationary after first differencing. It can be confirmed that all series are I (1), while the treasury bills rate of Japan and the money market rate of Singapore and Thailand are I (0).

1.3c Trace test of the cointegration rank

After determining the order of integration of the variables, the Johansen cointegration procedure is applied to a conventional unrestricted vector autoregressive model in order to test for the cointegration relationship among the seven variables in our system[3]. The Akaike Information Criterion (AIC) statistic is applied to determine the appropriate lag length of the VAR. The results suggest that the appropriate lag length is 2 for Thailand, 3 for Canada, the United Kingdom, Germany, France, Italy and Japan, and 4 for Korea and Singapore.

[3] Due to the availability of the data, for clarity purposes, Appendix A shows the variables used in each of the estimations.

A centralised seasonal dummy and three additional dummies (D-97, D-08 and D-Euro) are considered to offset the outlier problem of the data. The first dummy D-97 was included in the estimation of Asian countries (Japan, Korea, Singapore and Thailand) by taking on the value of 1 from May 1997 to December 1997 to account for the Asian financial crisis that started in mid-1997 and severely damaged the economy of Asian countries. D-08 is introduced to cover the 2008 financial crisis from September 2008 to March 2009 in all countries. Finally, the D-Euro is included in the estimation of European countries (United Kingdom, Germany, France and Italy) in order to capture the impact of the European Sovereign Debt crisis from August 2011 to March 2012. At that time, the yields of the long-term government bonds of some countries in the Eurozone rose above 6%, which indicates that the financial markets are highly concerned about the credit-worthiness of the country.

The next step in the Johansen cointegration procedure is to determine the number of cointegrating relationships. The results of the trace test for the cointegration rank are given in Table 1.2. It is apparent that the number of cointegration relationships is different between countries. For Canada, we reject the null of 1 cointegration in the money market rate, treasury bills rate and government bonds rate, respectively. For the case of the UK, Japan and Korea, only 1 cointegration relationship can be found, respectively, among models with different interest rates. For Germany, France and Thailand, the results suggest that 2 cointegration relationships can be found respectively among the interest rates. For Italy, we cannot reject the null at 10% significant level that no cointegration relationship is to be observed in the money market rate, but 1 cointegration relationship can be found in the treasury bills rate and the government bonds rate.

Table 1.1: ADF Test Results

	Canada	UK	Germany	France	Italy	Japan	Korea	Singapore	Thailand	US
p_t	1.28	1.10	1.17	0.44	-0.16	-1.06	0.57	0.52	0.16	-
$\triangle p_t$	-4.12**	-4.03**	-3.38**	-3.76**	-3.53**	-4.31**	-4.56**	-5.26**	-4.53**	-
p_t^*	1.29	1.10	1.32	1.34	-1.74	1.27	2.40	1.52	0.82	-
$\triangle p_t^*$	-3.96**	-3.82**	-2.47**	-4.68**	-4.44**	-3.80**	-4.53**	-4.32**	-4.79**	-
q_t	-1.06	-0.67	-0.35	-0.06	-0.25	-0.04	0.20	-0.78	-0.10	-
$\triangle q_t$	-4.39**	-5.56**	-2.90**	-4.38**	-4.13**	-3.96**	-4.76**	-3.99**	-5.14**	-
y_t	3.01**	2.89**	2.89**	2.29**	1.04	1.33	3.66**	3.47**	2.70**	-
$\triangle y_t$	-2.96**	-2.74**	-2.58**	-2.87**	-3.92**	-4.79**	-3.94**	-4.19**	-3.78**	-
y_t^*	2.00**	1.43	1.21	1.09	1.14	1.86*	0.12	2.29**	0.50	-
$\triangle y_t^*$	-4.02**	-5.21**	-2.91**	-4.57**	-4.26**	-3.60**	-4.74**	-4.30**	-5.11**	-
i_t^M	(-2.23) **	-1.10	-1.54	-	-1.43	[-3.37]*	-1.70*	[-3.87]**	[-3.99]**	-2.17**
$\triangle i_t^M$	-3.71**	-5.17**	-3.65**	-	-3.46**	-4.24**	-7.13	-4.39	-5.28	-4.86**
i_t^T	(-2.27) **	-1.10	-	-3.09**	-1.63	[-3.95]**	-	[-3.23]*	-	(-2.22)
$\triangle i_t^T$	-4.36**	-4.42**	-	-4.94**	-4.10**	-4.57	-	-4.59	-	-4.79**
i_t^G	(-2.26) **	-0.89	-0.56	-1.52	-1.49	[-3.07]	-1.75*	-	(-2.72)*	(-2.75)*
$\triangle i_t^G$	-4.43**	-4.77**	-3.44**	-4.81**	-5.92**	-4.97**	-5.58**	-	-5.66**	-4.91**

Notes: The figures in parentheses ( ) represent the ADF test results with intercept but no time trend; the figures in parentheses [ ] represent the ADF test results with intercept and time trend. ** and * represent the statistical significance at 5% and 10%, respectively.

Table 1.2: Trace Test of the Cointegration Rank

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
				Money market rate					
H_0: r									
0	147.61**	131.76*	153.26**	-	114.64	141.9**	147.73**	182.01**	161.65**
1	100.83*	81.52	98.50*	-	69.08	85.39	83.11	125.73**	96.56*
2	59.76	45.10	58.20	-	33.56	56.08	46.94	75.97*	60.25
3	32.62	24.11	30.21		17.25	31.84	29.96	40.49	35.62
				Treasury bill rate					
H_0: r									
0	172.53**	133.09*	142.2**	158.52**	125.61*	148.4**	-	174.14**	-
1	116.2**	81.37	98.51*	105.95**	75.22	89.73	-	116.63**	-
2	61.05	47.54	63.62	66.58	39.97	59.36	-	71.59*	-
3	33.53	25.66	35.08	36.14	24.80	29.99	-	41.99	-
				Government bonds rate					
H_0: r									
0	166.53**	127.54*	146.64**	171.81**	125.59*	144.41**	138.73**	-	147.15**
1	113.17**	88.54	98.91*	112.3**	87.71	93.33	78.39	-	104.45**
2	74.974*	57.59	67.28	68.24	57.79	57.52	50.47	-	68.33
3	42.10	31.25	40.62	38.06	34.27	30.30	29.95	-	40.05

Notes: The figures in parentheses represent the standard errors of the coefficients; ** and * represent the statistical significance at 5% and 10%, respectively.

1.3d Test for variable exclusion

We perform a zero-row test on β in order to identify whether the variables enter into the long-run equation. Since the foreign economic variable may not be useful in explaining the domestic phenomenon, it may be commonly considered as a trivial variable in the system. However, the main purpose of this chapter is to identify the structural relationship between the real exchange rate and the relative stock index differential, the real exchange rate and the real interest rate differential and the real exchange rate and the relative output differential. We therefore impose a joint exclusion restriction on the pair of variables by setting $\beta_1 = \beta_2 = 0$ for stock indices, $\beta_4 = \beta_5 = 0$ for interest rates and $\beta_6 = \beta_7 = 0$ for outputs, respectively. Table 1.3 summarises the results of these hypotheses.

It is interesting to note that the stock index variables (Panel A) should not be excluded in the estimation with the money market rate in all countries except Korea, while in the estimation with the government bonds rate, the null is only rejected at a 5% level of significance in Germany and Japan. This may be probably due to the fact that the long term interest rate is less related to the stock index. For the interest rate variables shown in Panel B, the null is rejected at a 5% level of significance in all cases except for the system with the government bond rate in the United Kingdom. For the output variables, only the estimation with the government bond rate in the United Kingdom and the estimation with the treasury bills rate and the government bonds rate in Italy accepted the null that the output variables should be excluded in the system. These results imply that the stock index, interest rates and output variables are all important to identify the long-run cointegration vector.

Table 1.3: Hypothesis Tests for Variable Exclusion

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
				Panel A: $\beta_1 = \beta_2 = 0$					
Eq.- i(m)	19.74	12.73	22.03	-	-	21.82	0.75	33.88	13.67
	(0.001)**	(0.002)**	(0.000)**	-	-	(0.000)**	(0.69)	(0.000)**	(0.008)**
Eq.- i(t)	15.01	16.44	-	18.53	4.66	1.36	-	37.60	-
	(0.005)**	(0.000)**	-	(0.001)**	(0.10)	(0.51)	-	(0.000)**	-
Eq.- i(g)	9.83	5.82	18.29	2.65	5.72	14.32	6.45	-	9.12
	(0.043)*	(0.05)	(0.001)**	(0.62)	(0.06)	(0.001)**	(0.04)*	-	(0.06)
				Panel B: $\beta_4 = \beta_5 = 0$					
Eq.- i(m)	22.37	14.55	29.58	-	-	16.30	40.09	38.05	32.14
	(0.000)**	(0.001)**	(0.000)**	-	-	(0.000)**	(0.000)**	(0.000)**	(0.000)**
Eq.- i(t)	31.25	17.07	-	24.62	22.12	82.16	-	51.11	-
	(0.000)**	(0.000)**	-	(0.000)**	(0.000)**	(0.000)**	-	(0.000)**	-
Eq.- i(g)	19.42	5.93	13.88	36.18	9.83	11.62	11.67	-	31.33
	(0.001)**	(0.05)	(0.008)**	(0.000)**	(0.007)**	(0.003)**	(0.003)**	-	(0.000)**
				Panel C: $\beta_6 = \beta_7 = 0$					
Eq.- i(m)	24.79	7.39	22.50	-	-	25.91	10.19	35.96	17.52
	(0.000)**	(0.025)*	(0.000)**	-	-	(0.000)**	(0.006)**	(0.000)**	(0.002)**
Eq.- i(t)	20.87	9.04	-	35.22	5.42	6.68	-	42.07	-
	(0.000)**	(0.011)*	-	(0.000)**	(0.07)	(0.0355)*	-	(0.000)**	-
Eq.- i(g)	21.79	4.36	23.96	10.73	3.11	23.38	7.07	-	23.67
	(0.000)**	(0.11)	(0.000)**	(0.0297)*	(0.21)	(0.000)**	(0.029)*	-	(0.000)**

Notes: *Eq. - i(m), Eq. - i(t) and Eq. - i(g)* represent the cointegration vector generated by the estimation with the money market rate, treasury bills rate and government bonds rate, respectively. The figures in parentheses represent the standard errors; ** and * represent the statistical significance at 5% and 10%, respectively.

IV Empirical Results

1.4a Test for theoretical relationships with the 'known' beta

On the basis of the results in Tables 1.2 and 1.3, we impose restrictions motivated by economic arguments on the cointegration vectors in order to test the validity of the relationship of the real exchange rate and the relative stock index (RERS), the real exchange rate and the real interest rate differential (RERI) and the real exchange rate and the real output differential (RERY) of 9 economies.

Under our 7-variable system $z_t = (p_t, p_t^* q_t, i_t, i_t^* y_t, y_t^*)$, three economic hypotheses are relevant for our empirical study. Assuming the cointegration vector is normalised by setting $q_t = \beta_3 = 1$ and leaving the second cointegration vectors unrestricted for the system with r = 2, the first one is the hypothesis of the RERS, which was formulated as: the variables (p_t), (p_t^*) and (q_t) enter into the cointegration vector, that is:

$$H_1(1): \beta' = [1 \quad -1 \quad 1 \quad * \quad * \quad * \quad *] \tag{3.1}$$

A second test solely conducted for the sticky-price approach of the RERI relationship holds in the cointegration vector by setting the hypothesis of: the variables (i_t), (i_t^*) and (q_t) enter into the cointegration vector. This can be formulated as:

$$H_1(2): \beta' = [* \quad * \quad 1 \quad 1 \quad -1 \quad * \quad *] \tag{3.2}$$

It is important to emphasise that this hypothesis is the conventional method of studying the RERI relationship. It imposes an absolute version sticky-price approach of the RERI relationship, which strictly assumed that the real interest rate differential is negatively related to the real exchange rate by setting $\beta_4 = 1$ and $\beta_5 = -\beta_4$.

The third test is only for the strong version of the RERY relationship entering the cointegration vector: the variables (y_t), (y_t^*) and (q_t) enter into the cointegration vector:

$$H_1(3): \beta' = [* \quad * \quad 1 \quad * \quad * \quad -1 \quad 1] \tag{3.3}$$

The LR statistic results for the three aforementioned hypotheses are presented in Table 1.4. In panel A, the null hypothesis of the RERS relationship is generally accepted in Canada, Germany, Korea, Singapore and Thailand, suggesting that the RERS relationship holds in the cointegration vector. For the hypothesis test on the RERI relationship, two findings can be noted. After a quick glance in Panel B, the RERI relationship is substantially confirmed in all countries except Japan, while the null hypothesis is rejected at a 10% level of significance in the case of Korea with the money market rate. This provides support for the sticky-price approach of the RERI relationship. The second finding is that the RERI relationship is not only confirmed in the long-term interest rates (Treasury bills rate and Government bonds rate), but that it rather also exists in the short-term interest rate (Money market rate), thus providing empirical support for the long-run relationship between the real exchange rate and the short-term real interest rate differential. In Panel C, no RERY relationship can be found in Japan and Singapore. For the UK, the RERY relationship cannot be definitely confirmed as the null is rejected at a 10% level of significance. For the rest of the countries, there is support for the idea that the cointegration vector contains the RERY relationship.

Table 1.4: Hypothesis Tests for Theoretical Relationships with 'Known' Beta

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
			Panel A	$H_1(1)$: (1 -1 1 * * * *)					
Eq.- i(m)	0.938	9.463	7.870	-	-	20.611	-	0.099	0.291
	(0.333)	(0.0088)**	(0.0050)**	-	-	(0.0000)**	-	(0.753)	(0.590)
Eq.- i(t)	0.240	14.048	-	15.758	-	13.318	-	0.477	-
	(0.624)	(0.0009)**	-	(0.0001)**	-	(0.0013)**	-	(0.490)	-
Eq.- i(g)	0.440	-	1.437	-	-	9.889	2.097	-	-
	(0.507)	-	(0.231)	-	-	(0.0071)**	(0.351)	-	-
			Panel B	$H_1(2)$: (* * 1 1 -1 * *)					
Eq.- i(m)	0.249	3.332	2.987	-	-	15.080	6.173	0.899	0.244
	(0.618)	(0.189)	(0.084)	-	-	(0.0005)**	(0.0457)*	(0.343)	(0.621)
Eq.- i(t)	0.166	5.523	-	11.733	3.752	9.860	-	3.309	-
	(0.683)	(0.063)	-	(0.0006)**	(0.153)	(0.0072)**	-	(0.069)	-
Eq.- i(g)	0.304	-	0.525	3.244	13.556	19.467	11.887	-	0.244
	(0.582)	-	(0.469)	(0.072)	(0.0011)**	(0.0001)**	(0.0026)**	-	(0.621)
			Panel B	$H_1(3)$: (* * 1 * * -1 1)					
Eq.- i(m)	11.535	6.128	1.025	-	-	26.035	5.977	14.492	6.289
	(0.0007)**	(0.0467)*	(0.311)	-	-	(0.0000)**	(0.050)	0.0001**	(0.0121)*
Eq.- i(t)	13.727	7.207	-	2.960	-	26.192	-	11.352	-
	(0.0002)**	(0.0272)*	-	(0.085)	-	(0.0000)**	-	0.0008**	-
Eq.- i(g)	3.147	-	0.210	0.314	-	16.396	8.986	-	0.260
	(0.076)	-	(0.647)	(0.576)	-	(0.0003)**	(0.0112)*	-	(0.610)

Notes: *Eq. - i(m), Eq. - i(t) and Eq. - i(g)* represent the cointegration vector generated by the estimation with the money market rate, treasury bills rate and government bonds rate, respectively. The figures in parentheses represent the standard errors; ** and * represent the statistical significance at 5% and 10%, respectively.

Other tests[4] such as: whether the RERS, RERI and RERY relationships hold in the long run without interaction for the country with r=2 and whether the RERS, RERI and RERY relationship is stationary by itself are also conducted in our empirical work. The results suggest that the RERS, RERI and RERY relationship holds in the cointegration vectors separately. However, there is no support for the idea that the RERS, RERI and RERY relationship exists on its own. These observations imply that a simple model cannot provide sufficient information in explaining the long-run changes of the real exchange rate.

1.4b Testing for the theoretical relationships with 'unknown' beta

We have already reported the results for the hypothesis tests on the relationship between the RERS, RERI and RERY, respectively. The results provide empirical evidence for the RERS, RERI and RERY relationships. Note that the restrictions imposed on the cointegration vector in the last section are motivated by the economic arguments that: i) the relative stock index is negatively related to the real exchange rate; ii) the real interest rate differential is negatively related to the real exchange rate and iii) the relative output differential is positively related to the real exchange rate.

When considering that these theoretical interpretations are reasonable from an economic point of view but not always present in empirical works (especially the RERI relationship), further testing is required in order to make our empirical works more precise. In the remainder of this chapter, in order to investigate whether our empirical works fit the theoretically anticipated sign, we do not impose restrictions on the sign of

[4] The results of these hypothesis tests are not included in this chapter. We can provide them upon request.

the variables in the cointegration vector. Only a homogeneity constraint is imposed on the first cointegration vector. Leaving the second vector unrestricted for the system with r = 2, the restrictions on the first cointegration vector comprise a homogeneity constraint $\beta_{i+1} = -\beta_i$ for i = 1,…, 6 and a normalised restriction $\beta_3 = 1$. This setting would allow us to identify the actual sign of the estimated coefficients and its significance. The hypothesis can be respectively written as:

Relative Stock index – Real Exchange rate relation (RERS):

$$H_2(1): \beta' = [\beta_1 \quad -\beta_1 \quad 1 \quad * \quad * \quad * \quad *] \tag{3.4}$$

Real Interest rate differential – Real Exchange rate relation (RERI):

$$H_2(2): \beta' = [* \quad * \quad 1 \quad \beta_4 \quad -\beta_4 \quad * \quad *] \tag{3.5}$$

Relative Output differential – Real Exchange rate relation (RERY):

$$H_2(3): \beta' = [* \quad * \quad 1 \quad * \quad * \quad \beta_6 \quad -\beta_6]\,[5] \tag{3.6}$$

As illustrated in Table 1.5, the results in Panel A indicate that the LR statistic results are all significant in the UK and Singapore, indicating that the relative stock index differential cannot be confirmed in these two countries. In panel B, the LR test results for the real interest rate differential are statistically insignificant in Canada, France, Italy, Japan, Korea and Singapore. In Germany and Thailand, we can only confirm the real interest rate differential at a 10% level of significance. In Panel C, the results basically confirm the existence of a relative output differential in all countries

[5] One may wonder why $-\beta_6$ and β_6 are not placed at the 6 and 7 variables. Different to the conventional method, we have not imposed an actual value in the beta. Thus, the hypothesis test is the only test for the homogeneity restriction. It is therefore necessary to check the value of the beta if we want to know whether RERY is positively related or not.

except Japan in which there is only the case of the government bonds rate being significant at a 10% level of significance.

Table 1.5: Hypothesis Tests for Theoretical Relationships with 'Unknown' Beta

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
			Panel A	$H_2(1)$: (β_1 $-\beta_1$ 1 * * * *)					
Eq.- i(m)	7.789	13.549	0.182	-	-	3.192	-	11.699	3.754
	(0.0053)**	(0.000)**	(0.670)	-	-	(0.074)	-	(0.001)**	(0.053)
Eq.- i(t)	7.766	19.771	-	0.062	-	-	-	12.991	-
	(0.0053)**	(0.000)**	-	(0.804)	-	-	-	(0.000)**	-
Eq.- i(g)	2.396	-	0.621	-	-	0.000	6.316	-	-
	(0.122)	-	(0.431)	-	-	(0.994)	(0.0120)*	-	-
			Panel B	$H_2(2)$: (* * 1 β_4 $-\beta_4$ * *)					
Eq.- i(m)	3.866	10.759	4.990	-	-	0.187	3.189	4.549	10.519
	(0.0493)*	(0.001)**	(0.0255)*	-	-	0 (0.666)	(0.074)	(0.033)*	(0.0012)**
Eq.- i(t)	0.092	16.001	-	3.219	0.363	0.252	-	3.497	-
	(0.762)	(0.000)**	-	(0.073)	(0.547)	7 (0.6153)	-	(0.062)	-
Eq.- i(g)	2.853	-	16.579	1.490	13.507	1.348	0.128	-	5.644
	(0.091)	-	(0.000)**	(0.222)	(0.000)**	(0.246)	(0.721)	-	(0.0175)*
			Panel C	$H_2(3)$: (* * 1 * * β_6 $-\beta_6$)					
Eq.- i(m)	4.564	0.550	3.889	-	-	9.726	3.029	1.682	4.839
	(0.033)*	(0.458)	(0.049)*	-	-	(0.002)**	(0.082)	(0.195)	(0.0278)*
Eq.- i(t)	1.994	0.707	-	10.391	-	8.023	-	3.081	-
	(0.158)	(0.400)	-	(0.0013)**	-	(0.0046)**	-	(0.079)	-
Eq.- i(g)	0.084	-	0.254	2.934	-	4.783	0.005	-	5.781
	(0.772)	-	(0.614)	(0.087)	-	(0.029)*	(0.945)	-	(0.0162)*

Notes: *Eq. - i(m), Eq. - i(t) and Eq. - i(g)* represent the cointegration vector generated by the estimation with the money market rate, treasury bills rate and government bonds rate, respectively. The figures in parentheses represent the standard errors; ** and * represent the statistical significance at 5% and 10%, respectively.

Following the hypothesis test results presented in Table 1.5, the corresponding estimated β is shown in Table 1.6[6]. Nevertheless, reference ought to be made to the fact that these estimated coefficients are obtained under the hypothesis of homogeneity restriction and normalised exchange rate. Table 1.6 gives the estimated coefficient of the stock index, interest rate and output variables, respectively. The test results of $H_2(i)$ for i = 1, 2, 3 illustrate the fact that there is no particular sign for the relative stock index differential, real interest rate differential, and relative output differential.

The Panel A in Table 1.6 provides the results of hypothesis $H_2(1)$. All estimated coefficients are statistically significant in France, Japan and Korea, suggesting that there is a relationship between the real exchange rate and stock index differential. Note also that the coefficients in Asian countries are all negative, while the coefficients in European countries are positive, which is inconsistent with the theoretical expected sign of the coefficient. The theoretical RERS relationship only exists in Asian countries. Any changes in capital movement would generate a significant impact on the performance of the stock market.

The estimated coefficients of the hypothesis $H_2(2)$ are shown in Panel B. All estimates are statistically significant. There are two findings here. The first finding is that the RERI relationship can be found in all interest rates, suggesting that the long term interest rate is not the only variable to form a linkage with the real exchange rate. Secondly, it is apparent that most of the signs of the estimated β are positive, which is not consistent with the expected sign of the sticky-price approach of the RERI relationship. These results seem to provide more favourable evidence for supporting the flexible-price approach of RERI rather than the sticky-price interpretation of the RERI

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[6] We only provide the coefficient which has not been rejected in Table 1.5.

relationship.

In Panel C, all output coefficients are significant with the exception of France. It is clear that the relative output differential is positively related to the real exchange rate except Singapore. Similar results can be found in an empirical study (Hoffmann & MacDonald, 2000) of the output, interest rate differentials and the real exchange rate for the G7 countries.

Table 1.6: The Estimated β of the Theoretical Relationships

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
			Panel A	$H_2(1)$: (β_1 $-\beta_1$ 1 * * * *)					
Eq.- i(m)	-	-	-0.167	-	-	0.163	-	-	0.104
	-	-	(0.115)	-	-	(0.021)**	-	-	(0.481)
Eq.- i(t)	-	-	-	-0.081	-		-	-	-
	-	-	-	(0.038)**	-		-	-	-
Eq.- i(g)	0.212	-	-0.089	-	-	0.182	0.120	-	-
	(0.106)	-	(0.213)	-	-	(0.037)**	(0.021)**	-	-
			Panel B	$H_2(2)$: (* * 1 β_4 $-\beta_4$ * *)					
Eq.- i(m)	0.109	-	-0.046	-	-	-0.022	-0.085	-0.565	-
	(0.022)**	-	(0.008)**	-	-	(0.005)**	(0.010)**	(0.084)**	-
Eq.- i(t)	0.032	-	-	0.009	0.120	-0.029	-	-0.158	-
	(0.005)**	-	-	(0.002)**	(0.016)**	(0.006)**	-	(0.017)**	-
Eq.- i(g)	-0.136	-	-	0.091	-	-0.028	-0.034	-	-0.057
	(0.026)**	-	-	(0.012)**	-	(0.007)**	(0.006)**	-	(0.011)**
			Panel C	$H_2(3)$: (* * 1 * * β_6 $-\beta_6$)					
Eq.- i(m)	-0.468	-2.625	-0.579	-	-	-	-2.023	21.650	-1.538
	(0.118)**	(0.320)**	(0.186)**	-	-	-	(0.286)**	(3.389)**	(0.372)**
Eq.- i(t)	-0.776	-3.019	-	-	-	-	-	2.408	-
	(0.043)**	(0.362)**	-	-	-	-	-	(0.407)**	-
Eq.- i(g)	-1.787	-	-1.520	0.055	-	-1.455	-0.628	-	-1.473
	(0.145)**	-	(0.380)**	(0.460)	-	(0.266)**	(0.032)**	-	(0.149)**

Notes: *Eq. - i(m), Eq. - i(t) and Eq. - i(g)* represent the cointegration vector generated by the estimation with the money market rate, treasury bills rate and government bonds rate, respectively. The figures in parentheses represent the standard errors of the coefficients; ** and * represent the statistical significance at 5% and 10%, respectively.

Based on the results of the existence of the RERS, RERI and RERY, the next hypothesis of interest is whether the RERS, RERI and RERY relationship is stationary by itself. If it is true, a simple model is likely to be sufficient in explaining the long-run changes of the real exchange rate. To see this, leaving the second vector unrestricted for the model with r = 2, the cointegration vector can be specified as:

Relative Stock index – Real Exchange rate relation (RERS):

$$H_3(1): \beta' = [\beta_1 \quad -\beta_1 \quad 1 \quad 0 \quad 0 \quad 0 \quad 0] \tag{3.7}$$

$$q_{1t} = -\beta_1(p_t - p_t^*) + \varepsilon_t$$

Real Interest rate differential – Real Exchange rate relation (RERI):

$$H_3(2): \beta' = [0 \quad 0 \quad 1 \quad \beta_4 \quad -\beta_4 \quad 0 \quad 0] \tag{3.8}$$

$$q_{1t} = -\beta_4(i_t - i_t^*) + \varepsilon_t$$

Relative Output differential – Real Exchange rate relation (RERY):

$$H_3(3): \beta' = [0 \quad 0 \quad 1 \quad 0 \quad 0 \quad \beta_6 \quad -\beta_6] \tag{3.9}$$

$$q_{1t} = \beta_6(y_t - y_t^*) + \varepsilon_t$$

In Table 1.7, we provide the LR statistic results for the hypothesis test $H_3(i)$, for i *=1, 2, 3.* The hypothesis that the cointegration vector only contains the RERS, RERI and RERY respectively, are all statistically rejected. There is no support for the idea that a single stationary relationship holds in the cointegration vector. This result is informative as it highlights that no particular relationship is sufficient to develop a long-run structural relationship between the variables in our system.

Table 1.7: Hypothesis Tests for Stationary Relationships

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
			Panel A	$H_3(1)$: (β_1 $-\beta_1$ 1 0 0 0 0)					
Eq.- i(m)	-	-	22.13	-	-	45.93	-	27.60	32.96
	-	-	(0.000)**	-	-	(0.000)**	-	(0.000)**	(0.000)**
Eq.- i(t)	-	-	-	38.05	-	-	-	-	-
	-	-	-	(0.000)**	-	-	-	-	-
Eq.- i(g)	16.84	-	13.73	-	-	47.76	21.19	-	-
	(0.002)**	-	(0.008)**	-	-	(0.000)**	(0.000)**	-	-
			Panel B	$H_3(2)$: (0 0 1 β_4 $-\beta_4$ 0 0)					
Eq.- i(m)	28.33	-	21.64	-	-	45.80	29.98	-	15.52
	(0.000)**	-	(0.000)**	-	-	(0.000)**	(0.000)**	-	(0.000)**
Eq.- i(t)	23.83	-	-	30.73	35.30	46.06	-	-	-
	(0.000)**	-	-	(0.000)**	(0.000)**	(0.000)**	-	-	-
Eq.- i(g)	13.38	-	12.31	20.31	-	36.88	17.60	-	27.83
	(0.010)**	-	(0.015)*	(0.000)**	-	(0.000)**	(0.002)**	-	(0.000)**
			Panel C	$H_3(3)$: (0 0 1 0 0 β_6 $-\beta_6$)					
Eq.- i(m)	25.45	24.76	33.09	-	-	-	29.89	29.82	35.75
	(0.000)**	(0.000)**	(0.000)**	-	-	-	(0.000)**	(0.000)**	(0.000)**
Eq.- i(t)	21.36	31.49	-	-	-	-	-	-	-
	(0.000)**	(0.000)**-	-	-	-	-	-	-	-
Eq.- i(g)	20.16	-	22.13	34.29	-	47.83	23.90	-	38.35
	(0.001)**	-	(0.000)**	(0.000)**	-	(0.000)**	(0.000)**	-	(0.000)**

Notes: *Eq. - i(m), Eq. - i(t) and Eq. - i(g)* represent the cointegration vector generated by the estimation with the money market rate, treasury bills rate and government bonds rate, respectively. The figures in parentheses represent the standard errors; ** and * represent the statistical significance at 5% and 10%, respectively.

1.4c Identifying the long-run structural relationships

It has already been pointed out that the RERS, RERI, and RERY relationship exists in the cointegration vector, but is not stationary by itself. This suggests that the other variables in the model should provide information to the long-run behaviour of the real exchange rate, and the cointegration vector is likely to contain other relationships.

Taking these observations one step further, it may be of interest that a joint hypothesis for the relationship would give a better result. In order to identify the exchange rate determination, three procedures are required. The first procedure includes three hypotheses to study the interaction between the relation of RERS, RERI and RERY. Each hypothesis combined any two relationships, two zero constraints and a normalised restriction $\beta_3 = 1$ in the cointegration vector. The first hypothesis test combined the relation of RERS and RERI in a cointegration vector. This setting is used for identifying the interaction between the financial market and the money market.

$$H_4(1): \beta' = [\beta_1 \quad -\beta_1 \quad 1 \quad \beta_4 \quad -\beta_4 \quad 0 \quad 0] \tag{3.10}$$

$$q_{1t} = -\beta_1(p_t - p_t^*) - \beta_4(i_t - i_t^*) + \varepsilon_t$$

The second hypothesis test is a combination of the RERY and RERI relationships. This setting is created in order to account for the interaction between the goods market and the money market.

$$H_4(2): \beta' = [0 \quad 0 \quad 1 \quad \beta_4 \quad -\beta_4 \quad \beta_6 \quad -\beta_6] \tag{3.11}$$

$$q_{1t} = -\beta_4(i_t - i_t^*) + \beta_6(y_t - y_t^*) + \varepsilon_t$$

The third hypothesis includes the relation of the RERS and RERY. This is formulated as follows:

$$H_4(3): \beta' = [\beta_1 \quad -\beta_1 \quad 1 \quad 0 \quad 0 \quad \beta_6 \quad -\beta_6] \tag{3.12}$$

$$q_{1t} = -\beta_1(p_t - p_t^*) + \beta_6(y_t - y_t^*) + \varepsilon_t$$

The second procedure is similar to hypotheses 3.10 to 3.12, which contain any two relationships but no zero constraint is included in the cointegration vector:

$$H_4(4): \beta' = [\beta_1 \quad -\beta_1 \quad 1 \quad \beta_4 \quad -\beta_4 \quad * \quad *] \tag{3.13}$$

$$q_{1t} = -\beta_1(p_t - p_t^*) - \beta_4(i_t - i_t^*) + \beta_3 y_t + \beta_4 y_t^* + \varepsilon_t$$

$$H_4(5): \beta' = [* \quad * \quad 1 \quad \beta_4 \quad -\beta_4 \quad \beta_6 \quad -\beta_6] \tag{3.14}$$

$$q_{1t} = \beta_1 p_t + \beta_2 p_t^* - \beta_4(i_t - i_t^*) + \beta_6(y_t - y_t^*) + \varepsilon_t$$

$$H_4(6): \beta' = [\beta_1 \quad -\beta_1 \quad 1 \quad * \quad * \quad \beta_6 \quad -\beta_6] \tag{3.15}$$

$$q_{1t} = -\beta_1(p_t - p_t^*) + \beta_3 i_t + \beta_4 i_t^* + \beta_6(y_t - y_t^*) + \varepsilon_t$$

The third procedure includes all relationships:

$$H_4(7): \beta' = [\beta_1 \quad -\beta_2 \quad 1 \quad \beta_4 \quad -\beta_4 \quad \beta_6 \quad -\beta_6] \tag{3.16}$$

$$q_{1t} = -\beta_1(p_t - p_t^*) - \beta_4(i_t - i_t^*) + \beta_6(y_t - y_t^*) + \varepsilon_t$$

Tables 1.8a to 1.8c[7] report the LR statistic results of hypotheses 3.10 to 3.16, respectively. Note that it is not possible to determine the exchange rate equation if we

[7] The results in Tables 1.8a to 1.8c are based on the results in Table 1.5. For example, in the equation *Eq. i(m)* of Canada, the null of the relative stock differential is rejected in Table 1.5; it will be considered that the RERS relationship does not exist in the cointegration vectors. Therefore, we do not conduct a hypothesis test about the RERS and RERI relationship with interaction. Although the RERS relation is excluded in the hypothesis test of the

study the table individually. Thus, we summarise the results in 1.8a to 1.8c, and conclude the following real exchange rate equations with the money market rate, *Eq.- i(m)*, treasury bills rate, *Eq.- i(t)*, and government bonds rate, *Eq.- i(g)* for each country. The (+/-) under the coefficient gives the sign of a significant estimated coefficient.

For Canada, the LR result in Table 1.8b (0.080) suggests that it is only the RERY and RERI relationships that enter the cointegration vector but are not stationary by themselves. Therefore, the exchange rate equation can be defined as:

CANADA

$$\textit{Eq.- i(m)}: \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \underset{(+)}{\beta_3}(i_t - i_t^*) + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

For the *Eq.- i(t)*, there is a clear contradiction between the results in Table 1.8a (7.07) and 1.8b (0.083) that both hypotheses are accepted, and the result in Table 1.8c is just rejected at a 10% level of significance. We then checked the significance of the variables and found that the stock index variables are significant. The exchange rate equation can be formulated as:

$$\textit{Eq.- i(t)}: \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \underset{(-)}{\beta_3}(i_t - i_t^*) + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

The results in Table 1.8c indicate that the *Eq.- i(g)* in Canada consists of three relationships:

$$\textit{Eq.- i(g)}: \quad q_{1t} = \underset{(+)}{\beta_1}(p_t - p_t^*) + \underset{(-)}{\beta_2}(i_t - i_t^*) + \underset{(+)}{\beta_3}(y_t - y_t^*) + \varepsilon_t$$

RERS and RERI relationship with interaction, it does not mean that the stock index variables are excluded from the long-run relationship.

For the United Kingdom, it is not necessary to conduct the hypothesis tests from 3.10 to 3.16. This is because the results in Table 1.5 indicate that only the RERY relationship is confirmed but not stationary as shown in Table 1.6, while the other two relationships are rejected.

UNITED KINGDOM

$$Eq.\text{- } i(m): \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \beta_3 i_t + \beta_4 i_t^* + \underset{(+)}{\beta_5}(y_t - y_t^*) + \varepsilon_t$$

$$Eq.\text{- } i(t): \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \beta_3 i_t + \beta_4 i_t^* + \underset{(+)}{\beta_5}(y_t - y_t^*) + \varepsilon_t$$

In the case of Japan, the exchange rate equation *Eq.- i(m)* is

JAPAN

$$Eq.\text{- } i(m): \quad q_{1t} = \underset{(-)}{\beta_1}(p_t - p_t^*) + \underset{(+)}{\beta_2}(i_t - i_t^*) + \beta_3 y_t + \beta_4 y_t^* + \varepsilon_t$$

However, hypotheses 3.13 and 3.15 for *Eq.- i(g)* are not rejected in each case. We then checked the significance of the relative stock differential and of the relative output differentials. The results suggest that only the relative stock index differential is statistically insignificant at 5%. The exchange rate equation can be formulated as:

$$Eq.\text{- } i(g): \quad q_{1t} = \underset{(-)}{\beta_1}(p_t - p_t^*) + \underset{(+)}{\beta_2}(i_t - i_t^*) + \beta_3 y_t + \beta_4 y_t^* + \varepsilon_t$$

Defining the exchange rate equation for Germany, France, Italy, Korea, Singapore and Thailand is straightforward. We define the exchange rate equation by the hypothesis which has not been rejected. The exchange rate equations for each country are shown below:

GERMANY

$$\textit{Eq.- i(m)}: \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \underset{(+)}{\beta_3}(i_t - i_t^*) + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

$$\textit{Eq.- i(g)}: \quad q_{1t} = \underset{(+)}{\beta_1}(p_t - p_t^*) + \beta_2 i_t + \beta_3 i_t^* + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

FRANCE

$$\textit{Eq.- i(t)}: \quad q_{1t} = \underset{(+)}{\beta_1}(p_t - p_t^*) + \underset{(-)}{\beta_2}(i_t - i_t^*) + \beta_3 y_t + \beta_4 y_t^* + \varepsilon_t$$

$$\textit{Eq.- i(g)}: \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \underset{(-)}{\beta_3}(i_t - i_t^*) + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

ITALY

$$\textit{Eq.- i(t)}: \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \underset{(-)}{\beta_3}(i_t - i_t^*) + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

KOREA

$$\textit{Eq.- i(m)}: \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \underset{(+)}{\beta_3}(i_t - i_t^*) + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

SINGAPORE

$$\textit{Eq.- i(m)}: \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \underset{(+)}{\beta_3}(i_t - i_t^*) + \underset{(-)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

$$\textit{Eq.- i(g)}: \quad q_{1t} = \beta_1 p_t + \beta_2 p_t^* + \underset{(+)}{\beta_3}(i_t - i_t^*) + \underset{(-)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

THAILAND

$$\textit{Eq.- i(m)}: \quad q_{1t} = \underset{(+)}{\beta_1}(p_t - p_t^*) + \beta_2 i_t + \beta_3 i_t^* + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

$$\textit{Eq.- i(g)}: \quad q_{1t} = \underset{(+)}{\beta_3}(i_t - i_t^*) + \underset{(+)}{\beta_4}(y_t - y_t^*) + \varepsilon_t$$

The aforementioned empirical results indicate that there is clear interaction between the relationships. It would be better to distinguish these countries into two groups. The first group represents the European region, which includes the United Kingdom, Germany, France and Italy. The second group is the Asia-Pacific region, which includes Canada, Japan, Korea and Thailand.

In the European region, we could see the RERS relationship is only rarely confirmed. For the RERI relationship, it is interesting that the real exchange rate and short-term interest rate differential are all positively related. In addition, regardless of whether reference is made to a short term or long term interest rate, the results suggest that the RERI relationships are positively related in all Asian countries (Japan, Korea and Singapore). However, the estimation with the long-term interest rate differential in Canada and European countries (Germany, France and Italy) supports the sticky-price approach of RERI relationship. Finally, the RERY relationship is basically consistent in all countries except for the estimation with the long term interest rate differentials in Korea.

V Conclusion

Previous studies in exchange rate literature on the exchange rate determination seems to be inconclusive in view of the choice between short- and long-term interest rates as proxies of the interest rate variable. In order to compare their difference in generating an impact on the real exchange rate, we use the interest rate determined in the treasury bills and government bonds markets (long-term), and in the money market (short-term) in our empirical study. The empirical results suggest that the RERI relationship is not only confirmed in the long-term interest rates (Treasury bills rate and Government bonds rate), but that it rather also exists in the short-term interest rate (Money market rate), thus providing empirical support for the long-run relationship between the real exchange rate and short-term real interest rate differential.

This chapter is trying to determine the long-run structural relationship between finance, money and goods markets through the real exchange rate, real interest rate, relative stock differential and relative output differential. In addition to the exchange rate and interest rate variables, our system also includes financial and output variables.

In determining the real exchange rate and real interest rate differential (RERI) relationship, many previous studies impose an absolute version sticky-price approach of the RERI relationship on the cointegration vector, which strictly assumed that the real interest rate differential is negatively related to the real exchange rate. Since this method strictly assumed the anticipated sign of the estimated coefficient, the 'actual sign' of the coefficient may be ignored. We suggest an alternative method, whereby only the homogeneity restriction and normalised exchange rate are imposed in the system. Our empirical results indicate that most of the signs of the estimated β are positive, which is not consistent with the expected sign of the sticky-price approach of the RERI relationship. These results provide more favourable evidence for supporting the flexible-price approach of the RERI rather than the sticky-price interpretation of the RERI relationship.

In addition to the RERI relationship, the hypothesis test of the homogeneity restriction and normalised exchange rate are also applied in the analysis of the real exchange rate and relative stock prices (RERS) and the real exchange rate and real output differential (RERY) relationship. We could see the RERS relationship is rarely confirmed in the European region. Other hypothesis tests in this chapter do not provide any empirical support for the idea that a single stationary relationship holds in the cointegration vector. This result is informative as it highlights that no particular relationship is sufficient in order to develop a long-run structural relationship between the variables in our system.

Table 1.8a: Test for each Relation with Interaction (Stationary)

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
			Panel A	$H_4(1)$: $(\beta_1 \ \ -\beta_1 \ \ 1 \ \ \beta_4 \ \ -\beta_4 \ \ 0 \ \ 0)$					
Eq.- i(m)	-	-	21.211	-	-	42.384	-	-	-
	-	-	(0.000)**	-	-	(0.000)**	-	-	-
Eq.- i(t)	-	-	-	19.032	-	-	-	-	-
	-	-	-	(0.000)**	-	-	-	-	-
Eq.- i(g)	5.351	-	-	-	-	36.184	39.939	-	-
	(0.148)	-	-	-	-	(0.000)**	(0.000)**	-	-
			Panel B	$H_4(2)$: $(0 \ \ 0 \ \ 1 \ \ \beta_4 \ \ -\beta_4 \ \ -\beta_6 \ \ \beta_6)$					
Eq.- i(m)	15.514		20.046	-	-		28.875	22.891	-
	(0.0014)**		(0.0002)**	-	-		(0.000)**	(0.000)**	-
Eq.- i(t)	7.070		-		21.927		-	18.660	-
	(0.070)		-		(0.0002)**		-	(0.000)**	-
Eq.- i(g)	4.371	-		9.417		34.955	28.875	-	6.540
	(0.224)	-		(0.0242)*		(0.000)**	(0.000)**	-	(0.088)
			Panel C	$H_4(3)$: $(\beta_1 \ \ -\beta_1 \ \ 1 \ \ 0 \ \ 0 \ \ -\beta_6 \ \ \beta_6)$					
Eq.- i(m)	-	-	12.166	-	-	-	-	-	25.415
	-	-	(0.007)**	-	-	-	-	-	(0.000)**
Eq.- i(t)	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
Eq.- i(g)	16.031	-	6.396	-	-	12.045	38.107	-	-
	(0.001)**	-	(0.094)	-	-	(0.0170)*	(0.000)**	-	-

Notes: *Eq. - i(m), Eq. - i(t) and Eq. - i(g)* represent the cointegration vector generated by the estimation with the money market rate, treasury bills rate and government bonds rate, respectively. The figures in parentheses represent the standard errors; ** and * represent the statistical significance at 5% and 10%, respectively.

Table 1.8b: Test for each Relation with Interaction (Not stationary)

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
			Panel A	$H_4(4)$: (β_1 -β_1 1 β_4 -β_4 * *)					
Eq.- i(m)	-	-	10.172	-	-	3.343	-	-	12.454
	-	-	(0.0014)**	-	-	(0.188)	-	-	(0.000)**
Eq.- i(t)	-	-	-	5.358	-	-	-	-	-
	-	-	-	(0.0206)*	-	-	-	-	-
Eq.- i(g)	0.316	-	-	-	-	1.372	11.676	-	-
	(0.574)	-	-	-	-	(0.504)	(0.0029)**	-	-
			Panel B	$H_4(5)$: (* * 1 β_4 - β_4 - β_6 β_6)					
Eq.- i(m)	0.080	-	0.325	-	-	-	3.728	0.221	8.962
	(0.777)	-	(0.569)	-	-	-	(0.155)	(0.639)	(0.0028)**
Eq.- i(t)	0.083	-	-	-	1.133	-	-	0.718	-
	(0.773)	-	-	-	(0.567)	-	-	(0.397)	-
Eq.- i(g)	1.511	-	-	1.283	-	23.542	0.869	-	-
	(0.219)	-	-	(0.257)	-	(0.000)**	(0.648)	-	-
			Panel C	$H_4(6)$: (β_1 - β 1 * * β_6 β_6)					
Eq.- i(m)	-	-	7.983	-	-	-	-	-	2.359
	-	-	(0.0047)**	-	-	-	-	-	(0.125)
Eq.- i(t)	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
Eq.- i(g)	1.109	-	0.048	-	-	5.683	18.097	-	-
	(0.292)	-	(0.827)	-	-	(0.058)	(0.000)**	-	-

Notes: *Eq. - i(m), Eq. - i(t) and Eq. - i(g)* represent the cointegration vector generated by the estimation with the money market rate, treasury bills rate and government bonds rate, respectively. The figures in parentheses represent the standard errors; ** and * represent the statistical significance at 5% and 10%, respectively.

Table 1.8c: Test for each Relation with Interaction

	Canada	United Kingdom	Germany	France	Italy	Japan	Korea	Singapore	Thailand
			Panel A	$H_4(7)$: (β_1 -β_1 1 β_4 -β_4 β_6 -β_6)					
Eq.- i(m)	8.370	16.400	11.762	-	-	41.232	-	9.267	12.577
	(0.015)*	(0.000)**	(0.000)**	-	-	(0.000)**	-	(0.010)**	(0.002)**
Eq.- i(t)	7.032	20.976	-	17.538	-	-	-	17.067	-
	(0.030)*	(0.000)**	-	(0.000)**	-	-	-	(0.000)**	-
Eq.- i(g)	1.872	-	5.751	-	-	30.321	14.298	-	-
	(0.392)	-	(0.056)	-	-	(0.000)**	(0.000)**	-	-

Notes: *Eq. - i(m), Eq. - i(t) and Eq. - i(g)* represent the cointegration vector generated by the estimation with the money market rate, treasury bills rate and government bonds rate, respectively. The figures in parentheses represent the standard errors; ** and * represent the statistical significance at 5% and 10%, respectively.

Chapter 2

The Dynamic Effects of Supply, Monetary, Currency Risk Premium and Expectation Shocks on Real Exchange Rate Fluctuations

I Introduction

There is extensive evidence to suggest that macroeconomic shocks are related to the fluctuations of the real exchange rate. Earlier papers in the exchange rate literature, including for example Balassa (1964) and Samuelson (1964), suggest that real shocks would play a central role in explaining real exchange rate fluctuations if the purchasing power parity (PPP) holds. On the other hand, the seminal paper of Dornbusch (1976) indicates that nominal shocks would cause short run excess volatility in the real exchange rate. The impact of nominal shocks on the real exchange rate movement is examined by many studies (see, for example, Beaudry and Devereux (1995), Rogoff (1996), Rogers (1999), Hoffmann and MacDonald (2000) and Chari, Kehoe and McGrattan (2002)). These studies confirmed that the monetary shock shares a sizeable contribution to the real exchange rate volatility. Other empirical works (such as Lastrapes (1992), Enders and Lee (1997)) decompose real exchange rate fluctuations into those attributable to real and nominal shocks and conclude that real shocks perform better in explaining the real exchange rate movement.

Clarida and Gali (1994) investigate the importance of the demand, supply and monetary structural shocks to real exchange rate fluctuations since the collapse of Bretton Wood by using the structural vector autoregressive (SVAR) model with the long-run restrictions obtained from the flexible price rational expectation equilibrium. The empirical results imply that the nominal shocks explain a substantial amount of the variance of the real exchange rate in some countries (Japan and Germany). The impact of supply shocks on the real exchange rate fluctuations is insignificant, whereas the demand shocks explain most of the real exchange rate fluctuations in the short-run as well as the long-run. Other papers, such as Webber (1997), Chadha and Prasad (1997), Roger (1999) and MacDonald and Swagel (2000), also report that the demand shocks play a dominant role in explaining real exchange rate volatility.

On the other hand, some earlier papers highlight the influence of the relative stock differential to the real exchange rate fluctuation. For instance, Malliaropulos (1998) proposes a theoretical linkage between the transitionary components of the real exchange rate and relative stock differential and this relationship is further supported by the empirical works of Wong and Li (2009), who examine the dynamic relationship of the relative stock differential and the real exchange rate of 11 economies during the two financial crises of 1997 and 2008. Other papers such as Eichler and Maltritz (2011) also provide empirical evidence to support this relation. On the basis of these findings, we are interested to investigate whether the international investment activities are one of the main incentives causing short-run fluctuations in the real exchange rate.

In fact, financial markets worldwide have been highly integrated within as well as across boundaries over the past two decades. Although central banks in various parts of the world began tightening regulations on capital movement following the onset of several financial crises in the last two decades, information technological developments in electronic payment and communication systems have substantially improved the mobility of capital across countries, thus causing international capital funds to become more important in explaining the stock price volatility and exchange rate fluctuation.

Following the conceptual framework of Dornbusch (1976), Clarida and Gali (1994), Malliaropulos (1998) and Hoffmann and MacDonald (2000), the present chapter investigates the sources of real exchange rate fluctuation by developing and estimating a four-equations open macro model, which links up the financial, money and goods markets of advanced and transition economies. Our model is based on Dornbusch's dynamic Mundell-Fleming model in which price is assumed to be sticky in the short-run.

Although theoretically the uncovered interest rate parity (UIP) seems to contribute to the determination of the real exchange rate, empirical studies have focused only to a limited extent on investigating how the shocks due to the deviations from the UIP influence the economy. In addition, relatively little is known about the importance of investors' expectation in determining the fluctuation of the real exchange rate. The contribution of the present paper is filling this gap in order to investigate the importance of these two factors in explaining the real exchange rate short-run fluctuation, particularly during the time of the financial crises. We recover the real output differential, real interest rate differential, the real exchange rate and the relative stock differential for 10 economies (Canada, France, Germany, Italy, Japan, Korea, Singapore, Thailand, the United Kingdom and the United States) into supply, monetary, currency risk premium (CRP) and expectation shocks, respectively. In the model, the CRP shock represents the deviations from the UIP. According to Malliaropulos (1998), the error term of the relative stock prices equation contains the expected depreciation of the real exchange rate and the expected risk premium of domestic stock prices. we recover the disturbance of relative stock prices by estimating VAR in unrestricted form and term the structural innovations of relative stock price as ‘expectation shocks’.

The rest of this chapter is organised as follows. Section II presents a theoretical framework of the real exchange rate determination. Section III introduces the methodology and discusses our identification scheme. Section IV illustrates the data description and presents the empirical findings of historical decomposition, variance decomposition and impulse response, respectively. The final section concludes the paper.

II Theoretical Framework

We build on the work of Dornbusch (1976), Malliaropulos (1998) and Hoffmann and MacDonald (2000) in order to develop a sticky-price model of the real output differential, real interest rate differential, real exchange rate and relative stock differential. The following summarises the elements of Dornbusch's sticky-price model:

IS Equation: $$y_t^d = \eta(s_t - p_t) - \sigma r_t, \tag{1}$$

Price Adjustment Equation: $$\dot{p}_t = \pi[\eta(e_t - p_t) + (\gamma - 1)y_t - \sigma i_t]. \tag{2}$$

LM Equation: $$m_t - p_t = y_t - \lambda i_t, \tag{3}$$

Uncovered Interest Parity: $$i_t = E_t \Delta s_{t+1} + \varepsilon_t^{RP}, \tag{4}$$

Equation (1) gives the IS equation in which the aggregate demand for home output relative to the foreign output (y_t^d) is positive related to the real exchange rate ($s_t - p_t$) and negative in relation to the expected real interest rate (r_t). Equation (2) is the rate of increase in the price of domestic goods, which can be described as proportional to an excess demand measure. Equation (3) is a standard LM equation, which gives the money market equilibrium condition, while Equation (4) is a statement of the uncovered interest parity condition augmented by a catch-all variable (ε_t^{RP}) that captures any deviations from the condition.

In order to investigate how the stock market results in a fluctuation of the real exchange rate, we consider the relationship of the real exchange rate and relative stock differential formulated by Malliaropulos (1998):

$$\nabla^k \rho_t = k(\xi u + v) - \xi \nabla^k q_t + \varepsilon_{k,t}^e \tag{5}$$

Equation (5) is the relationship between the ex-post risk premium of a k-period investment in the domestic stock market relative to an equivalent investment in the foreign stock market, and the k-period change in the real exchange rate. In which, $\xi = \frac{\vartheta - 1}{\phi - 1}$; ∇ is the forward difference operator; ρ_t represents the relative stock prices between the domestic economy and the US. According to the findings of Fama and French (1988) and Malliaropulos (1998), the relative stock prices variable ρ_t contains both a permanent and a temporary component $\rho_t \equiv \rho_t^P + \rho_t^T$. The permanent and temporary components of the relative stock price are respectively specified as:

$$\rho_t^P = v + \rho_{t-1}^P + \eta_t^P , \tag{6}$$

$$\rho_t^T = \phi \rho_{t-1}^T + \eta_t^T . \tag{7}$$

On the other hand, Huizinga (1987) and Baxter (1994) suggest that the real exchange rate contains both the permanent q_t^P and transitory q_t^T components, so that $q_t \equiv q_t^P + q_t^T$. The permanent and temporary components of the real exchange rate are equal to:

$$q_t^P = \mu + q_{t-1}^P + \varepsilon_t^P , \tag{8}$$

$$q_t^T = \vartheta q_{t-1}^T + \varepsilon_t^T . \tag{9}$$

Note that both the permanent component of the relative stock price as well as the real exchange rate are specified as a random walk with drift. The error term in the permanent components (η_t^P and ε_t^P) is a serial uncorrelated innovation; the transitory component is assumed to follow a stationary first-order autoregressive AR(1) process with

$0 < \vartheta < 1$, and the error term in the transitory components (η_t^T and ε_t^T) is a serial uncorrelated innovation.

Consider again equation (5), which suggests a negative forward difference relationship between the ex-post risk premium of a k-period investment in the home stock market relative to an equivalent investment in the foreign stock market, and the k-period changes of the real exchange rate and the disturbance $\varepsilon_{k,t}^e$ in equation (5) can be expressed as:

$$\varepsilon_{k,t}^e \equiv \frac{\vartheta - 1}{\phi - 1} \sum_{i=1}^{k} \varepsilon_{t+i}^P + \sum_{i=1}^{k} \eta_{t+i}^P + \nabla^k E_t \nabla rs_t \,, \qquad (10)$$

which not only includes the cumulated innovations of permanent components of the relative stock price and the real exchange rate: η_{t+i}^P and ε_{t+i}^P, but also includes the revision in the expected real return differential $\nabla E_t \nabla rs_t = \nabla E_t \nabla \rho_t + \nabla E_t \nabla q_t$ between the home and the foreign market. It is furthermore worth noting that $\nabla E_t \nabla \rho_t = v + (\phi - 1) \nabla \rho_t^T$ represents the revision of the conditional risk premium of domestic shares relative to the foreign shares and $\nabla E_t \nabla q_t = u + (\vartheta - 1) \nabla q_t^T$ is the revision of the expected real exchange rate, respectively. $\varepsilon_{k,t}^e$ can also be considered as the expectation shock, as it captures the influence of shocks to the real exchange rate as well as the relative stock price. For the sake of simplicity, we assume k =1 in the following.

In order to close the model, we need to specify the stochastic processes that govern the relative output supply and the relative money supply. Following Clarida and Gali (1994), we assume that the relative output differential and money supply are simple random walk processes. Therefore:

$$y_t^s = y_{t-1}^s + \varepsilon_t^S, \tag{11}$$

$$m_t = m_{t-1} + \varepsilon_t^M, \tag{12}$$

where (y_t^s) is the relative output supply, and (ε_t^S) and (ε_t^M) represent the supply and monetary shocks, respectively.

The steady state of the Dornbusch model can be represented by the following three equations:

$$\bar{y}_t = y_t^s, \tag{13}$$

$$\bar{q}_t = \frac{1}{\eta}(\bar{y}_t + \sigma \bar{r}_t), \tag{14}$$

$$\bar{p}_t = m_t - \bar{y}_t + \lambda \bar{i}_t. \tag{15}$$

Solving equation (11), we would get:

$$\Delta y_t^d = \varepsilon_t^S. \tag{16}$$

Equation (16) shows that the relative output differential is positive related to the supply shock.

Under the sticky-price Dornbusch model, goods prices are assumed to be sticky in the short-run. We assume that the domestic price level does not move instantly in response to an unanticipated monetary disturbance, but only adjusts slowly over time. If there is an unanticipated increase in money supply but the price level is temporarily fixed, then the demand for real balances must increase. Since the output is assumed to be fixed in the short run, the only way that the demand for real balances can move up is for the interest rate to fall simultaneously.

Based on the aforementioned assumptions, we then proceed to derive the 'sticky-price' real interest rate differential. Taking the first-difference of equation (14) and substituting it into equation (16), we obtain the change in the real interest rate differential:

$$\Delta r_t = \left(\eta r_t - \varepsilon_t^S\right) / \sigma \,. \tag{17}$$

Equation (17) indicates that the real interest rate differential is negatively related to the supply shock.

Returning to the money demand function as shown in equation (15), we would get the change in nominal interest rate after first-differencing on both sides of the equation:

$$\Delta i_t = (\varepsilon_t^S - \varepsilon_t^M) / \lambda \,. \tag{18}$$

Since the real interest rate $i_t = r_t - (E_t p_{t+1} - p_t)$ and the prices level is assumed to be sticky in the short-run, the expected change in the price level would not change in the short-run due to the rational expectation, $\Delta p_t = \Delta p_t^e = 0$. The real interest rate is then equal to the nominal interest rate in the short run[8]. Substituting equation (17) into equation (15), we obtain:

$$r_t = \eta\left[(\varepsilon_t^S(\sigma + \lambda) - \sigma\varepsilon_t^M\right] / \lambda \,. \tag{19}$$

Equation (19) shows that both the supply shock and the monetary shock influence the 'sticky-price' real interest rate differential. The 'sticky-price' real interest rate differential is positively related to the supply shock that an unanticipated increase in

[8] One may argue that this is empirically impossible. However, note that all these results are driven by the assumed rigidity of the price level. To improve the possibility, we use the monthly data to minimise the difference between the real and the nominal exchange rate.

aggregate supply would increase the domestic real interest rate while the real interest rate would decrease in response to the monetary expansion.

The next step is to derive an expression for the 'sticky-price' real exchange rate. We replace the expected value of the rate of change of the exchange rate by its actual value in Equation (4). Under the assumption that the real interest rate is equal to the nominal interest rate in the short-run, it is possible to substitute equation (19) into equation (15). We then obtain:

$$\Delta q_t = \left[\sigma(\varepsilon_t^S - \varepsilon_t^M)/\lambda + \varepsilon_t^S\right]/\eta - \varepsilon_t^{RP} . \tag{20}$$

The 'sticky-price' real exchange rate depreciates in response to a supply shock and appreciates in response to the monetary shock and the CRP shock, respectively. Substituting equation (20) into (5), we obtain:

$$\nabla^k \rho_t = k(\xi u + v) - \left[\sigma(\varepsilon_t^S - \varepsilon_t^M)/\lambda + \varepsilon_t^S\right]/\eta - \xi\varepsilon_t^{RP} + \varepsilon_{k,t}^e . \tag{21}$$

Equation (21) indicates that the relative stock differential decreases in response to the CRP shock and rises in response to the relative stock differential shock. This is equivalent to the expected sign of the coefficients.

Summarising these four equations, we see that the evolution of the sticky-price equilibrium over time can be represented by the following four equations:

$$\Delta y_t^d = \varepsilon_t^S ,$$

$$r_t = \eta\left[(\varepsilon_t^S(\sigma+\lambda) - \sigma\varepsilon_t^M\right]/\lambda ,$$

$$\Delta q_t = \left[\sigma(\varepsilon_t^S - \varepsilon_t^M)/\lambda + \varepsilon_t^S\right]/\eta - \varepsilon_t^{RP} , \tag{22}$$

$$\nabla^k \rho_t = k(\xi u + v) - \left[\sigma(\varepsilon_t^S - \varepsilon_t^M)/\lambda + \varepsilon_t^S\right]/\eta - \xi\varepsilon_t^{RP} + \varepsilon_{k,t}^e .$$

The four equations above clearly demonstrate that the relative output differential, the real interest rate differential, the real exchange rate and the relative stock price differential are driven by four shocks – the supply shock, the monetary shock, the currency risk premium (CRP) shock and expectation shock. In addition, we can see that the system is recursive when price-stickiness is assumed.

III Methodology and Identification Scheme

2.3a Methodology

In order to investigate the contemporaneous relationship and the inter-relationship between variables, we assume the economy can be described by the following SVAR system that expresses the contemporaneous interactions between the variables in structural form:

$$B(L)Y_t = \gamma_0 + e_t \, , \tag{23}$$

where $B(L)$ is a *4 x 4* matrix polynomial in the lag operator, L; Y_t is a *4 x 1* vector of variables, which consists of four endogenous variables in the vector:

$$Y_t = \begin{bmatrix} \Delta(y_t - y_t^*) \\ i_t - i_t^* \\ \Delta q_t \\ \Delta(p_t - p_t^*) \end{bmatrix} \tag{24}$$

and $\Delta(y_t - y_t^*)$, Δq_t and $\Delta(p_t - p_t^*)$ represent the first difference of the relative output differential, real exchange rate and relative stock differential, respectively. $i_t - i_t^*$ represents the real interest rate differential in level. e_t in equation (23) is a *4 x 1* vector structural disturbance, which is identical to the independent normal and var (e_t) = Λ . Λ is a diagonal matrix. Since the diagonal elements are the variances of the structural disturbances, therefore, each structural disturbance is assumed to be mutually uncorrelated, and is able explicitly assign to particular equation.

Let B_0 be the contemporaneous coefficient matrix on L^0 in the structural form, and $B^0(L)$ be the coefficient matrix in $B(L)$ without the contemporaneous coefficient B_0. The matrix polynomial in the lag operator, L, can be represented as follows:

$$B(L) = B_0 + B^0(L) \ . \tag{25}$$

Consider the following reduced form VAR equation:

$$Y_t = \alpha_0 + A(L)Y_t + u_t \ , \tag{26}$$

where $A(L)$ is a matrix polynomial in lag operator, L, and μ_t is a vector of reduced-form disturbances with no structural interpretation. We start with the SVAR equation, and multiply B_0^{-1} to the structural form equation, to obtain:

$$\begin{aligned} Y_t &= B_0^{-1}\gamma_0 + B_0^{-1}B(L)Y_{t-1} + B_0^{-1}e_t \\ &= \alpha_0 + A(L)Y_{t-1} + u_t. \end{aligned} \tag{27}$$

It can be found that the parameters of the reduced form VAR equation are related to the parameters of the SVAR equation:

$$A(L) = B_0^{-1}B^0(L) \ . \tag{28}$$

The reduced form residuals are related to the structural disturbances:

$$u_t = B_0^{-1}e_t \, , \tag{29}$$

and its covariance matrix is:

$$E(u_t u_t^{'}) = \Sigma = B_0^{-1}\Lambda B_0^{-1^{'}} \ . \tag{30}$$

The reduced form residuals are modelled as the linear combinations of the structural disturbances. Equation (30) indicates that the covariance matrix of the reduced form residuals is not diagonal, and the right hand side of the equation has $4\times(4+1)$ numbers of free parameters to be estimated. Since Σ contains $4\times(4+1)/2$ parameters, the parameters in the SVAR equation can be identified by imposing restrictions. In order to achieve identification, $4 \times (4+1)/2$ restrictions on B_0 . are required.

2.3b Identifying the structural shocks:

The zero (exclusion) restrictions are imposed on the contemporaneous structural parameters, $B_{0,}$ from equation (29). For the restrictions on the contemporaneous structural parameters $B_{0,}$ all zero restrictions that we imposed on the system are obtained from the sticky-price expressions as shown in equation (22). The following equations summarise our identification scheme from equation (7):

$$\begin{bmatrix} e_{y,t} \\ e_{i,t} \\ e_{re,t} \\ e_{rs,t} \end{bmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 \\ b_{41} & b_{42} & b_{43} & 1 \end{pmatrix} \begin{bmatrix} u_{y,t} \\ u_{i,t} \\ u_{re,t} \\ u_{rs,t} \end{bmatrix} \tag{31}$$

Equation (31) presents a recursive SVAR system, which contains a set of four sub-equations in the structural model. The four terms of $e_{i,t}, e_{re,t}, e_{rs,t}$ and $e_{y,t}$ represent, respectively, the unobserved structural innovations of the real interest rate differential (i) shock, the real exchange rate (re) shock, the relative stock differential (rs) shock and the relative output differential (y) shock. The observed residuals obtained from the reduced form of the VAR equations are $u_{y,t}, u_{i,t}, u_{re,t}$ and $u_{rs,t}$, which represent the unexpected moment of each variable in our system.

All restrictions imposed on the structural parameters of B_0 are contemporaneous without further restrictions on the lagged structural parameters. The first sub-equation represents the relative output differential equation; we assume that the relative output differential is exogenous to the variables of the system. The impacts of the real interest rate differential, real exchange rate and relative stock differential on the relative output differential appear only in the latter's lag value.

As shown in equation (22), the real interest rate differential responds only to the supply and monetary shock. The coefficient b_{21} in the second sub-equation will not be set to zero. On the other hand, equation (22) shows the real exchange rate with respect to the relative output and the real interest rate differentials shocks. Moreover, the exchange rate is a forward-looking asset price and the relationship between the real exchange rate and the real interest rate differential is also confirmed in recent papers (Hoffmann & MacDonald, 2003; Sollis & Wohar, 2006). We assume that all variables (except for the relative stock differential) have a contemporaneous effect on the real exchange rate. The coefficient estimates of b_{34} is then set equal to zero.

The final sub-equation is a relative stock differential equation. Our sticky-price expression of the relative stock differential indicates that the relative stock differential response to all shocks in our system is consistent with the empirical findings of earlier papers in financial literatures (Mauro, 2000; Ehrmann & Fratzcher, 2004; Wong & Li, 2009). In practice, since investors will respond quickly to any information available in the market, it is reasonable that all coefficient estimates in this sub-equation will not be set as zero.

IV Data and Empirical Results

2.4a The Data

In this chapter, the sample covers the period from January 1992 to December 2012. All data used in the empirical estimations are obtained from the International Financial Statistics (*IFS*) and DataStream, and are expressed in logarithm with the exception of the real interest rates. Monthly data are used in our estimations. Our use of monthly data rather than quarterly data as in the case of many empirical papers renders the informational assumptions as shown in equation (31) more appropriate because high frequency data enables us to capture the evolution of the variables closely, especially the financial variable, which changes rapidly over time.

The relative stock price (ρ_t) between the home economy and the foreign economy expressed in the domestic currency is calculated by:

$$\rho_t = s_t - s_t^* - e_t$$

where $s_t(s_t^*)$ is the domestic (foreign) stock price and (e_t) is the domestic nominal exchange rate[9], expressing the domestic currency per unit of US dollar.

The real exchange rate is defined as:

$$q_t = e_t + p_t^* - p_t$$

where $p_t(p_t^*)$ is the domestic (foreign) price index. Figure 2.1 shows the relative stock price and the real exchange rate for the nine countries on a log scale. The measures of the relative stock price and real exchange rate are shown on the left axis and right axis,

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[9] The nominal effective exchange rate index is used for the France, Italy and Germany.

respectively. It is clear that the relative stock price and the real exchange rate are moving to opposite directions in most countries, showing the negative relationship between these two variables by visual inspection, especially during the Asian financial crisis (South Korea, Singapore and Thailand) in 1997 and the European sovereign debt crisis (France and Italy) in late 2011.

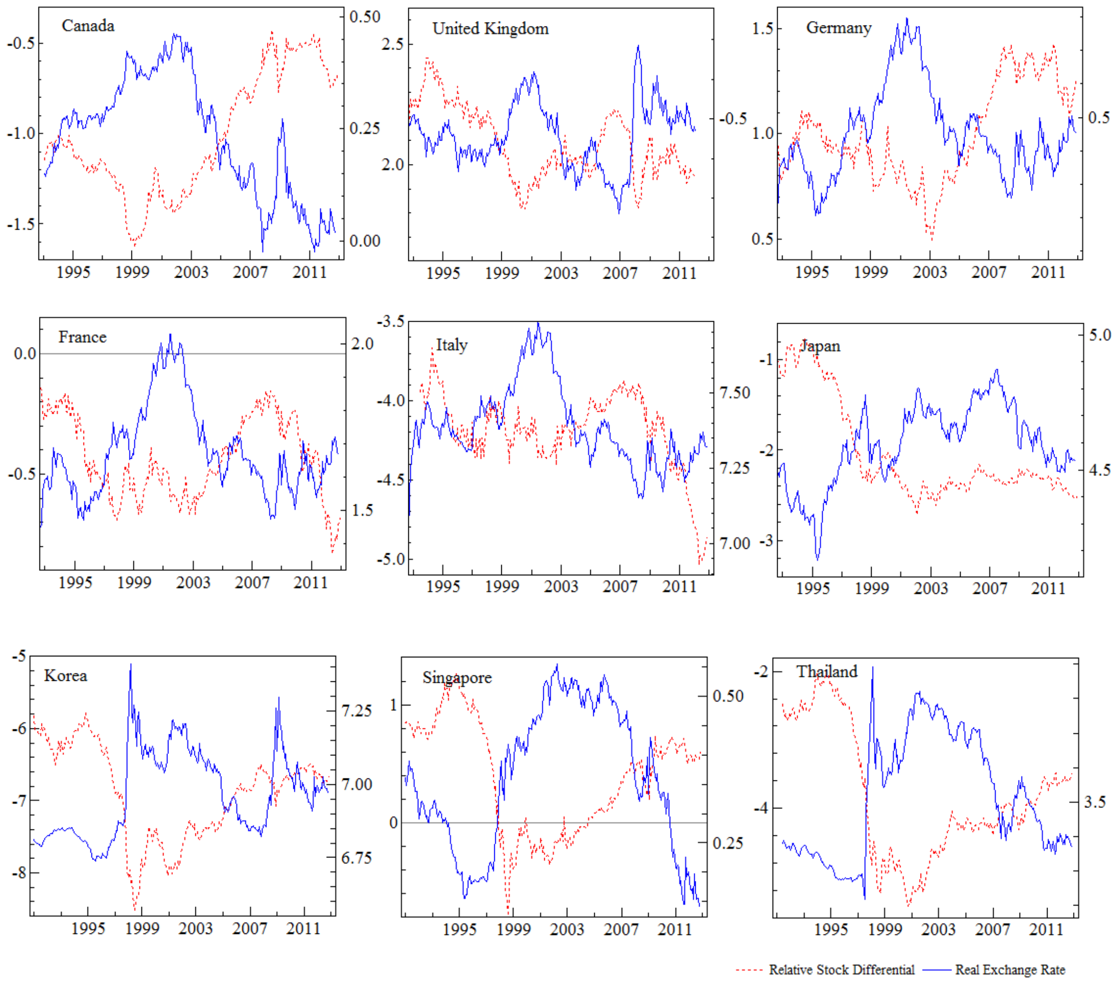

Figure 2.1: Time Series Plots of the Relative Stock Differential and Real Exchange Rate

Figure 2.2 shows the real interest rate differential of the 9 economies in a natural scale. The real interest rate (i_t) is constructed by the equation:

$$i_t = r_t - E_t(p_{t+1} - p_t)$$

Where (r_t) is the nominal interest rate and $(E_t p_{t+1} - p_t)$ is the expected inflation rate. Similar to Hoffmann and MacDonald (2009), the expected inflation was achieved by the moving window procedure starting with a univariate autoregressive estimation of inflation with 4 lags[10] using the past five years data (60 observations) in-sample period data to predict the one-step-ahead (month) inflation rate, and then we shift the in-sample estimation period forward by one period for estimation and prediction. This process is repeated *N* times until the last observation of the sample period. The real interest rate differential $(i_t - i_t^*)$ is measured by deducting the real interest rate for the US from the real interest rate of each economy.

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[10] The number of lags is based on the AIC criteria.

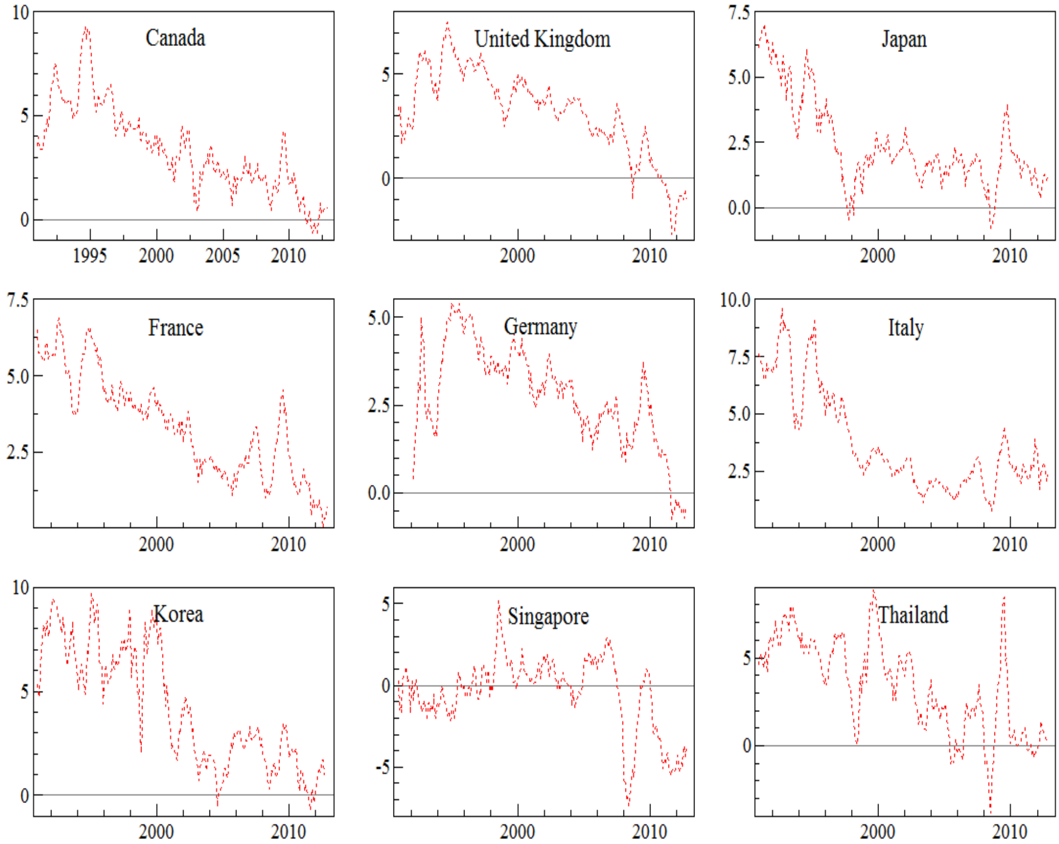

Figure 2.2: Time Series Plots of the Real Interest Rate Differential

The relative output differential as shown in Figure 2.3 is measured by the domestic GDP (y_t) minus the foreign GDP (y_t^*). The foreign GDP is converted into home currency. The monthly GDP is constructed from the quarterly real GDP using the state space approach with the monthly industrial production data serving as the related interpolator variable, assuming that the interpolation is describable as an AR(1) process. Table 2.1 reports the ADF test results. As can be seen in Table 2.1, the ADF test result shows that all variables in level in our system are non-stationary with the exception of the real interest rate differentials.

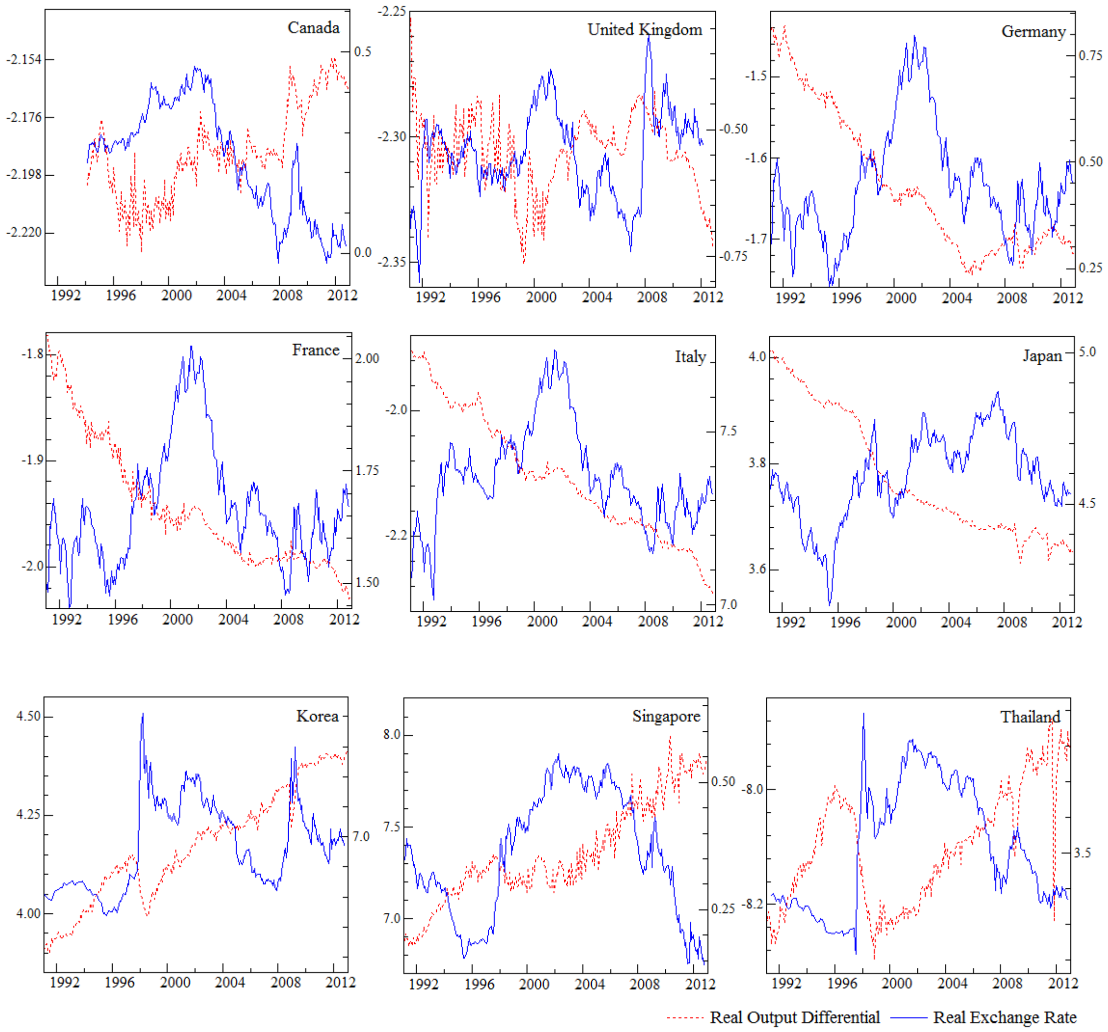

Figure 2.3: Time Series Plots of the Real Output Differential and Real Exchange Rate

Table 2.1: ADF Test

	Canada	France	Germany	Italy	Japan	Korea	Singapore	Thailand	UK
p_t - p_t*	-0.77	0.38	0.33	1.54	0.96	0.2	-1.52	0.05	-1.11
$\triangle(p_t - p_t^*)$	-3.95**	-5.12**	-6.07**	-4.61**	-3.96**	-4.06**	-3.88**	-3.39**	-5.41**
q_t	-1.06	-0.06	-0.35	-0.25	-0.04	0.2	-0.78	-0.1	-0.67
$\triangle q_t$	-4.39**	-4.38**	-2.90**	-4.13**	-3.96**	-4.76**	-3.99**	-5.14**	-5.56**
y_t - y_t*	-0.7	2.83	2.06	2.98	-2.51**	2.42	2.68	-0.64	0.18
$\triangle(y_t - y_t^*)$	-5.49**	-3.33**	-3.46**	-3.26**	-3.26**	-4.77**	-4.72**	-3.52**	-6.40**
$i_t^G - i_t^{G*}$	-3.11**	-3.01**	-3.33**	-2.56**	-2.72**	-2.53**	-2.43**	-3.88**	-2.55**

Note: ** and * represent the statistical significance at 5% and 10%, respectively.

2.4b Empirical results:

In our SVAR estimations, a constant variable, time trend and a set of dummy variables[11] are included. The number of lag length included in each model is based on the Akaike information criterion. We firstly present the historical decomposition for the real exchange rate in level, which allows us to access the quantitative importance of each shock in the real exchange rate at each point in time between 1992 and 2012. Figure 2.4 provides the historical decomposition of the real exchange rates of the Asian countries (Japan, Korea, Singapore and Thailand). The highlighted area represents the 97 Asian financial crisis, 01 dot-com bubble, 07/08 global financial crisis and the 11/12 European sovereign debt crisis, respectively.

Overall, the CRP shocks play a dominant role, while the contribution of the supply and monetary shocks in explaining the real exchange rate fluctuation is relatively low in all countries (with the exception of Singapore), particularly during the crisis periods. We note that the contribution of the expectation shock is likely higher than the CRP shock prior to the Asian financial crisis in (AFC) 1997 in the case of Thailand and Korea when their exchange rate was pegged with the US dollar and in the case of Singapore. The collapse of the fixed exchange rate of Thailand's currency, and the unexpected subsequent shift of the exchange rate regime to independently floating in Korea, caused a clear 'jump' in the contributions of the CRP shock, reflecting the risk reversion behaviour of the international investors. In Thailand, the impact of the supply

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[11] The first dummy θ_{AFC} was included in the estimation by taking on the value of 1 from May 1997 to September 1998 to account for the Asian financial crisis that started in mid-1997 and severely damaged the economy of the Asian countries. θ_{GFC} is introduced to cover the 2008 financial crisis from September 2008 to September 2009. Finally, θ_{ESC} is included to capture the impacts of the European sovereign debt crisis from August 2011 to March 2012. At that time, the yields of the long-term government bonds of some countries in the Eurozone exceeded 6%, which indicates that the financial markets are highly concerned about the credit-worthiness of the country.

shock on the real exchange rate seems to be more moderated after the adoption of the floating exchange rate. This may due probably to the increase in the proportion of the CRP and expectation shocks that result from the increase in uncertainty.

In order to investigate how the structural shocks react to the financial crises, we also review the historical decompositions of the real exchange rate of the European countries and Canada, respectively (Figure 2.5). During the AFC, there are no significant changes in the contribution of the shocks in the European countries. However, the demise of the dot-com bubble in early 2001 triggered an apparent increase in the CRP shock in all countries with the exception of Singapore and the United Kingdom. Investors were paying a risk discount in order to avoid the risk bearing of the domestic currency. During the dot-com bubble burst, the sharp depreciation thereof is associated with a high expectation shock in most countries.

Compared to the dot-com bubble crisis, we are surprised that the magnitude of the changes in the CRP shock in the 2007/08 global financial crisis (with the exception of the United Kingdom) and the 2011 European sovereign debt crisis are relatively low. Similar to the Asian countries, the contribution of supply and monetary shocks is not high while the expectation shock shares the second largest contribution and its movements are likely to be periodical over the sample periods in all cases. One interesting finding in Figure 2.5 is that the contribution of the CRP shock in Germany becomes higher after the introduction of the Euro dollar.

We report the next results regarding the sources of the real exchange rate fluctuations. In Table 2.2, we report the forecast error variance decomposition of the first differenced real exchange rate at various horizons. The numbers in each row represent the fraction of the variance of the kth-month ahead forecast error for the real exchange rate explained by each of the random innovations (structural shocks). The results show that the CRP shock plays a dominant contribution in explaining the real exchange rate variance at all horizons in all countries, yet this is not a surprising finding. The contribution of the supply shock is the smallest among the structural shocks with the exception of Thailand. In Asian countries, the monetary policy shock's contribution is less than one in most cases with the exception of Korea, while the contribution in the European countries and Canada is higher, particularly in the long-run. We note that the expectation shock has apparently outperformed other shocks in explaining the fluctuations of the real exchange rate in all economies (with the exception of Canada and Italy) and its proportion has further increased over the course of 5 months. Since the expectation shock consists of the revision of the expected real exchange rate, $\nabla E_t \nabla q_t = u + (\vartheta - 1)\nabla q_t^T$ and the conditional risk premium of domestic shares relative to the foreign shares, $\nabla E_t \nabla \rho_t = v + (\phi - 1)\nabla \rho_t^T$. The significance of the expectation shock (particularly in the UK) might be due to the expected change in the relative stock differential causing a massive capital movement between countries. Indeed, financial markets all over the world have been highly integrated in recent decades. International capital funds play an important role in stock price volatility. Investors are willing to pay a higher risk premium in the foreign exchange market in return to expected returns from the foreign stock market. Our results strongly confirm that the expectation shock is one of the main incentives causing a real exchange rate fluctuation over the short-run.

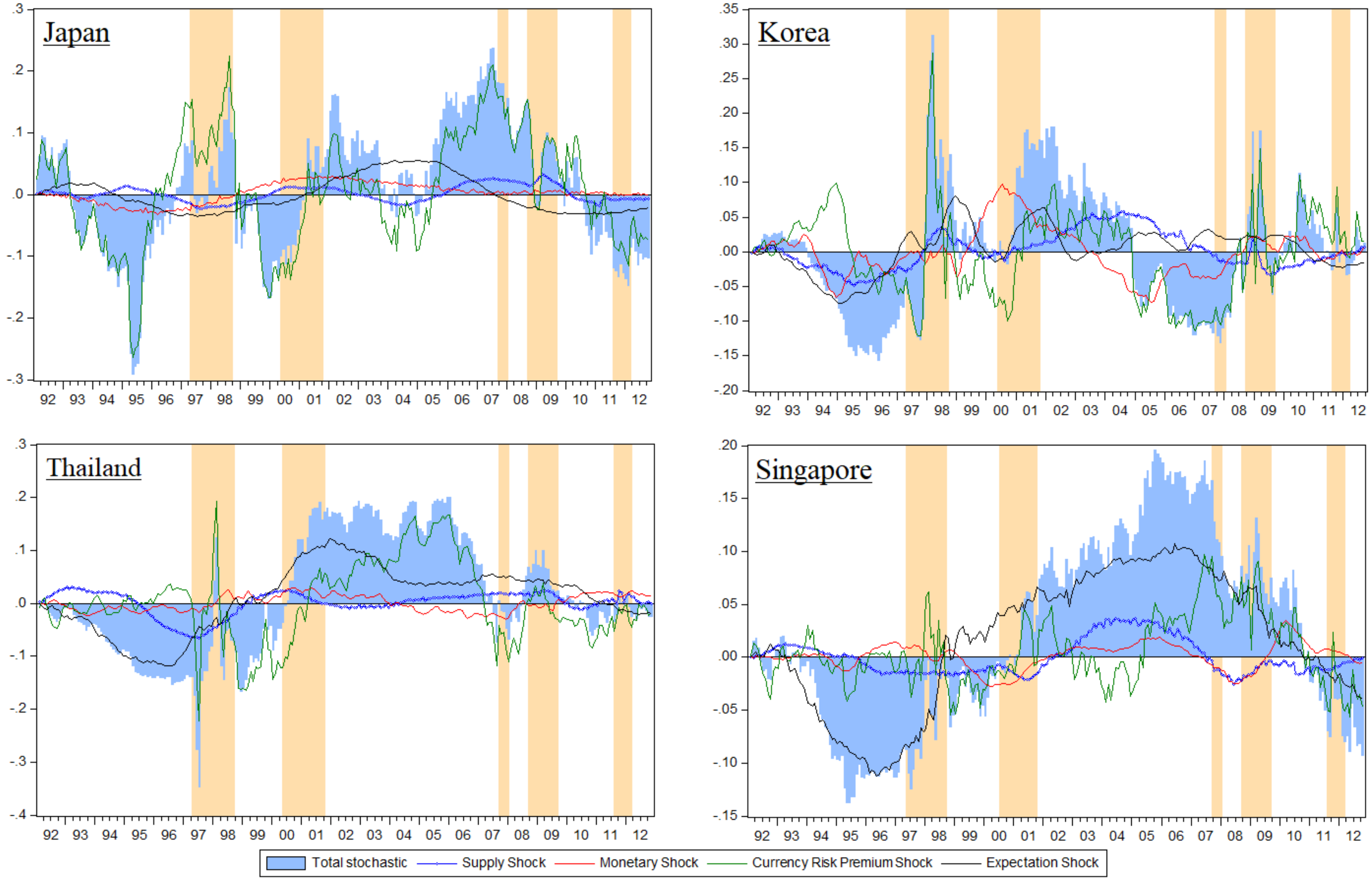

Figure 2.4: Historical Decomposition of the Real Exchange Rates of Asian Countries

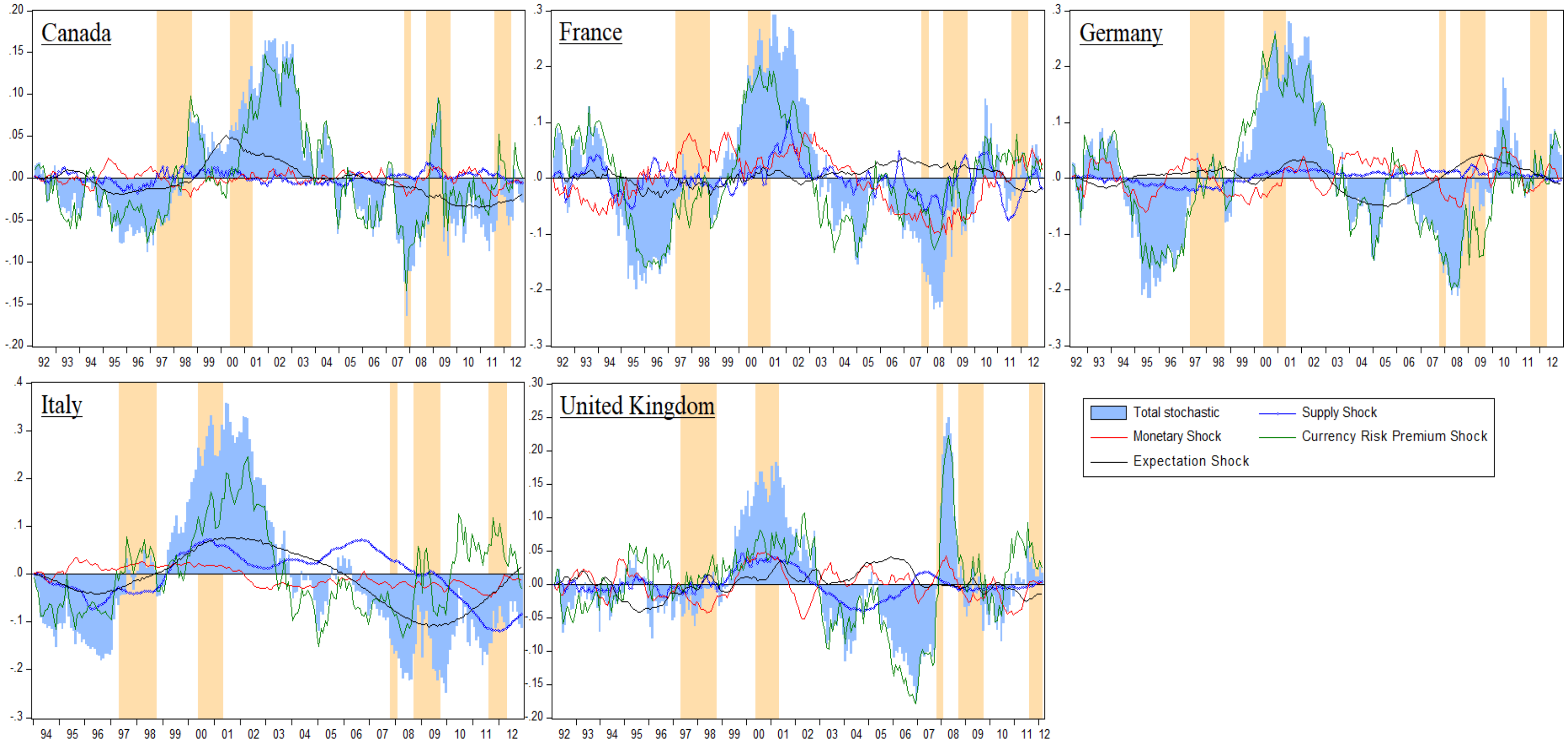

Figure 2.5: Historical Decomposition of the Real Exchange Rates of European Countries and Canada

Table 2.2: Variance Decomposition of the Real Exchange Rate

	Supply	Monetary	CRP	Expectation		Supply	Monetary	CRP	Expectation
Canada					***Korea***				
1 month	0.94	1.61	97.45	0.00	1 month	0.12	0.36	99.52	0.00
5 months	2.24	2.75	94.68	0.33	5 months	1.56	1.57	80.73	16.15
10 months	2.27	3.40	94.00	0.33	10 months	1.55	2.27	80.11	16.07
15 months	2.27	3.63	93.78	0.33	15 months	1.55	2.38	80.03	16.05
20 months	2.27	3.70	93.70	0.33	20 months	1.55	2.39	80.02	16.05
France					***Singapore***				
1 month	0.20	4.33	95.47	0.00	1 month	0.48	0.46	99.06	0.00
5 months	1.94	10.19	68.96	18.91	5 months	1.30	0.72	87.80	10.18
10 months	2.07	12.39	67.04	18.50	10 months	1.31	0.86	87.66	10.17
15 months	2.07	12.58	66.89	18.46	15 months	1.31	0.91	87.61	10.17
20 months	2.07	12.60	66.88	18.45	20 months	1.31	0.93	87.59	10.16
Germany					***Thailand***				
1 month	0.00	3.59	96.41	0.00	1 month	0.49	0.00	99.51	0.00
5 months	0.90	8.87	75.53	14.70	5 months	1.24	0.29	85.44	13.03
10 months	0.94	9.57	74.87	14.63	10 months	1.30	0.47	85.13	13.10
15 months	0.94	9.65	74.80	14.61	15 months	1.30	0.51	85.10	13.10
20 months	0.94	9.66	74.79	14.61	20 months	1.30	0.52	85.09	13.09
Italy					***UK***				
1 month	0.04	0.90	99.06	0.00	1 month	0.12	0.16	99.72	0.00
5 months	0.21	1.48	98.07	0.23	5 months	2.51	2.35	53.64	41.50
10 months	0.21	1.90	97.65	0.23	10 months	2.89	2.63	52.35	42.12
15 months	0.21	2.09	97.46	0.23	15 months	2.90	2.79	52.26	42.06
20 months	0.21	2.19	97.37	0.23	20 months	2.90	2.81	52.24	42.04
Japan									
1 month	0.02	0.51	99.47	0.00					
5 months	0.29	0.73	83.18	15.79					
10 months	0.29	0.77	83.14	15.79					
15 months	0.29	0.78	83.13	15.79					
20 months	0.29	0.79	83.13	15.79					

Note: This table provides the percentage of variance due to supply, monetary, CRP and expectation shock, respectively.

Supply shocks:

In Figures 2.6a to 2.6d, we report the dynamic effects of a supply shock on the relative output differential, real interest rate differential, real exchange rate and relative stock differential, respectively. Each figure gives the impulse responses to a structural standard deviation positive innovation over a horizon of 20 months. The horizontal axis measures the time horizon in terms of months after the shock, while the vertical axis represents the response of the variables. The upper and lower dashed lines plotted in each graph are the one standard error bands.

In response to a positive supply shock, both the relative output differential and the real interest rate differential increase initially in all economies (with the exception of France and Singapore in Figure 2.6b), which are consistent as predicted by current economic theories. Later, these two variables decline after the first month and the impact on the real interest rate differential is likely to be persistent.

Let us now consider the impulse responses of the other variables to a supply shock; the response of the real exchange rate is mixed and less persistent. For instance, an initial real depreciation can be found in Canada and the European countries, but the real exchange rates tend to appreciate after a few months. Given the wide confidence interval bands, however, the initial impact is not statistically significant. With the exception of Korea and Singapore, the relative stock differential declines initially in all countries, following a positive supply shock, which is in line with our model identification presented in the last section.

Monetary shocks

It is interesting that a monetary contraction causes a positive impact on the relative output differential (Figure 2.7a) in most countries, which does not match with the general prediction of conventional economic models. However, the impacts are small and not significant. Figure 2.7b shows that the monetary shocks have an apparently positive effect (ranging from 0.35 to 0.6% approximately) on the real interest rate differential for all countries. The response peaks in the first or second month and declines monotonically thereafter.

Figure 2.7c provides the impulse response functions of the real exchange rate to a positive monetary shock. A negative effect can obviously be found at the beginning in the case of Canada, France, Italy, Germany Thailand and Korea. It can be noted, however, that the effects experience an opposing trend after the second month and reach a peak at roughly 3 to 4 months (with the exception of Japan and Singapore). This is consistent with Dornbusch's overshooting model that, under the assumption of price rigidity, an unanticipated decrease in money supply will lead to a persistent appreciation of the exchange rate in the beginning. The initial appreciation must be proportionately larger than the long-term depreciation. The excess exchange rate appreciation ensures the depreciation needed in order to simultaneously clear the money and bonds markets in each case. We could see in the figure that the monetary shock generates a long-lasting impact (more than 12 months) on the real exchange rate in most cases, and the real exchange rate will eventually return to its pre-shock level after all prices and wages have adjusted.

By considering the response of the relative stock differential (Figure 2.7d), our empirical results show that the relative shock differential declines in response to a monetary contraction in most cases. The reason for this negative impact might be explained by the present-value valuation model, which suggests that an increase in the interest rate would increase the rates at which future cash flows are discounted and hence the relative stock differential decreases. One might also note that the response is persistent and will eventually return to its pre-shock level. This result is consistent with the papers (see for example: Fama & French, 1988; Poterba & Summers, 1988) arguing that the stock prices contain a mean-reverting property.

Currency risk premium (CRP) shock

It is worth mentioning once more that the currency risk premium (CRP) shock represents a catch-all innovation, which captures any deviation from the uncovered interest parity condition. A positive CRP shock might enable the domestic interest rate to rise relative to the foreign interest rate, or imply that investors are paying a risk discount in order to avoid the risk bearing of the domestic currency. In Figure 2.8a, with the exception of Canada, Italy and Japan, it is sensible to assume that the relative output differential declines in all countries following a positive CRP shock as the capital outflow may damage the economic performance of a country, particularly in some Asian countries.

We now consider the effect of the CRP shock on the real interest rate. In the European countries, the impact on Germany's real interest rate is much higher when compared to the other regional countries. The real interest rate declines apparently after a brief period, as it tends to return to its pre-shock level smoothly. The negative impacts of the CRP can also be found in other countries (Canada, Japan and Korea). These findings might be in line with the argument of Hoffmann and MacDonald (2009) that the current real exchange rate contains sufficient information in order to forecast the future movement of the real interest differential. As for the real exchange rate, it is clear that an initial sharp real depreciation (Figure 2.8c) can be seen in all nine countries and the effect reaches the trough after the second month. It might reflect the overreaction of the investors in response to any unfavourable news available in the markets. We note that the relative stock differential rises following to the positive CRP shock in some countries (France, Germany, Japan, Korea and Thailand), but the results are not statistically significant. In contrast, those countries with a negative response to the CRP shock are all statistically significant. These results fulfil the theoretical linkage between the real exchange rate and the relative stock differential implying that the capital outflow would result in a decline in the relative stock differential.

Expectation shock

Figures 2.9a to 2.9d report the impulse response functions to the expectation shocks due to the expected change in the real exchange rate and in the relative stock price (conditional risk premium) between the domestic and US stock market. To be clear, it is worth reviewing the equation of the relationship between the relative stock price and the real exchange rate as shown in equation (5). In the equation, the error term contains the expected change in the real exchange rate: $\nabla E_t \nabla q_t = u + (\vartheta - 1)\nabla q_t^T$ and the expected change in the relative stock prices: $\nabla E_t \nabla \rho_t = v + (\phi - 1)\nabla \rho_t^T$. Fama and French (1988) indicate that the mean-reverting property of the transitionary component of stock prices renders the stock prices predictable so that the mean-reversion of the relative stock prices could be one of the main components that formed the expectation shock.

In Figure 2.9a, the response of the relative output differential to the expectation shock is positive, while the real interest rate (Figure 2.9b) declines in most cases. Although the expectation shock results in changes in the relative output differential and the real interest rate differential, we do not consider that the expectation shock could affect these two variables in the short-run. In addition, the impact is not statistically significant due to the wide confidence interval bands.

It is interesting that there is likely a ‘delayed’ real appreciation of the real exchange (Figure 2.9c) in response to a positive expectation shock in all cases with the exception of Canada and Italy. The impact is short-lasting in that the real exchange rate is apparently appreciated during the second month and then the response quickly reverts to its pre-shock level after the third month in most countries. In Figure 2.9d, the relative stock differential initially increases following an apparent positive expectation shock. The positive impact turns into negative in the second month and rebounds subsequently in most countries after the third month. We note that the rebound of the relative stock differential is likely matched with the time of the delayed appreciation.

One possible reason for the delayed appreciation might be the herd behaviour in the financial markets. The Federal Reserve Bank of New York (1998) reports that the five largest trading firms accounted for 31% of the market share in the spot market. It suggests that some currencies are dominated by a few big players. Capital will flow into domestic countries if those big players become aware that the domestic stock market is profitable. Their actions would initially cause changes in the real exchange rate and the relative stock differential, and the real exchange rate would further appreciate once the other investors become aware of these trends and follow those big players' actions.

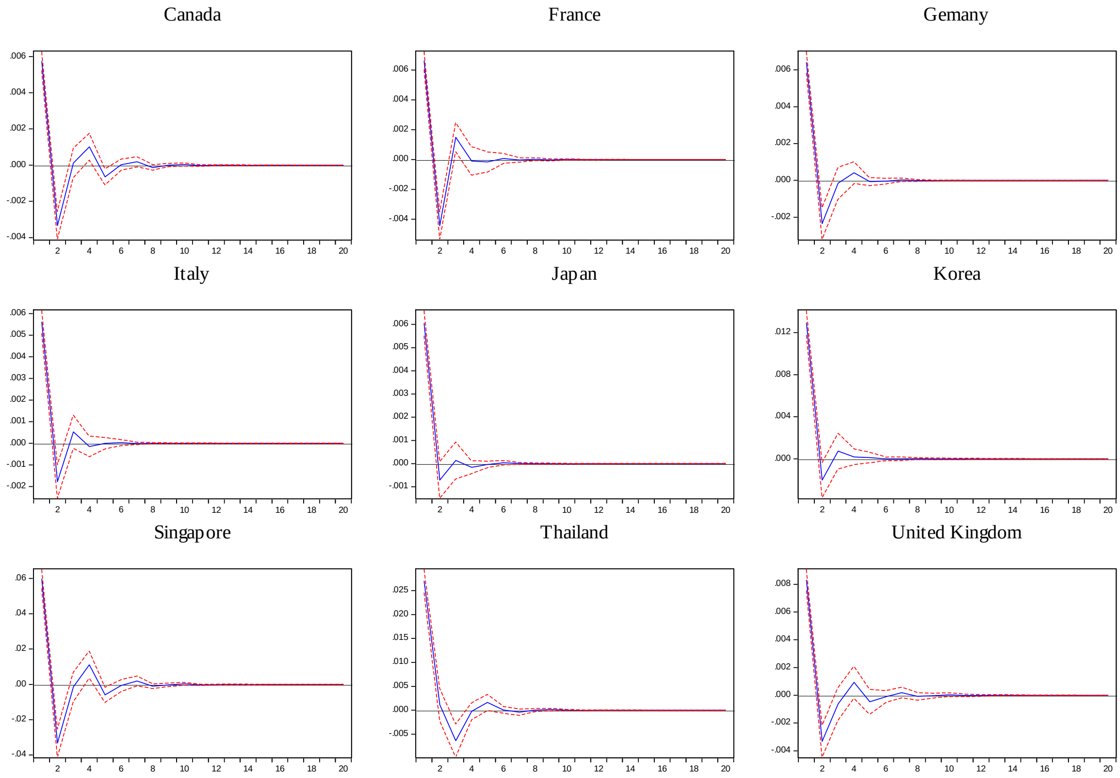

Figure 2.6a: Relative Output Differential Response to Supply Shock

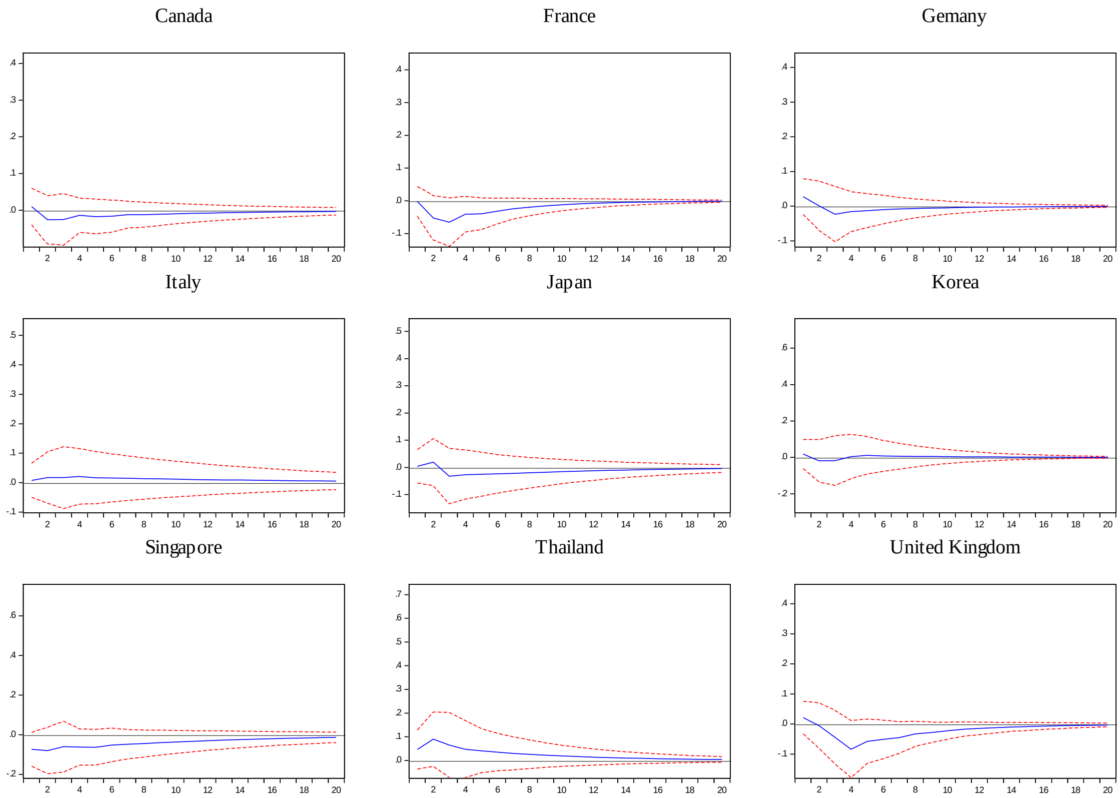

Figure 2.6b: Real Interest Rate Differential Response to Supply Shock

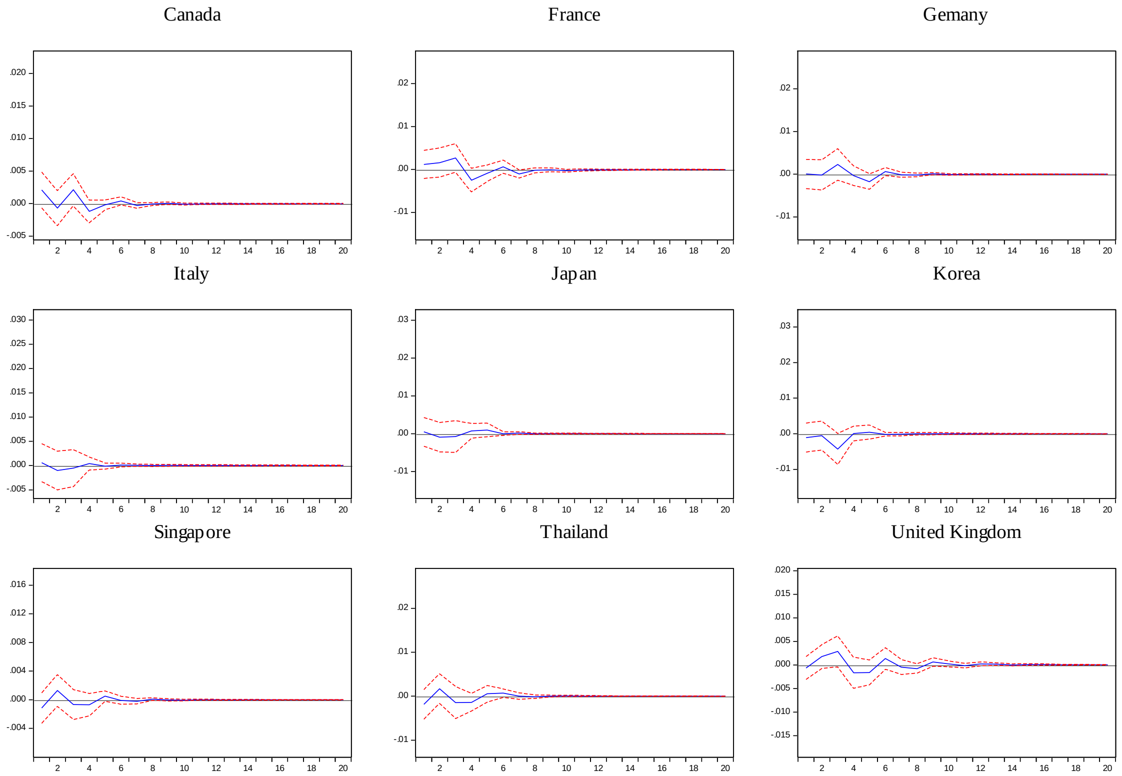

Figure 2.6c: Real Exchange Rate Response to Supply Shock

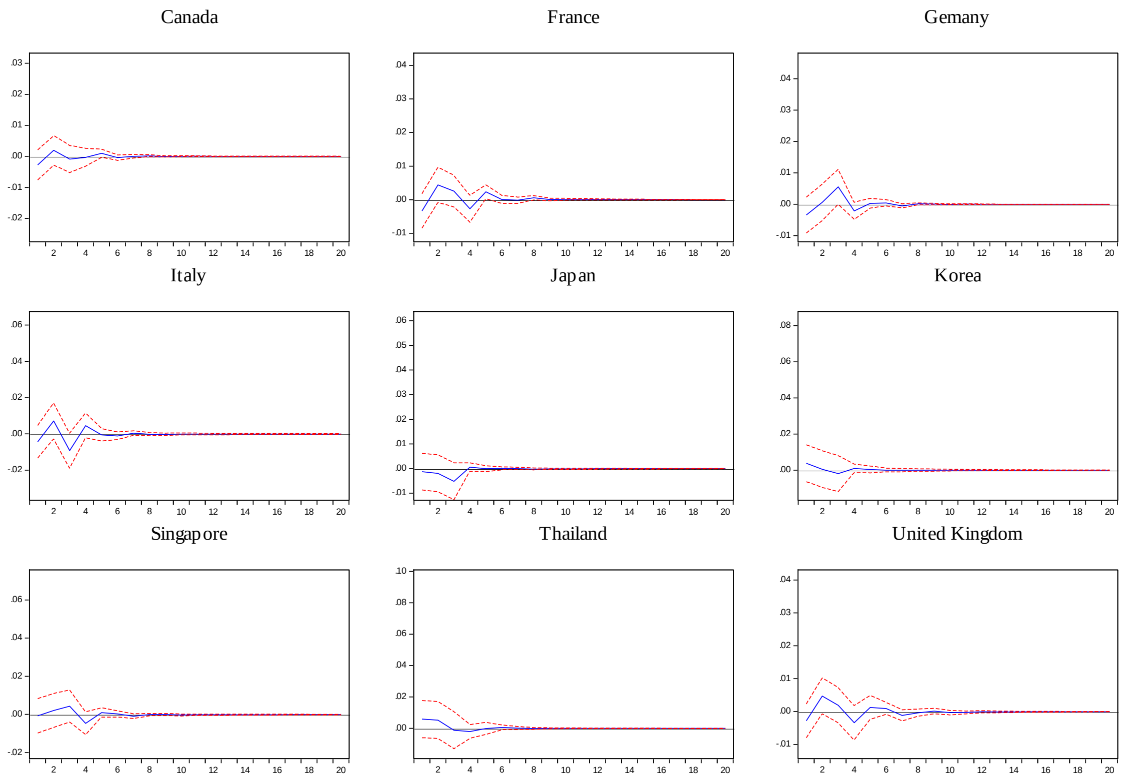

Figure 2.6d: Relative Stock Differential Response to Supply Shock

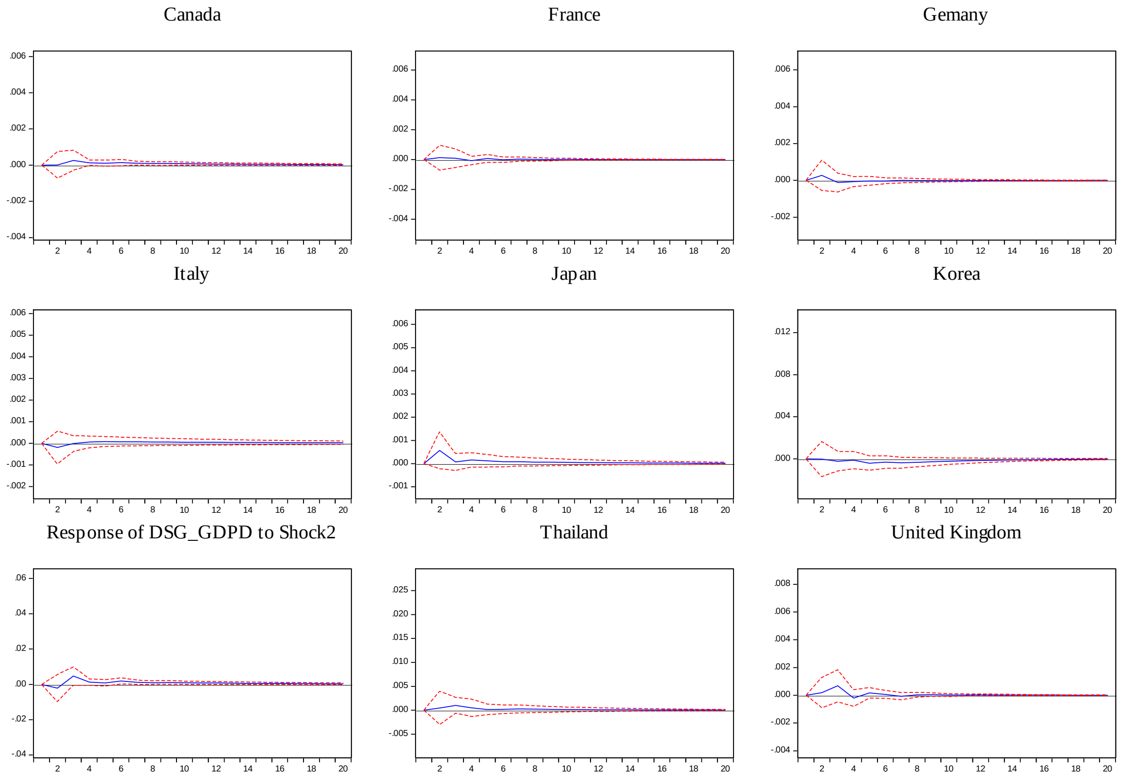

Figure 2.7a: Relative Output Differential Response to Monetary Shock

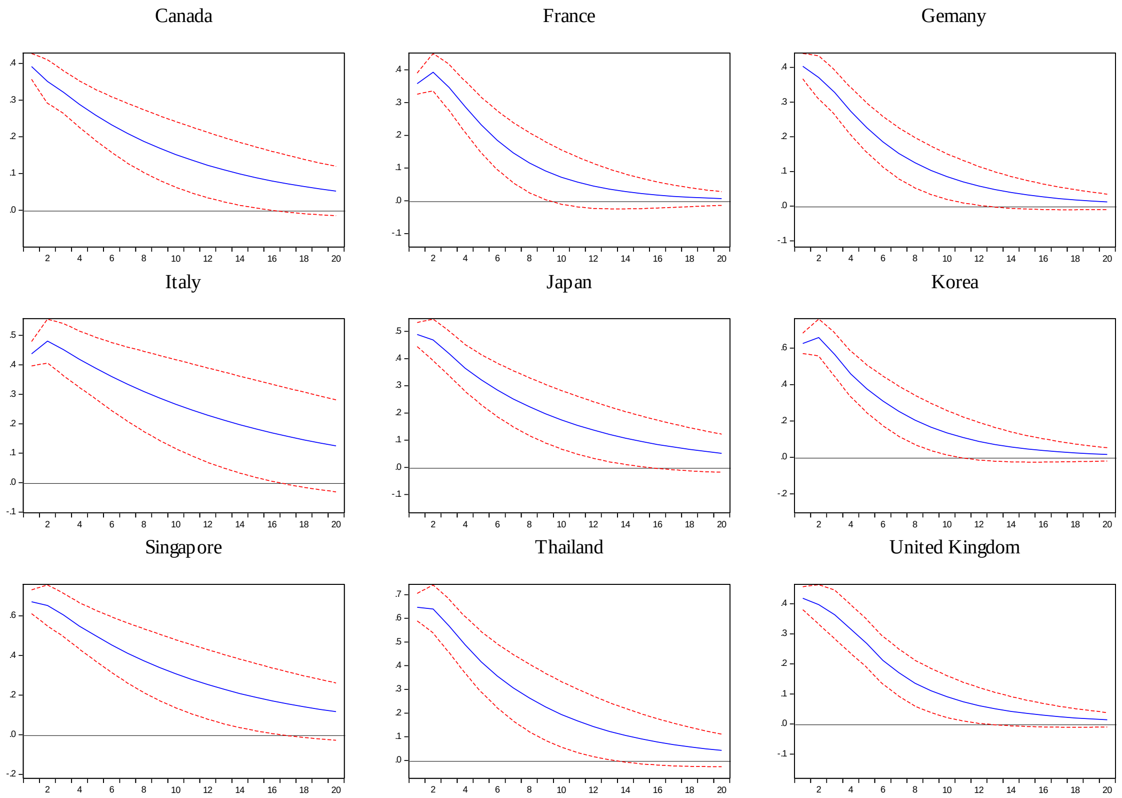

Figure 2.7b: Real Interest Rate Differential Response to Monetary Shock

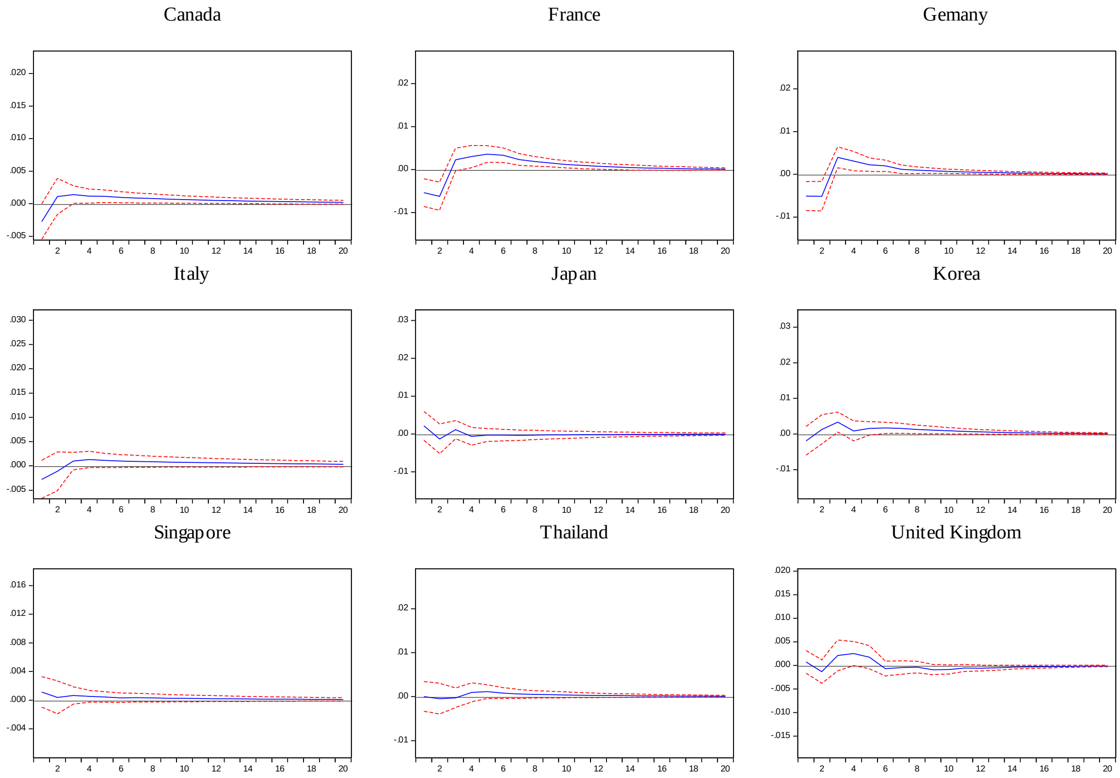

Figure 2.7c: Real Exchange Rate Response to Monetary Shock

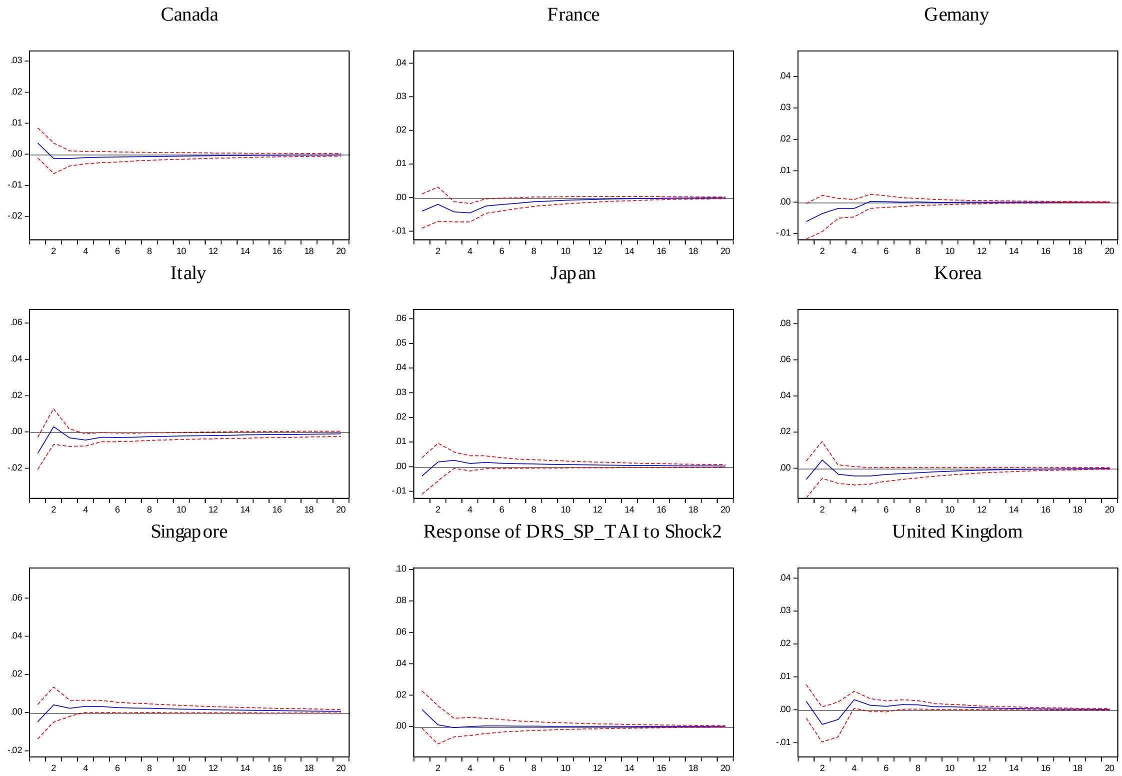

Figure 2.7d: Relative Stock Differential Response to Monetary Shock

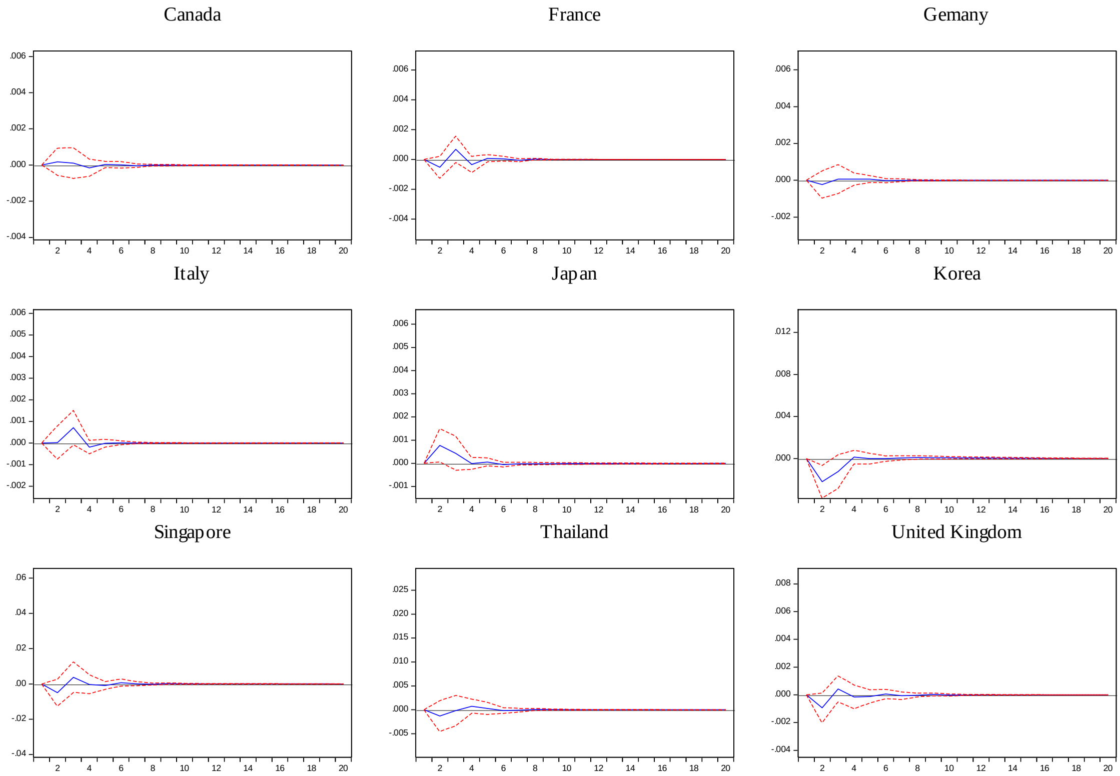

Figure 2.8a: Relative Output Differential Response to Currency Risk Premium Shock

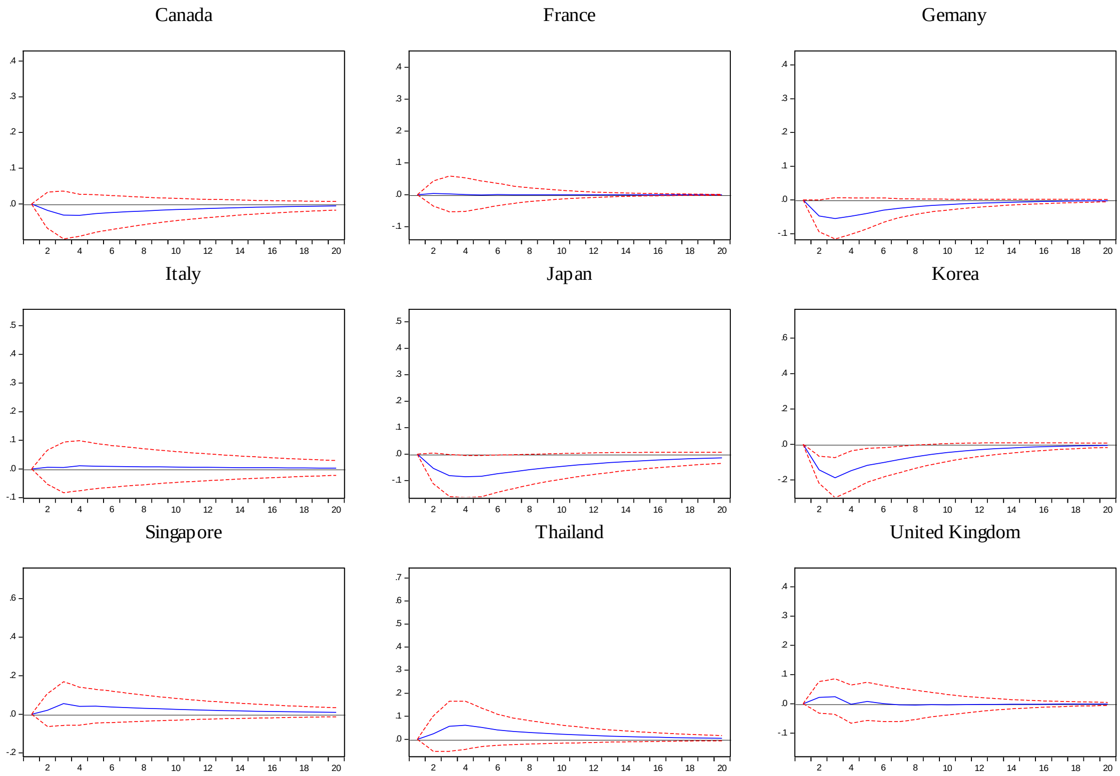

Figure 2.8b: Real Interest Rate Differential Response to Currency Risk Premium Shock

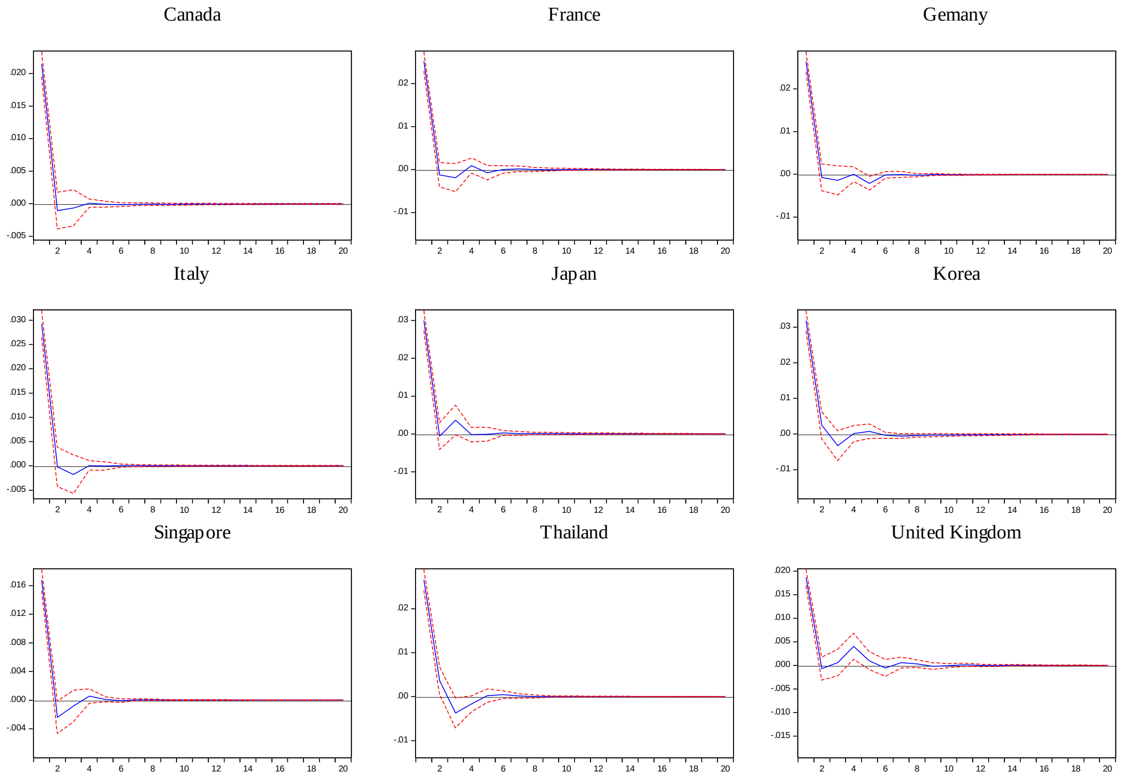

Figure 2.8c: Real Exchange Rate Response to Currency Risk Premium Shock

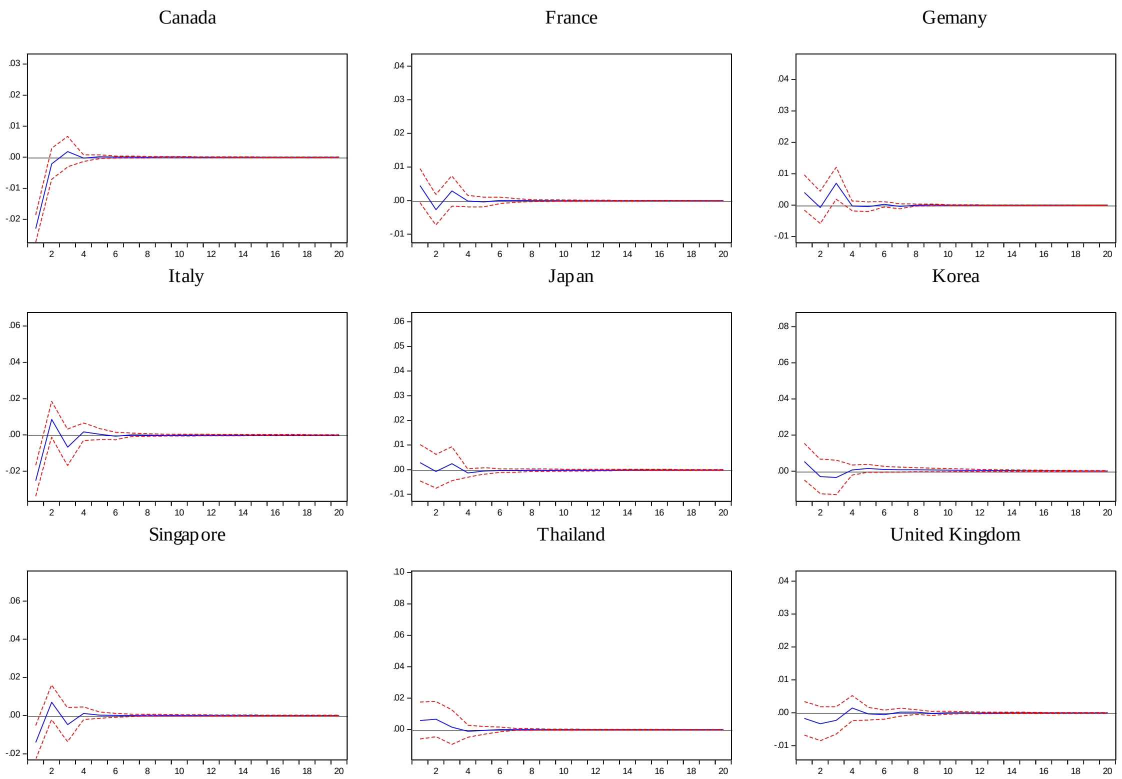

Figure 2.8d: Relative Stock Differential Response to Currency Risk Premium Shock

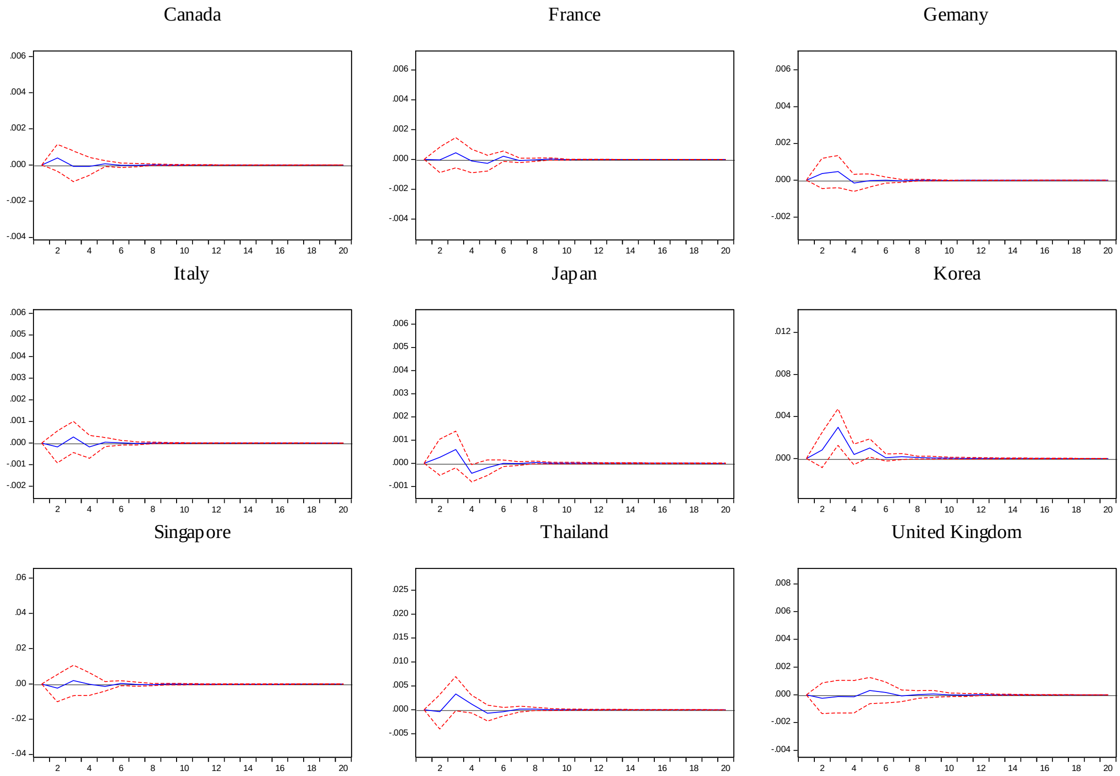

Figure 2.9a: Relative Output Differential Response to Expectation Shock

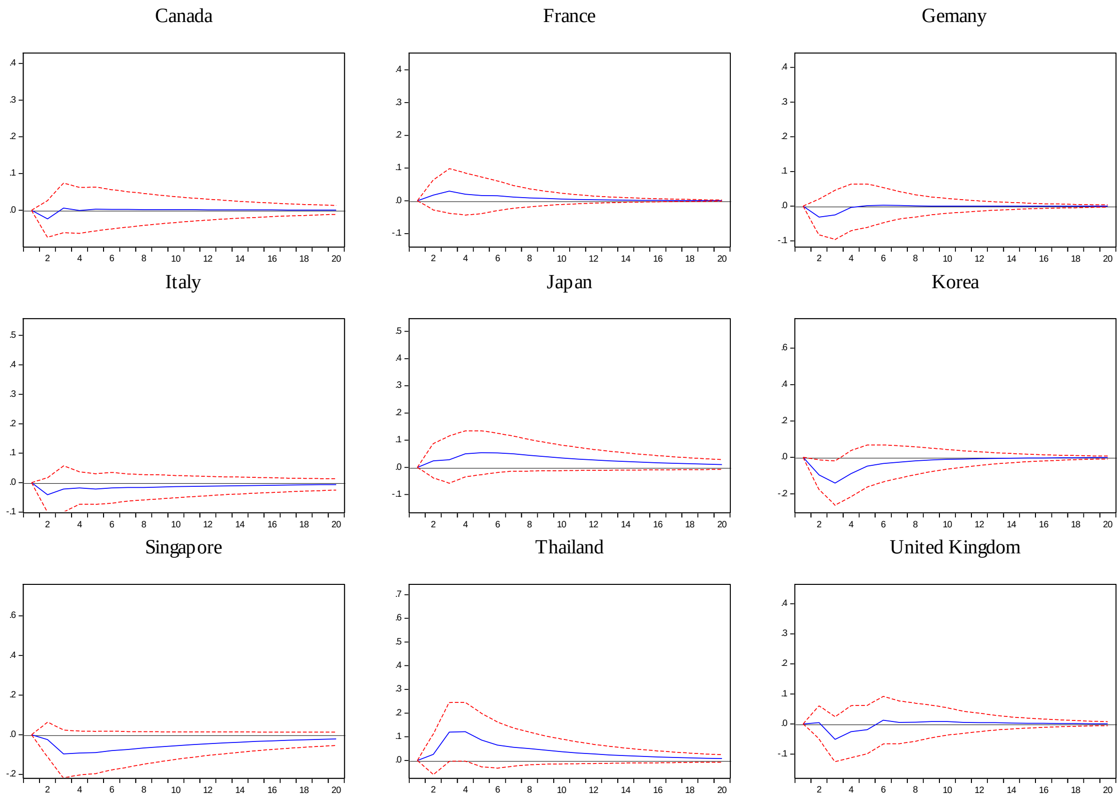

Figure 2.9b: Real Interest Rate Differential Response to Expectation Shock

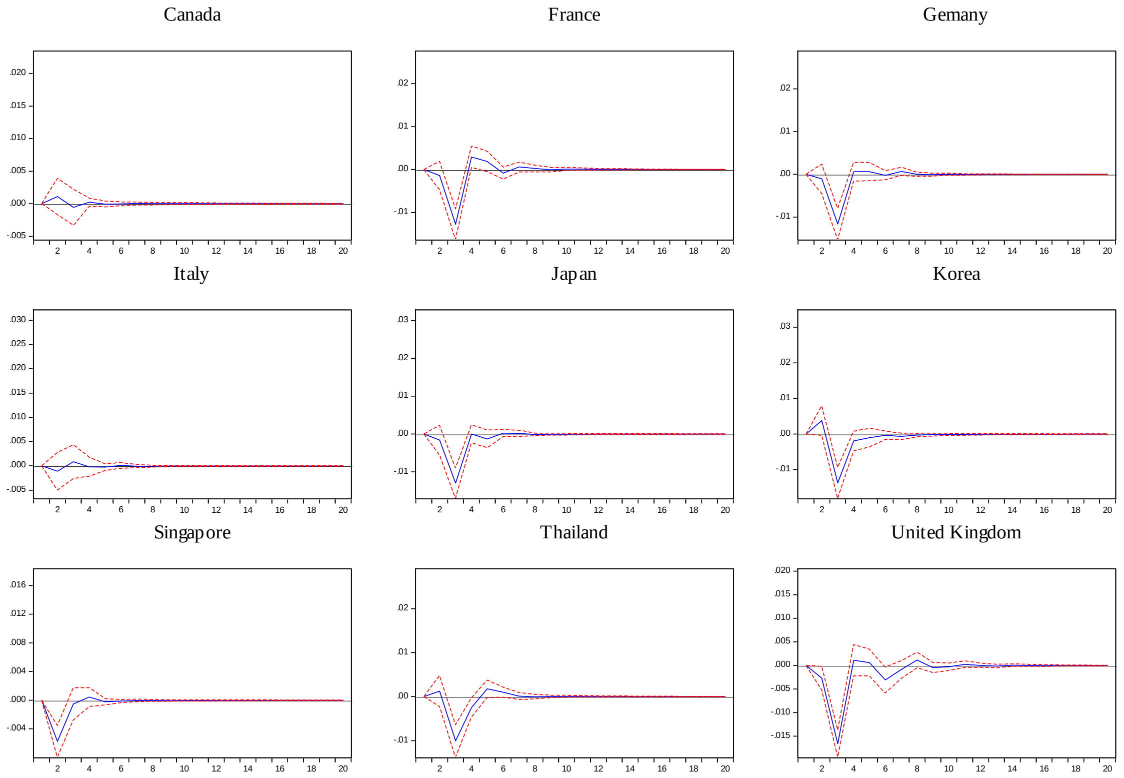

Figure 2.9c: Real Exchange Rate Response to Expectation Shock

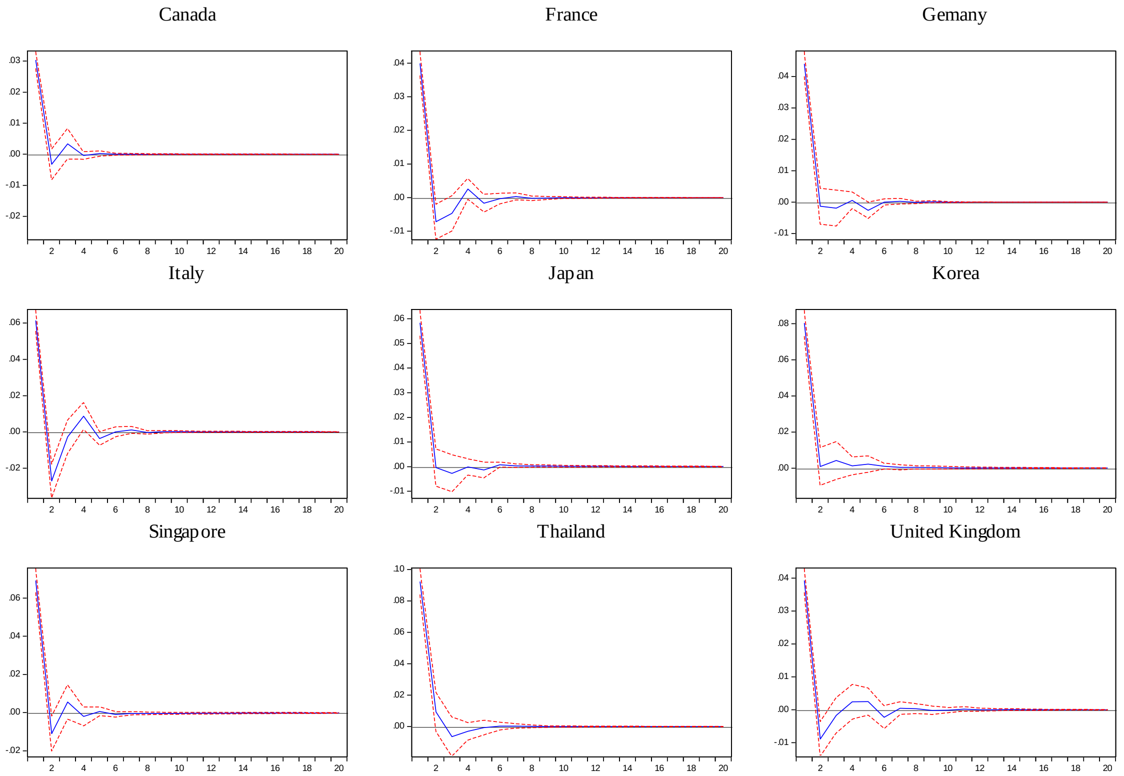

Figure 2.9d: Relative Stock Differential Response to Expectation Shock

V Conclusion

Over the past two decades, financial markets all over the world have been perceived as highly integrated. International capital funds not only play an important role for the stock price volatility, but also for the exchange rate fluctuation. This chapter investigates the sources of the real exchange rate fluctuation by developing and estimating a four-equation open macro model, which links up the financial, money and goods markets of advanced and transition economies. Following the conceptual framework of Clarida and Gali (1994), Malliaropulos (1998) and Hoffmann and MacDonald (2000), we present a theoretical model, which explains the interaction between the real exchange rate, real interest rate differential, relative stock differential and relative output differential. The model clearly demonstrates that the relative output differential, the real interest rate differential, the real exchange rate and the relative stock price differential are driven by four structural shocks – the supply shock, the monetary shock, the currency risk premium (CRP) shock and the expectation shock in the short-run when price-stickiness is assumed.

We note that the CRP shocks play a dominant role while the expectation shock has apparently outperformed the supply and monetary shocks in explaining the fluctuations of the real exchange rate in most of our sample countries, particularly during the crisis periods. The contribution of the expectation shock is likely to be periodically over the sample periods in all cases. In addition, the contribution of the expectation shock is likely higher than the CRP shock prior to the Asian financial crisis in 1997 in the case of Thailand and Korea when their exchange rate was pegged with the US dollar. The collapse of the fixed exchange rate of Thailand's currency and the subsequent unexpected shift of the exchange rate regime to independently floating in Korea caused a clear 'jump' in her CRP shock's contributions.

During the AFC, there are no significant changes in the contribution of the shocks in the European countries. However, the demise of the dot-com bubble burst in early 2001 triggered an apparent increase in the CRP shock in most countries. Surprisingly, the magnitude of the changes in the CRP shock in the 2007/08 global financial crisis (with the exception of the United Kingdom) and the 2011 European sovereign debt crisis are relatively lower than in the case of the dot-com bubble crisis.

In the impulse response analysis, we find that the response of the real exchange rate to supply shock is mixed and less persistent and the initial impact is not statistically significant. On the other hand, the monetary shock obviously generates a negative effect at the beginning in most countries. It can be noted, however, that the effects experience an apparent opposing trend after the second month and reach the peak at roughly 3 to 4 months (with the exception of Japan and Singapore). This is consistent with Dornbusch's overshooting model that, under the assumption of price rigidity, an unanticipated decrease in money supply will lead to a persistent initial appreciation of the exchange rate. The initial appreciation must be proportionately larger than the long-run depreciation. As for the CRP shock, it is clear that an initial sharp real depreciation can be found in all nine countries. It might reflect the overreaction of the investors in response to any unfavourable news available in the markets. It is interesting that there is likely a 'delayed' real appreciation of the real exchange rate in response to a positive expectation shock in most cases. One possible reason for the delayed appreciation might be the herd behaviour in the financial markets, since some currencies are dominated by a few big players as evidenced in The Federal Reserve Bank of New York (1998). Capital will inflow to the country if those big players become aware that the stock market of the country is profitable. Their actions would initially cause changes in real exchange rate and the relative stock differential, and the real exchange rate would further appreciate as a result when the other investors become aware of current trends and follow those big players' actions.

Chapter 3

The Dynamic Impact of Exchange Rate Regime Switching, Financial Crises and Monetary Policy Actions on the Real Exchange Rates Equicorrelations

I Introduction

It has been twenty years since the onset of the Asian financial crisis (AFC). The crisis that began in early July 1997 with the collapse of the fixed exchange rate system in Thailand led to considerable impacts on the Asian economies. Many earlier research papers investigated the causes of the AFC and emphasised the unsustainable deterioration in economic fundamentals as the principal factor in the subsequent AFC (Eichengreen *et al*., 1998; Radelet & Sachs, 1998a, 1998b; Corsetti et al., 1999). Calvo (1998) argues that the rapid reversal in capital flow may generate a financial crisis.

Similar results can also be found in the research works of Rigoborn (1998). Other studies have considered the 'herd behaviour' as an additional explanation of the AFC (Chari & Kehoe, 2003; Kaminsk & Schmukler, 1999).

Instead of examining the cause or the consequence of the AFC, the main objective of this chapter is to empirically investigate the real exchange rate co-movement among four Asian economies (Korea, Thailand, Malaysia and Indonesia) from the period of 1993[12] to 2015. Prior to the onset of the AFC, Thailand maintained its exchange rate linked to a basket of other foreign currencies with a high proportion of the US dollar, while the others operated a managed floating exchange rate regime. During the AFC, the rapid reversal of capital movements and the perpetual speculative attacks of international hedge funds eventually led to a collapse of financial markets and a clear devaluation of neighbouring countries' currency. In the meantime, Thailand's currency was forced to float in July 1997, followed by the subsequent adoption of the free floating exchange rate in Indonesia in August 1997, Korea in November 1997 and of the pegged exchange rate in Malaysia in September 1998.

Summarising their experience in the AFC, the exchange rate dynamics of these countries provide a good experiment on examining the manner in which the cross-country real exchange rate correlation responds to an official exchange rate regime switching[13]. Moreover, our sample period covers at least three other financial crises, the 2000/01 dot-com bubbles (DCB), the 2008/09 global financial crisis (GFC) and the 2011/12 European sovereign debt crisis (ESC), which allows us to observe the manner in which the cross-country real exchange rate correlation responds to each crisis.

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[12] The trade balance data in Thailand is only available after 1993.

[13] Please refer to Appendix B for more details regarding the exchange rate regime for the four countries before and after the Asian financial crisis (AFC).

To a certain extent, the exchange rate can be regarded as an important asset price. Investors hold indirect positions in foreign currencies when they invest in the foreign countries without hedging the currency exposure implied by the total holdings of foreign assets. Most importantly, the exchange rate policy varies across countries and time. A diversified portfolio of currencies might be a safer investment than any one currency alone. It is generally believed that international diversification is an effective strategy to lower unsystematic risk, which has predominantly relied on the existence of low cross-country exchange rate correlations. In addition to the cross-country real exchange rates correlation, the evolution of the cross-country equilibrium real exchange rates correlation and cross-country temporary real exchange rates correlation are also examined in this chapter.

The dynamic conditional correlation (DCC) model of Engle (2002) has been widely used in order to measure the dynamic correlation in financial literature. However, as suggested by Caporin and McAleer (2014), in the case of the DCC model only the pairwise time-varying conditional correlation can be calculated simultaneously. The dynamic equicorrelation (DECO) model of Eagle and Kelly (2012), which sets the equicorrelation equal to the average pairwise dynamic conditional correlations (DCC) of Engle (2002) in order to eliminate the computational and presentational difficulties of the high-dimension system, is used to estimate the time-varying average cross-country - i) real exchange rate correlation, or namely real exchange rate equicorrelation (REC), ii) behavioural equilibrium exchange rate equicorrelation (BEC) and iii) temporary real exchange rate equicorrelation (TEC) among the four countries over the sample period.

We adopt the behavioural equilibrium exchange rate (BEER) approach of Clark and MacDonald (1998) and the cointegration technique in order to decompose the real exchange rate into permanent and temporary components. Of course, there are a number of specific exchange rate models or econometric approaches to measure the equilibrium and the temporary real exchange rate. For example, Chinn (2000) applies the purchasing power parity (PPP) approach and monetary model of exchange rates in order to evaluate whether the currencies of some Asian economies were overvalued, and finds an overvaluation in Indonesia and Thailand prior to the AFC. Nevertheless, the PPP approach is unlikely to be a useful measure of an equilibrium exchange rate due to the high volatility and slow mean reversion properties of the real exchange rate (MacDonald & Dias, 2007).

The fundamental equilibrium exchange rate (FEER) proposed by Williamson (1994) might be an alternative to measuring the equilibrium exchange rate. However, as Wren-Lewis (1992) indicates, the FEER is just a method of calculation rather than an estimated exchange rate model, whereas the BEER approach is able to capture all the systematic and fundamental movements of the real exchange rate and can be subject to rigorous statistical testing. Low frequency data are usually used for the calculation of the equilibrium exchange rate in previous studies. In this chapter, we use monthly data for our estimations, as a higher frequency reduces the likelihood that any changes in the real exchange rates correlation, particularly the cross-country temporary real exchange rates correlation, are due to some other economic factors not included in the estimation.

Earlier papers (Calvo, 1998; Rigoborn, 1998; Wong & Li, 2009) documented that the rapid reversal of capital flow would result in a sharp adjustment in the stock markets. Following the findings of these papers, it is expected that the abrupt decline in stock markets should associate with a joint increase in the temporary component of real exchange rates during the financial crisis. As noted, our sample period covers four financial crises. Understandably, the causes of the financial crises are always different from each other, but the impact on each economy is always similar. Therefore, it may be of particular interest to examine whether the equicorrelation of the temporary component in the real exchange rate (TEC) would increase in each financial crisis significantly.

Furthermore, it is also instructive to investigate whether the US monetary variables related to the REC, BEC and TEC movement as market participants in the foreign exchange market and central banks of many countries might concern about the US monetary policy changes. Many papers suggested that the US monetary policy generates impacts on the foreign exchange rates movement. For example, Kalyvitis and Michaelides (2001) used the monetary policy indicator proposed by Bernanke and Mihov (1998) in order to examine the impact of the US monetary policy shocks on exchange rates and found that there was a statistically significant appreciation of the US dollar for around 3 months after a positive monetary shock for all the currencies (Japan, Germany, Italy, France and the UK). In this chapter, we follow the earlier studies (Bernanke & Blinder, 1992; Lewis, 1995; Sim & Zha, 1995) and use the monetary aggregates M1, M2 and the federal funds rate (FFR) as a measure of the monetary transmission mechanism.

The global financial markets have become more integrated over the last two decades. The issue of financial contagion has received an enormous amount of attention in the economic literature. Much of this research, however, focuses almost exclusively on the security co-movements between countries (Dellas & Hess, 2005; Bekaert *et al*., 2009 and Christoffersen *et al*., 2014), while the analysis of the cross-country real exchange rates correlation appears to be widely neglected in academic research. This chapter contributes to filling this gap by studying the exchange rates co-movement using the DECO model, which can be considered as a measure of aggregate time-varying correlations.

On the other hand, understanding what drives the exchange rates co-movement and the evolution of the exchange rate correlations is relevant for various areas in finance, including portfolio diversification, risk management, hedging and pricing of financial derivatives and other structural products, and asset allocation decisions. Specifically, we decomposed the real exchange rate into the temporary and equilibrium exchange rates for studying their equicorrelation. It is particularly useful for institutional investors to decide their short- and long-term investments.

The remainder of the paper is organised as follows. Section II reviews the methodology of the behavioural equilibrium exchange rate (BEER) and the dynamic equicorrelation (DECO) model. Section III gives the data description and the preliminary test. The empirical results in Section IV consist of three parts. The first part shows the estimated behavioural equilibrium exchange rate and temporary component of the real exchange rate for the four countries. The second part presents our empirical findings pertaining to the time-varying cross-country - real exchange rate equicorrelation (REC), behavioural equilibrium exchange rate equicorrelation (BEC) and temporary real exchange rate equicorrelation (TEC) over the sample period and how they respond to each financial crisis. The final part reports the statistical results regarding the impacts of the US monetary policy actions on the REC, BEC and TEC. Section IV concludes the paper.

II Methodology

3.2a The behavioural equilibrium exchange rate (BEER) approach

There are three steps to measure the equilibrium real exchange rate. We firstly apply the Johansen (1995) procedure in order to test for the existence of a long-run cointegrating relationship between the real exchange rate and its fundamental variables. The next step is to identify the long-run value for the fundamentals by decomposing the series into permanent and transitory components. Finally, the extracted permanent components of the fundamentals are used to compute the equilibrium real exchange rate and the real exchange rate misalignment, which is the deviation between the actual current real exchange rate and its equilibrium level.

We assume the system is described by the following vector autoregressive (VAR) representation:

$$x_t = \eta + \sum_{i=1}^{p} \Pi_t x_{t-i} + \Psi D_t + \varepsilon_t \qquad (1)$$

where x_t is a (4 x 1) vector:

$$x_t = [q_t, r_t - r_t^*, tb_t, prod_t].$$

η is a (4 x 1) vector of constants; Π_i are the coefficient matrices of the lagged variables, where $i = 1...P$; D_t is a vector of dummy variables and ε_t is a (4 x 1) vector of white noise disturbance with mean zero and covariance matrix Ω. The variables in the system x_t are those fundamentals considered in BEER[14], where q_t denotes the real exchange rate, r_t - r_t^* is the real interest rate differential, tb_t is the trade

[14] Different to Macdonald and Dias (2007), we only estimate the BEER with these four variables due to the unavailability of the terms of trade data in Malaysia and Thailand.

balance and $prod_t$ is the relative productivity, measured by the domestic GDP per capita relative to the US. Assume the system x_t is integrated of order one, equation (1) can be reparameterised into the vector error correction mechanism (VECM) representation:

$$\Delta x_t = \eta + \prod x_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta x_{t-i} + \Psi D_t + e_t\,, \qquad (2)$$

where Δ represents the first difference operator; Γ_i is a (4 x 4) coefficient matrix (equal to $-\sum_{j=i+1}^{P} \Pi_j$) and Π is (4 x 4) matrix (equal to $\sum_{i=1}^{P} \Pi_i - I$) whose rank determines the number of cointegrating vectors. In this chapter, the trace test statistic of Johansen (1995) is used in order to determine the existence of cointegration amongst the variables in x_t. If the rank of Π is either 4 (full rank) or 0 (zero rank), then no cointegration exists among the variables. In these cases, it will be appropriate to estimate the model, respectively, in levels for full rank or first difference for zero rank. If Π is of reduced rank (r), where r < 4, it suggests that an r cointegration(s) exists among the variables, and (n x r) matrices α and β, such that $\Pi = \alpha\beta^{'}$, where matrix α represents the speed of adjustment to the disequilibrium and $\beta^{'}$ is the matrix whose columns are the linearly independent cointegrating vector(s).

In our estimations, the cointegrating vector is normalised by the real exchange rate so that the estimated vector β can be used to provide a measure of the equilibrium real exchange rate and also a quantification of the temporary real exchange rate, which represents the difference between the actual real exchange rate and its equilibrium level.

3.2b The DECO model

Engle (2002) proposes the dynamic conditional correlation (DCC) model, which has the flexibility of the GARCH models coupled with the parsimonious parametric models for the correlations. The model greatly simplifies multivariate specifications. However, the estimation becomes cumbersome as the size of the system grows. The dynamic equicorrelation (DECO) model of Eagle and Kelly (2012) can be considered as an advanced case of the DCC model, which sets all series pairs share the same correlation on a given day. This hypothesis eliminates the computational and presentational difficulties of high-dimension systems.

Similar to the DCC model, the DECO model implements a two-step procedure in order to estimate the dynamic correlation. In the first step, the individual series are regressed on the univariate GARCH process. The variance equation of the GARCH (*p*, *q*) process can be defined as:

$$h_t = w_0 + \sum_{i=1}^{q} \alpha_i u_{t-1}^2 + \sum_{i=1}^{p} \beta_i h_{t-i}, \tag{3}$$

where $w_0 > 0$, $\alpha_i \geq 0$ and $\beta i \geq 0$ ($\forall i$). The standardised residuals obtained in the first stage are then provided as an input to the second step for estimating the conditional correlation. Different to the DCC model, the correlation matrix of the n x 1 vector random variables is defined as:

$$R_t = (1 - \bar{\rho}_t) I_n + \bar{\rho}_t J_{nxn} \tag{4}$$

where ($\bar{\rho}_t$) represents the equicorrelation; (I_n) is the n-dimensional identity matrix; and (J_{nxn}) is the nxn matrix of ones. All series pairs are restricted to have the same correlation on a given day.

Under the DECO framework, the conditional correlation (ρ_t) specification is firstly derived from the DCC model of Engle (2002) and its cDCC modification proposed by Aielli (2009). The scalar version of the DECO model specifies the evolution of Q_t as:

$$Q_t = (1-\alpha_2-\beta_2)\bar{Q} + \alpha_2 e_{t-1}e_{t-1}^{'} + \beta_2 Q_{t-1} \ , \qquad (5)$$

and the equicorrelation ($\bar{\rho}_t$) is computed as the average pairwise DCC correlations, $\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}q_{jj,t}}}$, at time t, so that:

$$\bar{\rho}_t = \frac{2}{n(n-1)}\sum_{t\neq j}\frac{q_{ij,t}}{\sqrt{q_{ii,t}q_{jj,t}}} \ . \qquad (6)$$

where $\bar{Q}$ is the unconditional covariance of standardised residuals and $q_{ij,t}$ represents the i, j^{th} elements of Q_t .

III Data and Preliminary Test

All *data* in this chapter are *obtained* from DataStream and the International Financial Statistics. The sample covers the period from January 1993 to December 2015. The data used for constructing the equilibrium real exchange rate includes the real exchange rate, the real interest rate differential, the trade balance and the GDP per capita of the four Asian economies (Thailand, Korea, Malaysia and Indonesia). The US is considered as the 'foreign' country.

The real exchange rate is expressed in logarithm and calculated by the equation $q_t = e_t + p_t^* - p_t$, where e_t is the nominal exchange rate against the US dollar and p_t^* (p_t) represents the foreign (home) consumer price index. The real interest rate is expressed in the Fisher equation format: $r_t = i_t - (E_t p_{t+1} - p_t)$, which is equal to the nominal interest i_t rate minus the expected inflation rate. All the series are expressed in logarithm with the exception of the interest rates and trade balance. In this chapter, we use monthly data for our estimation. In the case where the only available data frequency is quarterly or annual, the interpolation technique is used in order to convert them into comparable monthly data.

Before proceeding to the real equilibrium exchange rate construction, it is necessary to determine the order of integration of those economic fundamentals in our system. Table 3.1 reports the statistic results of the Augmented Dickey-Fuller (ADF) test in levels and first differences of the variables. The statistic results indicate that most series in levels are non-stationary but become stationary after being first-differenced.

Table 3.1: ADF Test

	Korea	Thailand	Indonesia	Malaysia
tb_t	-0.19	-2.42**	-1.28	-0.08
$\triangle tb_t$	-8.38**	-6.53**	-6.15**	-7.54**
r_t - r_t^*	-1.99**	-2.13**	-2.68**	-3.01**
Δr_t - r_t^*	-6.76**	-5.20**	-4.26**	-4.92**
q_t	0.20	0.26	0.14	0.60
$\triangle q_t$	-4.94**	-5.45**	-5.47**	-4.09**
$prod_t$	2.40**	1.13	1.31	1.58
$\triangle prod_t$	-3.29**	-2.91**	-3.01**	-3.53**

Note: ** and * represent the statistical significance at 5% and 10%, respectively.

IV Empirical Results

3.4a Constructing the equilibrium exchange rate and the temporary component

We firstly perform the Johansen cointegration procedure to an unrestricted vector autoregressive (VAR) model (equation (1)) in order to test for the number of cointegrating relationships among the 4 variables in our systems. The Akaike Information Criterion (AIC) statistic results suggest that the appropriate lag length is 1 for Thailand and 2 for Korea, Malaysia and Indonesia. The dummy variables[15] for the

[15] The first dummy θ_{AFC} was included in the estimation by taking on the value of 1 from May 1997 to September 1998 to account for the Asian financial crisis that started in mid-1997 and severely damaged the economy of the Asian countries. θ_{DCR} is included in order to capture the effects of the dot-com bubble burst from Jul 2000 to Apr 2001. The demise of the dot-com bubble in 2001 triggered a long-lasting decline in the global stock markets. θ_{GFC} is introduced to cover the 2008 financial crisis from September 2008 to September 2009. Finally, θ_{ESC} is included to capture the impacts of the European sovereign debt crisis from Aug 2011 to Mar 2012. At that time, the yields of the long-term government bonds of some countries in the Eurozone rose above 6%, which indicates that the financial markets are highly concerned about the credit-worthiness of the country.

1997/98 Asian currency crisis, the 2000/01 dot-com bubble, 2008/09 financial crisis and 2011/12 European sovereign debt crisis are included in order to prevent the presence of outliers.

The results[16] of the trace test for the cointegration rank are reported in the top panel of Table 3.2. Overall, the cointegration test results indicate the presence of a cointegration relationship for each economy. The null hypothesis stipulating that there is no cointegrating vector is significantly rejected in all cases. Furthermore, the null hypothesis indicating that there is at most 1 cointegrating vector is also rejected in the case of Korea and Malaysia.

[16] Note that the critical values for the standard cointegration test may not be appropriate for the system with dummy variables. Please refer to Saikkonen and Lütkepohl (2000) for more detail.

Table 3.2: Trace test of the cointegration rank and estimated coefficients

	Korea	Thailand	Indonesia	Malaysia
Cointegration rank				
H_0: r				
0	68.42**	78.87**	115.81**	85.68**
1	31.77**	22.40	29.57	45.69**
2	15.39	8.91	12.40	10.62
3	5.98	1.87	2.33	3.05
Coefficients				
$r_t - r_t^*$	-0.034	-0.099	0.015	-0.004
	(0.013)**	(0.008)**	(0.003)**	(0.016)
tb_t	2.61×10^{-5}	-9.06×10^{-6}	9.59×10^{-5}	3.83×10^{-5}
	(0.000)**	(0.000)	(0.000)**	(0.000)**
$prod_t$	-3.115	-5.914	0.597	-3.396
	(1.215)**	(0.680)**	(1.267)	(1.187)**
C	9.879	8.574	8.565	3.978
	(1.127)**	(0.566)**	(0.996)**	(1.037)**
θ_{AFC}	0.274	0.327	-0.206	0.123
	(0.076)**	(0.051)**	(0.154)	(0.063)*
θ_{DCB}	0.155	-0.038	0.443	0.102
	(0.081)*	(0.062)	(0.123)**	(0.074)
θ_{GFC}	0.194	-0.009	0.063	-0.137
	(0.064)**	(0.043)	(0.092)	(0.057)**
θ_{ESC}	0.081	-0.021	-0.218	-0.203
	(0.094)	(0.063)	(0.138)	(0.081)**

Note: The figures in parentheses represent the standard errors of the coefficients. ** and * represent the statistical significance at 5% and 10%, respectively.

The cointegration test results suggest that there is a long-run relationship between the real exchange rate and the identified fundamentals thereof for each economy. We then move into computing the equilibrium real exchange rate by using the long-run component of the fundamentals and the estimated cointegrating vectors. Assuming the cointegration vector is normalised by setting the real exchange rate $q_t = \beta_1 = 1$ and leaving the second cointegration vectors unrestricted for the system with $r = 2$.

The bottom panel of Table 3.2 gives the estimates for the cointegrating vector together with their standard errors, where r_t - r_t^* is the real interest rate differential, tb_t is the trade balance, expressing as a proportion of GDP in domestic currency. A positive trade balance represents that exports are taking a larger proportion of the CDP than that of the imports, vice versa. $prod_t$ is the relative productivity, measured by the domestic GDP per capita relative to the US. The estimated coefficient of the real interest rate differentials is statistically significant in all cases except for Malaysia. Three countries have the expected negative sign, which is consistent with the sticky-price interpretation of the exchange rate determination (see, for example, Dornbusch, 1976). All the estimated coefficients of trade balance are positive and significant with the exception of Thailand although the value is extremely small. The positive sign indicates that the real exchange rate will depreciate when exports are taking a larger proportion of the GDP to that of imports. The estimated coefficient of relative productivity is significant in Korea, Thailand and Malaysia at a 5% level of significance and all coefficients are negative related to the real exchange rate, which is correctly signed in terms of the theoretical interpretation of the effects of productivity on the exchange rate (see, for instance, MacDonald & Ricci, 2002). Most of the dummy variables are positive and statistically significant, implying that the financial crises would result in the real exchange rate depreciation.

Figure 3.1 displays the evolution of the actual real exchange rate and the estimated equilibrium exchange rate for four economies for the period 1993 to 2015, respectively. The equilibrium real exchange rates are derived from the equilibrium value of the fundamental variables in the bottom panel of Table 3.2. The actual real exchange rate of all economies is apparently below its equilibrium level prior to mid-1997, suggesting that the Korean Won, Indonesian Rupiah, Malaysian Ringgit and Thailand Baht were overvalued prior to the AFC. An obvious adjustment (depreciation/devaluation) can be seen during the onset of the crisis, in which the real exchange rate overshot to its equilibrium level. Note that the estimated equilibrium exchange rate of Malaysia is highly fluctuated from 2011 to 2014. This may due to the sharp volatility in the economic fundamental caused by the subprime mortgage crisis in 2008 and the subsequent sovereign debt crisis in 2011.

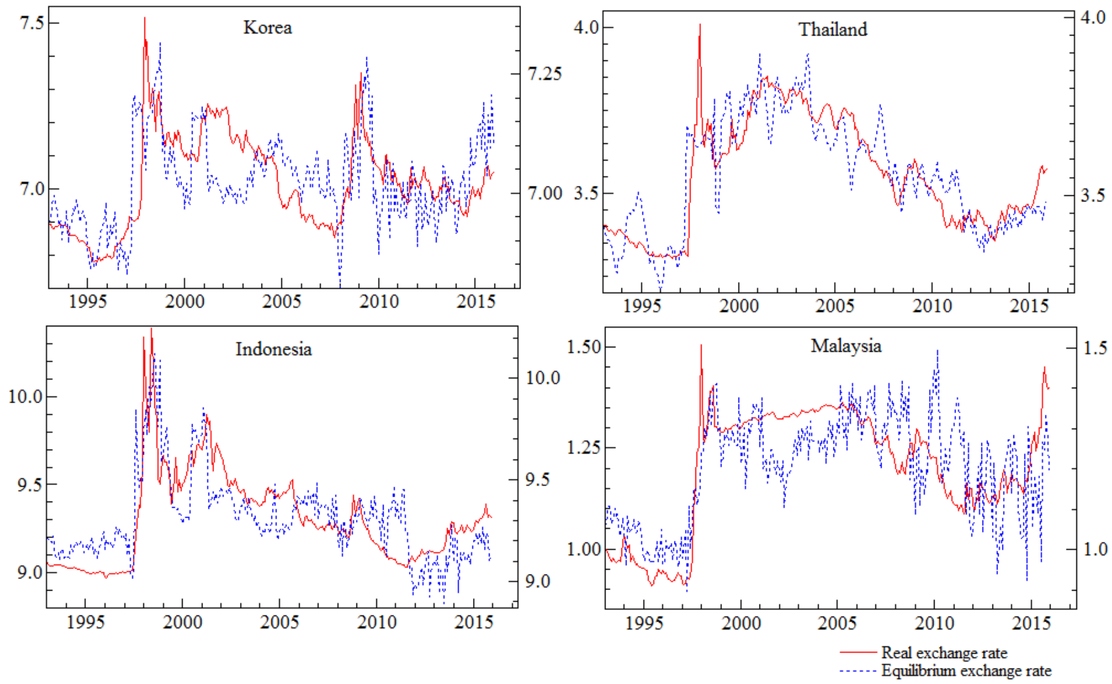

Figure 3.1: Time Plots of the Real Exchange Rate and Equilibrium Exchange Rate

The calculated temporary real exchange rate (the deviation between the actual current real exchange rate and its equilibrium level) for the four economies were plotted in Figure 3.2. All economies went through a period of undervaluation from 1998 to 2005, with the exception of Thailand. It ought to be borne in mind that all four economies were operating a floating exchange rate during this period of time with the exception of Malaysia. The poor performance of the actual real exchange rate might reflect that the market participants were suffering from a lack of confidence about the economic recovery of those countries.

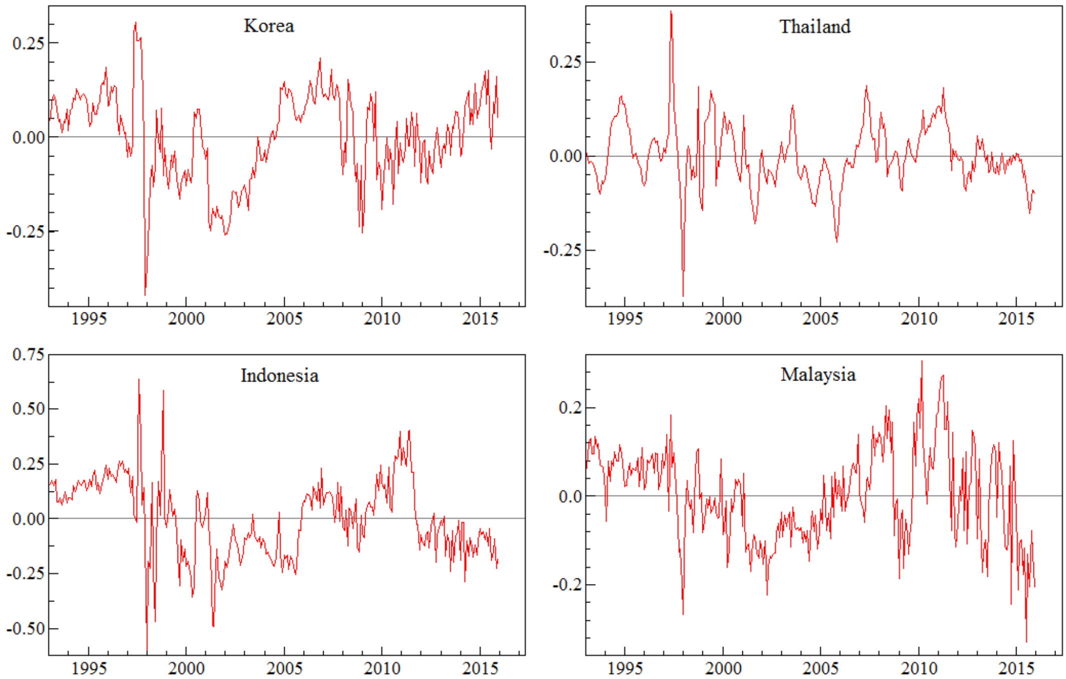

Figure 3.2: Time Plots of the Temporary Real Exchange Rate

3.4b Estimating the REC, BEC and TEC

As discussed in the methodology section, there is a two-step procedure implemented in order to estimate the equicorrelations. In the first step, the individual series are regressed by a univariate GARCH process. Due to the asymmetric effect feature in the financial markets, we consider the $GJR(1,1)$ model for the univariate GARCH specifications. The appropriate lagged dependent variable in the mean equations is based on the AIC criteria. The standardised residuals obtained in the first step are then given as an input to the second step DECO model.

Tables 3.3a to 3.3c report the estimates of the DECO model for the real exchange rate, the behavioural equilibrium real exchange rates and the temporary real exchange rate, respectively. Panel A in each table gives the estimates for the AR (ψ) – GJR (1, 1) specification, their standard errors, and the diagnostics test, while Panel B illustrates the estimates for the DECO model. Parameters α and β are the GARCH parameters from equation (3), while γ represents the asymmetry parameter and ψ_i are the coefficients of the AR process.

Summarising the results from Table 3.3a to 3.3c, it can be noted that the AR (ψ) terms in the mean equation are mostly statistically significant in Table 3.3b and 3.3c, suggesting that these economies are better characterised with the AR process. In the variance equations, α and β are highly significant in most cases, while the coefficient of asymmetry γ is significant only in few cases, indicating that the asymmetric effect does not exist in most series.

Table 3.3a: The estimates of the DECO model – real exchange rate (REC)

	Korea	Thailand	Indonesia	Malaysia
Panel A: AR (ψ) - GJR (1, 1)				
The mean equation:				
w_{I}	0.000	0.002	-0.003	0.001
	(0.001)	(0.005)	(0.001)**	(0.001)
ψ_1	0.018	0.143	0.005	0.211
	(0.088)	(0.135)	(0.068)	(0.078)**
ψ_2	0.062	-0.075	-0.028	0.011
	(0.068)	(0.093)	(0.117)	(0.090)
The variance equation:				
w_{I}	1.788	0.924	0.129	0.018
	(0.945)*	(1.518)	(0.176)	(0.014)
α_{I}	0.848	0.222	1.904	0.601
	(0.393)**	(0.210)	(0.928)**	(0.202)**
β_{I}	0.311	0.795	0.489	0.749
	(0.135)**	(0.534)	(0.108)**	(0.057)**
γ_{I}	-0.429	-0.326	-1.560	-0.454
	(0.415)	(0.082)**	(0.815)*	(0.253)*
Ljung-Box Q-statistics:				
$Q(8)$	5.791	5.706	6.840	7.818
	(0.671)	(0.680)	(0.554)	(0.451)
$Q^2(8)$	8.284	0.787	2.006	0.873
	(0.406)	(0.999)	(0.981)	(0.999)
Panel B: DECO parameter				
α_{D}	0.056			
	(0.022)**			
β_{D}	0.944			
	(0.023)**			
df	4.470			
	(0.487)**			
Vector normality	635.220			
	(0.000)**			

Note: The figures in parentheses represent the standard errors of the coefficients and the *p*-value for the Ljung-Box Q-statistics. ** and * represent the statistical significance at 5% and 10%, respectively.

Table 3.3b: The estimates of the DECO model – behavioural equilibrium exchange rate (BEC)

	Korea	Thailand	Indonesia	Malaysia
<u>Panel A: AR (ψ) - GJR (1, 1)</u>				
The mean equation:				
w_I	0.000	0.000	0.010	0.001
	(0.002)	(0.002)	(0.131)	(0.005)
ψ_1	-0.236	0.003	-0.277	-0.546
	(0.066)**	(0.093)	(0.003)**	(0.092)**
ψ_2	-0.066	0.087	-0.180	-0.147
	(0.081)	(0.105)	(0.001)**	(0.049)**
ψ_3	-0.128	-0.144	0.105	0.090
	(0.089)	(0.086)*	(0.050)**	(0.054)*
ψ_4	-0.131	-0.116	-0.040	-0.035
	(0.072)*	(0.054)**	(0.032)	(0.038)
The variance equation:				
w_I	0.562	3.162	0.036	0.010
	(0.775)	(1.459)**	(0.300)	(0.000)
α_I	0.082	1.064	-0.093	0.115
	(0.064)	(0.997)	(0.300)	(0.067)*
β_I	0.897	0.341	0.388	-0.634
	(0.020)**	(0.183)*	(0.048)**	(0.028)**
γ_I	0.046	-0.552	-0.263	0.092
	(0.132)	(0.962)	(0.027)**	(0.074)
Ljung-Box Q-statistics:				
$Q(8)$	3.167	17.76	5.115	9.373
	(0.923)	(0.023)**	(0.745)	(0.312)
$Q^2(8)$	1.487	2.089	8.148	2.282
	(0.993)	(0.978)	(0.419)	(0.971)
<u>*Panel B: DECO parameter*</u>				
α_D	0.039			
	(0.045)			
β_D	0.961			
	(0.047)**			
df	6.005			
	(1.011)**			
Vector normality	271.340			
	(0.000)**			

Note: The figures in parentheses represent the standard errors of the coefficients and the *p*-value for the Ljung-Box Q-statistics. ** and * represent the statistical significance at 5% and 10%, respectively.

Table 3.3c: The estimates of the DECO model – temporary exchange rate (TEC)

	Korea	Thailand	Indonesia	Malaysia
Panel A: AR (ψ) - GJR (1, 1)				
The mean equation:				
w_I	0.044	1.045	0.023	0.413
	(0.039)	(0.072)**	(0.192)	(0.057)**
ψ_1	0.780	-0.205	0.575	0.416
	(0.070)**	(0.072)**	(0.076)**	(0.057)**
ψ_2	0.137	0.000	0.399	0.000
	(0.069)**	(0.003)	(0.083)**	(0.004)
The variance equation:				
w_I	0.000	0.000	0.000	0.000
	(0.000)**	(0.000)	(0.000)*	(0.000)
α_I	0.083	0.152	0.215	0.102
	(0.095)	(0.057)*	(0.107)**	(0.034)**
β_I	0.777	0.775	0.668	0.891
	(0.049)**	(0.053)**	(0.061)**	(0.035)**
γ_I	0.222	-0.029	0.347	-0.014
	(0.261)	(0.008)*	(0.294)	(0.014)
Ljung-Box Q-statistics:				
$Q(8)$	6.608	10.494	9.311	12.558
	(0.579)	(0.232)	(0.317)	(0.128)
$Q^2(8)$	17.332	0.555	13.974	6.946
	(0.027)**	(0.999)	(0.082)*	(0.542)
Panel B: DECO parameter				
α_D	0.026			
	(0.029)			
β_D	0.974			
	(0.036)**			
Df	5.662			
	(0.829)**			
Vector normality	245.12			
	(0.000)**			

Note: The figures in parentheses represent the standard errors of the coefficients and the *p*-value for the Ljung-Box Q-statistics. ** and * represent the statistical significance at 5% and 10%, respectively.

We apply the residual-based diagnostics test in order to check whether each individual model in the first step is well specified. This is essential for ensuring that the relevant dynamics can be captured in the correlation structure. Both Ljung-Box Q-statistics results confirm the elimination of the higher order serial correlation for the standardised residuals (which specify the model fit of the mean equation) and squared standardised residuals (which specify the model fit of the conditional variance equation) in most cases so that the standardised residuals obtained can be used for estimating the time varying correlation matrix of the REC, BEC and TEC.

In panel B, we note that most of the DECO parameters α_D and β_D for the REC, BEC and TEC are statistically significant and in the range of typical estimates from the GARCH models, indicating the time-varying properties of the correlations. In addition, the sum of α_D and β_D is close to 1, denoting that the equicorrelation is nearly integrated. The student distribution (*df*) is statistically significant in all cases. The vector normality test provides the identical results that these series do not follow a multivariate normal distribution.

Figure 3.3 provides the fitted equicorrelation of the behavioural equilibrium real exchange rate (BEC). The BEC experienced a continuous decline over the sample period and turned negative after 2007. From 2008 to 2015, the BEC remained at a low negative level, except for the period of the European sovereign debt crisis (ESC). If the real exchange rate is mean[17] reverting in the long-run, the BEC results suggest that the low and negative correlations decrease the overall risk of a long-term diversified portfolio.

[17] We assume that the real exchange rate will convert to an equilibrium level in the long-run.

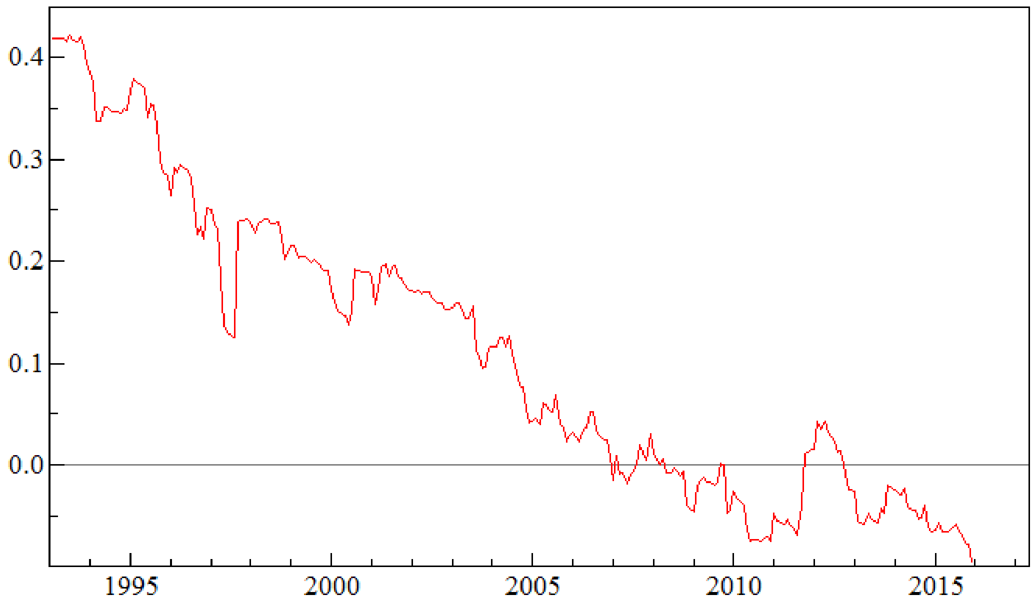

Figure 3.3: The Equicorrelation of the Behavioural Equilibrium Exchange Rates (BEC)

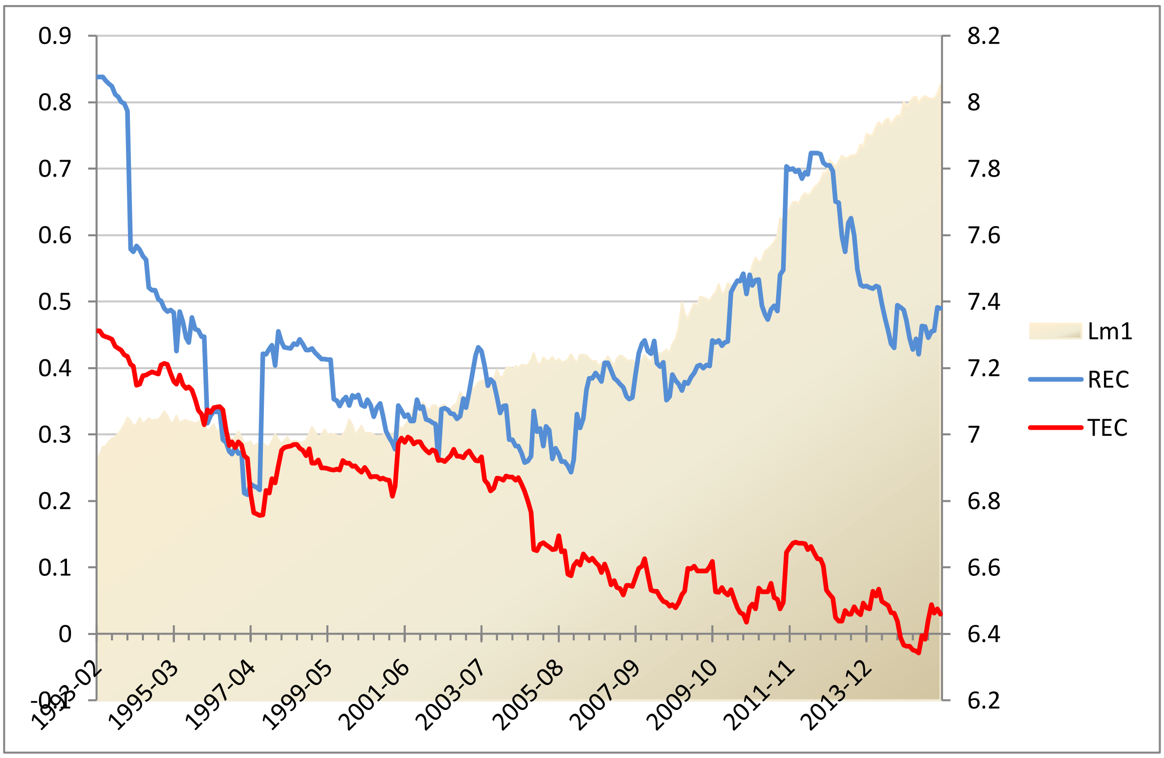

Figure 3.4: The Equicorrelation of the Real Exchange Rates (REC) and Temporary Real Exchange Rates (TEC)

Figure 3.4 plots the fitted equicorrelation (left axis) of the temporary real exchange rate (TEC) and the real exchange rate (REC) respectively against the M1(right axis) of the US from 1993 to 2015. The first impression from the figure is that the long-run trend behaviour of the TEC is declining, and there is a strong negative relationship between M1 and the TEC from 1993 to 2015. On the other hand, a positive relationship between the REC and M1 can be found from 2005 to late 2011 though one may argue that the upward trend in the REC might be interpreted as a result of the growing integration among the economies[18]. In addition, several interesting observations emerge. For clarity's sake, we identify the movement of the TEC and REC into three distinct phases.

The first phase could be identified in the period from 1993 to late 1998. Both correlations declined significantly prior to the Asian financial crisis (AFC). Prior to the AFC, all four countries operated the managed float exchange rate regime with the exception of Thailand, whose exchange rate was pegged with the US dollar before the AFC. From mid-1995 to early 1997, the TEC was slightly higher than the REC. The most striking feature of this phase is during the time of the AFC that began with the collapse of the fixed exchange rate of Thailand's currency, and the subsequent unexpected shift of the exchange rate regime to independently floating in Indonesia and Korea, causing a clear 'jump' in correlations. Nevertheless, it may be noted that the change of the REC is more rapid and larger than that of the TEC.

The second phase could be considered as the 'post-AFC' period from late 1998 to late 2005. In September 1998, Malaysia pegged its exchange rate to the US dollar again.

[18] The relationship between the US monetary policy and the equicorrelations will be further discussed in the next section.

Both the TEC and REC decreased steadily until 2004 although the dot-com bubble (DCB) crisis triggered an increase in correlations in early 2001. The TEC was further diminished in late 2004, as a result of the rapid appreciation of the Korean Won. The reason behind might be due to market participants regaining confidence in the Korean economy while the others remain unchanged.

The final phase could be identified in the period from mid-2005 to 2015. The removal of the pegged exchange rate in Malaysia in July 2005 might be a turning point of the downward movement in the REC and the gap between the two correlations obviously widened. The REC clearly increased but the TEC continued to decrease after Malaysia adopted the managed floating exchange rate regime. Asymmetric responses can be found from the REC correlation in response to the 'in' and 'out' pegged exchange rate system in Malaysia. The correlation decreased slightly and steadily after September 1998 (managed floating to pegged) but increased rapidly after July 2005 (pegged to managed floating). If a country is likely to shift her exchange rate regime from fixed to float, it may raise the market's concerns on the exchange rate system of the neighbouring countries, causing outflow of capital. The central bank of the neighbouring countries should have taken appropriate measures (such as issuing Central bank securities to manage liquidity) to anticipate any likely exchange rate shocks rather than involve herself in market intervention subsequent to a shock.

The global financial crisis (GFC) that began with the collapse of the sub-prime mortgage industry in the United States and the subsequent appearance of a worldwide credit crunch caused a massive capital outflow in some emerging countries. This factor is likely to have contributed to the slight increase in the TEC in late 2008. It ought to be noted however that the REC almost returned to the level before when Malaysia pegged its exchange rate to the US dollar, while the TEC was still far from the level in

September 1998. On the other hand, the European sovereign debt crisis (ESC) that began in late 2009, peaked in late 2011 with the deterioration of the credit quality of some European countries, with the possibility of sovereign debt default leading to financial markets expressing their concerns about the credit-worthiness of the countries. Subsequently, this resulted in an apparent increase in the long-term interest rate yields of the government bonds of some European countries. Two correlations increased rapidly during the peak of the ESC. Similar to the AFC, the changes of the TEC were remarkably smaller than those of the REC.

Table 3.4: The impacts of the financial crises on the equicorrelations (REC, BEC and TEC)

	ψ_1	c	θ_{AFC}	θ_{DCB}	θ_{GFC}	θ_{ESC}	$\Delta\rho_{RS}$	*LM test*
$\triangle REC$	-0.079	-0.004	0.017	0.002	0.008	0.031	-0.743	0.209
	(0.061)	(0.002)*	(0.008)**	(0.010)	(0.008)	(0.011)**	(1.413)	(0.989)
$\triangle BEC$	0.006	-0.003	0.008	0.009	0.004	0.016	-0.460	0.666
	(0.061)	(0.001)**	(0.004)**	(0.005)*	(0.004)	(0.005)**	(0.689)	(0.721)
$\triangle TEC$	0.063	-0.003	0.007	0.007	0.007	0.013	-1.231	0.305
	(0.060)	(0.001)**	(0.003)**	(0.004)*	(0.004)**	(0.005)**	(0.638)*	(0.964)

Note: The REC, BEC and TEC represent the equicorrelations of the real exchange rates, behavioural equilibrium exchange rates and temporary component, respectively. $\triangle$ is the first difference operator. Four dummies (θ_{AFC}, θ_{DCR}, θ_{GFC} and θ_{ESC}) are considered to represent the financial crises. The first dummy θ_{AFC} was included in the estimation by taking on the value of 1 from May 1997 to September 1998 to account for the Asian financial crisis that started in mid-1997 and severely damaged the economy of the Asian countries. θ_{DCR} is included to capture the effects of the dot-com bubble burst from Jul 2000 to Apr 2001. The demise of the dot-com bubble in 2001 triggered a long lasting decline in the global stock markets. θ_{GFC} is introduced to cover the 2008 financial crisis from September 2008 to September 2009. Finally, θ_{ESC} is included to capture the impacts of the European sovereign debt crisis from Aug 2011 to Mar 2012. At that time, the yields of the long-term government bonds of some countries in the Eurozone rose above 6%, which indicates that the financial markets were highly concerned about the credit-worthiness of the country. $\Delta\rho_{RS}$ represents the equicorrelation of relative stock differentials. The figures in parentheses represent the standard errors of the coefficients. ** and * represent the statistical significance at 5% and 10%, respectively.

Table 3.4 reports the estimated results for $\triangle REC$, $\triangle BEC$ and $\triangle TEC$ during different financial crises θ_i and the equicorrelation of the relative stock differentials[19] $\Delta\rho_{RS}$. $\triangle$ is the first difference operator. The relative stock differential is measured by the equation: $\rho_t = s_t - s_t^* - e_t$, where e_t is the nominal exchange rate against the US dollar and $s_t(s_t^*)$ represents the home (foreign) stock price index. All equicorrelations

[19] The estimates of the relative stock differentials equicorrelations are not included in this chapter. These may be provided upon request.

are first-differenced. Before proceeding to the estimation, we conduct the LM test for the ARCH effect and the results indicate that there is no heteroscedasticity in all cases, therefore the conventional autoregressive model is appropriate for the estimations. The number of the lagged dependent variable ϕ_t is determined by the AIC. θ_{AFC}, θ_{DCB}, θ_{GFC} and θ_{ESC} represent the dummy variables for the Asian financial crisis (AFC), the dot-com bubble (DCB), the 2008 global financial crisis (GFC) and the European sovereign debt crisis (ESC), respectively. The significance of the estimated coefficient of the crisis dummy variables implies that the crises caused significant changes in the correlation.

It is clear that the estimated coefficients θ_{AFC} and θ_{ESC} are positive and significant in the REC, indicating that the real exchange rate equicorrelation increased during these two crises. In the case of the BEC, θ_{AFC} and θ_{ESC} are statistically significant at 5%, while θ_{DCB} is statistically significant at a 10% level of significance. As for the TEC, all crisis dummies are statistically significant at a 10% level of significance or less. Note that the TEC is the only case in which all the crisis dummy variables are statistically significant among the equicorrelations. This provides robust evidence to indicate that the contagion effect of the financial crisis is primarily reflected in the temporary component of the real exchange rates. In addition, all dummy variables are positive. This may be due to the increased uncertainty in the financial markets, and therefore, capital outflows consistently from the sample countries.

We also find that the coefficient of the equicorrelation of the relative stock differentials $\Delta\rho_{RS}$ is significant at the 10% level, suggesting a significant negative relationship between the TEC and the relative stock differentials equicorrelation. The negative sign indicates that an increase in the TEC (e.g. jointly depreciation) does not generate homogeneous impacts (e.g. jointly decrease) on the relative stock differentials across the sample countries, and that the equicorrelation $\Delta\rho_{RS}$ therefore declines. This finding is inconsistent with the theoretical model of Malliaropulos (1998) indicating that the relative stock differential is negatively related to the temporary components of the real exchange rate.

3.4c How do the equicorrelations respond to the US monetary policy action?

Figure 3.4 shows that the REC and TEC are likely related to the US monetary policy in a visual manner. We then investigate whether these linkages can be subject to statistical testing by introducing the current and lagged monetary variables in the equicorrelation regressions. The equicorrelations generated in equation (6) are considered as the dependent variables, therefore ΔREC_t , ΔBEC_t and ΔTEC_t are specified as:

$$\Delta REC_t = c + \sum_{i=1}^{p} \phi_t \Delta REC_{t-i} + \sum_{t=1}^{p} \delta_t \Delta M(j)_t + \varepsilon_t \tag{7}$$

$$\Delta BEC_t = c + \sum_{i=1}^{p} \phi_t \Delta BEC_{t-i} + \sum_{t=1}^{p} \delta_t \Delta M(j)_t + \varepsilon_t \tag{8}$$

$$\Delta TEC_t = c + \sum_{i=1}^{p} \phi_t \Delta TEC_{t-i} + \sum_{t=1}^{p} \delta_t \Delta M(j)_t + \varepsilon_t \tag{9}$$

where *c* is the constant, ϕ_t is the coefficient of the lagged dependent variable and δ_t is the coefficient of the monetary variable $\Delta M(j)_t$ for *j* = federal funds rate (FFR), narrow money (M1) and broader money (M2). In line with the findings of Kalyvitis and Michaelides (2001), all the monetary variables are tested for a period of up to three successive months (quarterly). The sample period is divided into three subsamples in order to compare the impacts of the US monetary policy action on the equicorrelations under the different exchange rate regimes operating in the four countries. The first two subsamples correspond to the pre-[20] and post-AFC[21] periods. The third sub-sample corresponds to the period in which all countries were operating either floating or managed a floating exchange rate regime since July 2005.

Tables 3.5a to 3.5c present our empirical findings about the relationship between the equicorrelations (REC, BEC and TEC) and the US monetary policies (FFR, M1 and M2), respectively. First, by examining the results in Table 3.5a, we find that there is no instantaneous relationship between the FFR and the equicorrelations in samples A and B, as all current coefficients are statistically insignificant. In the pre-AFC period (sample A), the third lag of the FFR is positive and significantly different from zero in the REC at the 5% level. The estimated coefficient indicates that a 1% point increase in the FFR three months before results in a 0.096% rise in the REC, but this relationship disappears after the AFC (sample B and C). Moreover, the FFR is found to relate to the other two correlations (BEC and TEC) with 5% when all countries were operating either floating or managed a floating exchange rate regime (sample C). For instance, the coefficients of the first lag of the FFR are negative and significant in the TEC. The negative sign implies that an increase in the FFR has various impacts on the temporary real exchange rates across the sample countries and the correlation therefore declines.

Similar to the FFR, the third lag of M1 is significant but negatively related to the REC in the pre-AFC period, which is consistent with our observation in Figure 3.4. A contractionary policy through either the FFR or M1 would cause an increase in the REC

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[20] The pre-AFC period (1/1993 – 5/1997) is the period in which Thailand maintained its exchange rate linked to a basket of other foreign currencies with a high proportion of the US dollar, while the others operated and managed a floating exchange rate regime.

[21] The post-AFC period (9/1998 – 7/2005) is the period in which Malaysia pegged its exchange rate to the US dollar again, while the other countries operated a floating exchange rate regime.

in the pre-AFC period. The lagged M1 is highly significant in the BEC and TEC in sample C, suggesting that two equicorrelations are apparently positively related to the lagged M1 when all countries are adopting the exchange rate regime with a low degree of government intervention. For the broader money M2, only one significant current value of M2 can be found in sample C. The significant coefficient of the current M2 indicates that the BEC declines in response to a simultaneous increase in M2, which is in contrast to the impact of the FFR. In addition, the impacts of M2 on the equicorrelations are the largest among the three monetary variables, and its lagged value is the only monetary variable that is statistically significant in all equicorrelations.

Table 3.5a: The effectiveness of the federal funds rate to the equicorrelations (REC, BEC and TEC)

	Sample A (1/93 - 5/97)			Sample B (9/98 - 7/05)			Sample C (8/05 - 12/15)		
	△REC	△BEC	△TEC	△REC	△BEC	△TEC	△REC	△BEC	△TEC
ψ_1	-0.149	0.234	0.255	-0.171	0.081	0.149	0.049	-0.001	0.047
	(0.145)	(0.156)	(0.152)**	(0.113)	(0.114)	(0.116)	(0.092)	(0.094)	(0.092)
c	-0.016	-0.005	-0.004	-0.002	-0.002	-0.002	0.002	-0.001	-0.001
	(0.006)**	(0.003)**	(0.002)**	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
δ_t	-0.066	0.009	-0.001	-0.015	-0.004	0.002	0.003	-0.006	-0.004
	(0.047)	(0.020)	(0.015)	(0.019)	(0.010)	(0.011)	(0.007)	(0.003)**	(0.004)
δ_{t-1}	0.002	0.003	-0.009	-0.006	0.006	0.002	-0.003	-0.003	-0.010
	(0.060)	(0.025)	(0.019)	(0.019)	(0.010)	(0.011)	(0.008)	(0.004)	(0.004)**
δ_{t-2}	0.062	-0.020	-0.015	0.008	-0.007	-0.002	0.003	0.002	-0.003
	(0.059)	(0.025)	(0.019)	(0.019)	(0.010)	(0.011)	(0.008)	(0.004)	(0.005)
δ_{t-3}	0.096	0.014	0.021	0.010	0.002	-0.010	0.006	0.007	0.005
	(0.047)**	(0.020)	(0.016)	(0.019)	(0.010)	(0.011)	(0.007)	(0.004)**	(0.004)

Note: The REC, BEC and TEC represent the equicorrelations of the real exchange rates, behavioural equilibrium exchange rates and temporary component, respectively. The figures in parentheses represent the standard errors of the coefficients. ** and * represent the statistical significance at 5% and 10%, respectively.

Table 3.5b: The effectiveness of the US M1 to the equicorrelations (REC, BEC and TEC)

	Sample A (1/93 - 5/97)			Sample B (9/98 - 7/05)			Sample C (8/05 - 12/15)		
	△REC	△BEC	△TEC	△REC	△BEC	△TEC	△REC	△BEC	△TEC
ψ_1	-0.203	0.203	0.176	-0.193	0.068	0.155	0.061	-0.081	0.034
	(0.145)	(0.159)	(0.159)	(0.112)**	(0.113)	(0.113)	(0.091)	(0.091)	(0.092)
c	-0.014	-0.005	-0.005	-0.005	-0.001	-0.001	0.001	-0.002	-0.003
	(0.006)**	(0.003)**	(0.002)**	(0.003)**	(0.001)	(0.002)	(0.003)	(0.002)	(0.002)
δ_t	0.738	-0.015	0.027	0.210	-0.020	-0.102	0.129	-0.097	0.020
	(0.472)	(0.205)	(0.164)	(0.189)	(0.098)	(0.110)	(0.147)	(0.074)	(0.082)
δ_{t-1}	-0.462	0.301	0.209	0.298	0.010	-0.036	-0.097	0.044	0.003
	(0.445)	(0.196)	(0.154)	(0.197)	(0.101)	(0.113)	(0.146)	(0.073)	(0.081)
δ_{t-2}	-0.150	-0.024	0.064	0.155	-0.136	-0.136	0.189	0.123	0.262
	(0.435)	(0.197)	(0.157)	(0.197)	(0.101)	(0.113)	(0.146)	(0.073)**	(0.082)**
δ_{t-3}	-1.087	0.176	0.039	0.163	-0.131	-0.015	-0.072	0.132	0.019
	(0.456)**	(0.200)	(0.157)	(0.190)	(0.099)	(0.111)	(0.148)	(0.074)**	0.086

Note: The REC, BEC and TEC represent the equicorrelations of the real exchange rates, behavioural equilibrium exchange rates and temporary component, respectively. The figures in parentheses represent the standard errors of the coefficients. ** and * represent the statistical significance at 5% and 10%, respectively.

Table 3.5c: The effectiveness of the US M2 to the equicorrelations (REC, BEC and TEC)

	Sample A (1/93 - 5/97)			Sample B (9/98 - 7/05)			Sample C (8/05 - 12/15)		
	△REC	△BEC	△TEC	△REC	△BEC	△TEC	△REC	△BEC	△TEC
ψ_1	-0.130	0.172	0.168	-0.173	0.049	0.134	0.045	-0.111	0.001
	(0.151)	(0.156)	(0.154)	(0.112)	(0.114)	(0.113)	(0.091)	(0.091)	(0.092)
c	-0.020	-0.001	-0.002	-0.010	0.002	-0.004	-0.003	-0.005	-0.006
	(0.010)**	(0.004)	(0.003)	(0.006)	(0.003)	(0.004)	(0.005)	(0.003)**	(0.003)**
δ_t	3.317	-0.404	0.404	-0.135	-0.032	0.201	-0.020	-0.520	-0.276
	(2.726)	(1.148)	(0.905)	(0.675)	(0.354)	(0.394)	(0.629)	(0.313)**	(0.348)
δ_{t-1}	1.152	0.039	-0.053	1.031	0.005	0.156	-0.594	-0.255	-0.347
	(2.927)	(1.213)	(0.958)	(0.677)	(0.353)	(0.395)	(0.627)	(0.309)	(0.346)
δ_{t-2}	-3.729	0.270	-0.488	-0.080	-0.438	0.122	1.189	0.785	1.254
	(2.877)	(1.211)	(0.955)	(0.687)	(0.352)	(0.395)	(0.630)**	(0.309)**	(0.347)**
δ_{t-3}	1.338	-1.601	-0.815	0.573	-0.327	-0.020	0.382	0.650	0.370
	(2.706)	(1.122)	(0.892)	(0.677)	(0.358)	(0.395)	(0.640)	(0.321)**	(0.369)

Note: The REC, BEC and TEC represent the equicorrelations of the real exchange rates, behavioural equilibrium exchange rates and temporary component, respectively. The figures in parentheses represent the standard errors of the coefficients. ** and * represent the statistical significance at 5% and 10%, respectively.

V Conclusion

This chapter aims to address the question regarding the drivers of the real exchange rate co-movement. Understanding what drives the exchange rates co-movement and the evolution of the exchange rate correlations is relevant for various areas in finance, including portfolio diversification, risk management, hedging and pricing of financial derivatives and other structural products, and asset allocation decisions. Specifically, we decomposed the real exchange rate into the temporary and equilibrium exchange rates in order to study their equicorrelation. It is particularly useful for institutional investors to decide their short- and long-term investments.

Equicorrelations are used to statistically represent the degree of relationship between the movements of our aggregate sample countries' real exchange rate. By using the DECO model, we generate the real exchange rate equicorrelation (REC), behavioural equilibrium real exchange rate equicorrelation (BEC) and temporary real exchange rate equicorrelation (TEC) among the four countries (Korea, Thailand, Malaysia and Indonesia) from the period 1993 to 2015, which covers at least four financial crises. Summarising their experience over the last two decades, our DECO results indicate that the collapse of the fixed exchange rate of Thailand's currency and the subsequent unexpected shift of the exchange rate regime to independently floating in Indonesia and Korea caused a rapid increase in the REC and TEC, and the change in the REC is more significant than in the case of the TEC apparently.

Another important finding from the equicorrelations is that both the BEC and the TEC decline to a low level of correlations since 2005, which decreases the overall risk of the short- and long-term international diversified portfolio. In particular, asymmetric responses can be found from the REC correlation in response to the 'in' and 'out' pegged exchange rate system in Malaysia. The correlation decreases slightly and steadily after September 1998 (managed floating to pegged) but increases rapidly after July 2005 (pegged to managed floating). A rapid increase in correlation indicates that the exchange rates move in the same direction, suggesting that the impact of 'pegged to managed floating' is significant for the neighbouring countries. Therefore, if a country is likely to shift her exchange rate regime from fixed to float, it may raise the market's concerns on the exchange rate system of the neighbouring countries, causing an outflow of capital. The central banks of the neighbouring countries should have taken appropriate measures (such as issuing central bank securities to manage liquidity) in order to anticipate any likely exchange rate shocks rather than become involved in market intervention subsequent to a shock.

The impacts of the Asian financial crisis (AFC), dot-com bubble (DCB), global financial crisis (GFC) and European sovereign debt crisis (ESC) on the REC, BEC and TEC are examined in this chapter. The estimated coefficients of the dummy variables θ_{AFC} and θ_{ESC} are positive and significant at 5% in the REC and BEC, indicating that the real exchange rates and the equilibrium real exchange rates equicorrelations improved during these two crises. We note that the TEC is the only case in which all the crisis dummy variables are statistically significant among the equicorrelations. This provides robust evidence to demonstrate that the contagion effect of the financial crisis is primarily reflected in the temporary component of the real exchange rates. In addition, the coefficient of the equicorrelation of the relative stock differentials $\Delta\rho_{RS}$ is significant at the 10% level, suggesting a significantly negative relationship between the equicorrelations of the TEC and the relative stock differential. The negative sign indicates that an increase in the TEC (e.g. jointly depreciation) does not generate homogeneous impacts (e.g. jointly decrease) on the relative stock differentials across the sample countries, and the correlation $\Delta\rho_{RS}$ therefore declines.

We also examined the impacts of the US monetary policy action (FFR, M1 and M2) on the REC, BEC and TEC, respectively. We did not find any instantaneous relationship between the monetary variables and the equicorrelations in the pre-AFC and post-AFC periods. This suggests that the US monetary policy does not generate significant impacts on the equicorrelations instantaneously if at least one of the sample countries is operating a pegged exchange rate regime. In the pre-AFC period (sample A), a contractionary monetary policy through either the FFR or M1 would cause an increase in the REC but this relationship disappears after the AFC. All monetary policy variables are found to relate to the BEC and TEC with 5% when all countries were operating either floating or managed floating exchange rate regime. Compared to the FFR and M1, the impact of M2 on the correlations is the strongest among the three monetary variables, and its lagged value is the only monetary variable that is statistically significant in all correlations.

Chapter 4

Identifying the Source of Relative Stock Prices Fluctuations

I Introduction

Identifying the source of stock price fluctuations is one of the most controversial topics in financial economics. Many existing papers studying the evolution of stock returns document that the fluctuations in stock prices can be generally explained in terms of macroeconomic shocks. For instance, early studies such as Fama and Schwert (1977) and Fama (1981) indicate that the real stock returns are adversely influenced by both expected and unexpected inflation.

Lastrapes (1998) relies on theoretically motivated long-run restrictions based on the neutrality of money in order to investigate the impacts of money supply shocks on real stock prices. He finds that positive money supply shocks increase the real stock prices and lower the interest rate in the short-run, whereas the aggregate supply shock increases real stock prices over both short and longer horizons. Hess and Lee (1999) argue that the supply (demand) shock generates a negative (positive) relation between the stock returns and inflation, and indicate that the stock returns and inflation relationship varies over time and across countries. On the other hand, Gallagher and Taylor (2002) present a model, which indicates that the aggregate demand shock affects real stock prices temporarily, while the supply shock may exert a permanent effect on the level of real stock prices. All these papers provide a good lesson for understanding the linkage between the stock returns and the macroeconomic shocks.

The purpose of this study is to investigate whether the relative stock prices fluctuations can be explained by four different types of shocks, which are respectively due to the supply, demand, nominal and expectation disturbances. Given the disturbance of the relative stock prices equation which contains both the expected depreciation of the real exchange rate and the expected risk premium of domestic stock prices (Malliaropulos, 1998), we recover the disturbance of relative stock prices by estimating VAR in unrestricted form and term the structural innovation of the relative stock price as 'expectation shock'.

In an influential paper, Fama and French (1988) argue that stock prices contain permanent and transitory components, and provide empirical evidences that stock prices are mean-reverting and induce stock returns characterised by a large negative autocorrelation for long investment horizons. These findings highlight the strong predictability of long-horizon stock returns owing to the slow decaying price components in the transitory component of stock prices. An expectation shock is formed when the investors are anticipating an increase in stock prices. This anticipation might be due to the mean-reverting properties of stock prices (see Fama & French, 1988;

Poterba & Summers, 1988) or to other psychological factors or market sentiments, such that investors are willing to pay a higher risk premium in domestic stocks relative to the foreign stocks in return to the expected returns in the future.

Following the works of Obstfeld (1985), Clarida and Gali (1994) and Malliaropulos (1998), we present a model, which can be used to explain the evolution of relative stock prices with different macroeconomic shocks. The model predicts that the expectation shocks generate a permanent impact on relative stock prices and the demand shocks lead to both short- and long-run changes in the relative stock prices. However, the supply and nominal shock only affect the relative stock prices on a temporary basis when prices are sluggish.

We employ the structural VAR (SVAR) approach developed by Blanchard and Quah (1989). All appropriate identifying restrictions are derived from the long-run properties of the flexible-price model. This approach explicitly addresses the issue of endogeneity of the variables in a structural model. Our analysis addresses this issue by considering the relative output, real exchange rate, relative price level and relative stock prices as the endogenous variables reacting to a set of structural shocks. The decomposition of our estimated SVAR innovations into supply, demand, nominal and expectation shocks is conducted by using the long-run economic restrictions of the flexible-price model.

This chapter contributes to the financial literature in three different ways. Firstly, we present a model, which builds on the works of Obstfeld (1985), Clarida and Gali (1994) and Malliaropulos (1998). The model clearly exhibits the interaction between the relative stock prices and various macroeconomic shocks when price adjustments are flexible or sluggish. Secondly, the relationship between macroeconomic shocks and stock returns has been documented in numerous empirical works. However, all these works generally focus on analysing the real stock price movement of a single country. Different from those existing papers, all the variables in this chapter have been used in a relative manner. This setting offers a much broader international horizon in studying the relationship between the relative stock price and macroeconomic shocks, and also considers the exchange risk for international investments. Finally, compared to the vast number of studies that analyse the influence of demand, supply and nominal shocks to the real stock price, the interaction between the relative stock prices and the macroeconomic variables as well as the investors' expectation seems to be neglected in the financial literature though the investors' expectation plays an essential role in determining the stock prices. Our analysis sheds new light on studying how the expectation influences the evolution of the relative stock prices, particularly in the period of the global financial crisis in 2008.

The rest of this chapter is organised as follows. Section II presents the theoretical framework. Section III discloses the data and the methodology and discusses our economic interpretation of the structural disturbances. Section IV presents the empirical results of the variance decomposition, historical decomposition as well as the impulse response. The final section concludes the paper.

II Theoretical Framework

In this section, we present a theoretical model, which highlights the manner in which different types of macroeconomic shocks influence the relative stock prices. Our model builds on the stochastic rational expectations open macro model presented by Obstfeld (1985) and Clarida and Gali (1994), which exhibits the results of Dornbusch's dynamic Mundell-Fleming model in the short-run when prices adjust sluggishly to demand, money, and supply shocks, and includes the long-run properties that characterise macroeconomic equilibrium in the open economy when prices adjust fully to all shocks. The present model furthermore incorporates Malliaropulos's (1998) theoretical relationship between the real exchange rate and the relative stock differential.

Let us consider the following stochastic version of the two-country, rational expectations open macro model. All variables below with the exception of interest rates are in logarithm and represent home relative to foreign levels. The model is composed of the following relations:

IS equation:

$$y_t^d = g_t + \eta(s_t - p_t) - \sigma[i - E_t(p_{t+1} - p_t)], \tag{1}$$

where g_t denotes the demand shock; s_t is the log of the nominal exchange rate at time *t*; i_t is the nominal interest rate and p_t represents the log of the domestic price level. Equation (1) gives the open-economy IS-relation in which the aggregate demand for home output relative to the foreign output y_t^d is positive in relation to the real exchange rate: $q_t = s_t - p_t$ and negative in relation to the expected real interest rate: $r_t = i_t - (E_t p_{t+1} - p_t)$.

Price Adjustment Equation:

$$p_t = (1-\theta)E_{t-1}p_t^e + \theta p_t^e, \tag{2}$$

Equation (2) is a price adjustment equation, which captures the sluggish adjustment of the price level to its flexible price equilibrium. This equation suggests that prices are fully flexible and the output is supply-determined when $\theta = 1$. Moreover, prices are fixed and predetermined 1 period in advance when $\theta = 0$.

LM Equation:

$$m_t - p_t = y_t - \lambda i_t, \tag{3}$$

Equation (3) is a standard LM equation, which gives the money market equilibrium condition suggesting that the demand for real money balances is assumed to depend on the domestic interest rate and on the real income, and the income elasticity is assumed to be 1. m_t is the nominal quantity of money and is assumed to capture the influence of shocks on the relative national money supplies and the relative national demand for real money balances.

Uncovered Interest Parity:

$$i_t = E_t(e_{t+1} - e_t) \tag{4}$$

Equation (4) is a statement of the uncovered interest parity condition, which indicates that the expected rate of depreciation of the domestic exchange rate is equal to the difference between the domestic and the foreign nominal interest rate.

Real exchange rate - relative stock differential relation:

$$\nabla^k \rho_t = k(\xi u + v) - \xi \nabla^k q_t + \varepsilon^e_{k,t} \tag{5}$$

Equation (5) is the relationship between the ex-post risk premium of a k-period investment in the domestic stock market relative to an equivalent investment in the foreign stock market, and the k-period change in the real exchange rate proposed by Malliaropulos (1998). In which $\xi = \frac{\vartheta - 1}{\phi - 1}$; ∇ is the forward difference operator; ρ_t

represents the relative stock prices between the domestic economy and the US. According to Fama and French (1988) and Malliaropulos (1998), the relative stock price variable ρ_t is assumed to contain both a permanent and a temporary component $\rho_t \equiv \rho_t^P + \rho_t^T$. The permanent and temporary components of relative stock price are respectively specified as:

$$\rho_t^P = v + \rho_{t-1}^P + \eta_t^P \, , \tag{6}$$

$$\rho_t^T = \phi \rho_{t-1}^T + \eta_t^T \, . \tag{7}$$

Similarly, Huizinga (1987) and Baxter (1994) suggest that the real exchange rate contains both the permanent q_t^P and transitory q_t^T components, so that $q_t \equiv q_t^P + q_t^T$ and

$$q_t^P = \mu + q_{t-1}^P + \varepsilon_t^P \, , \tag{8}$$

$$q_t^T = \vartheta q_{t-1}^T + \varepsilon_t^T \, . \tag{9}$$

The permanent components of the relative stock price and real exchange rate are specified as a random walk with drift. The error term (η_t^P and ε_t^P) is a serial uncorrelated innovation, while the transitory component is assumed to follow a stationary first-order autoregressive process with $0 < \vartheta < 1$, and the error term (η_t^T and ε_t^T) is a serial uncorrelated innovation. Note that equation (5) gives a negative forward difference relationship between the ex-post risk premium of a k-period investment in the home stock market relative to an equivalent investment in the foreign stock market and the k-period changes of the real exchange rate and the disturbance $\varepsilon_{k,t}^e$ in equation (5) can be expressed as:

$$\varepsilon_{k,t}^{e} \equiv \frac{\vartheta-1}{\phi-1}\sum_{i=1}^{k}\varepsilon_{t+i}^{P} + \sum_{i=1}^{k}\eta_{t+i}^{P} + \nabla^{k}E_{t}\nabla rs_{t}\ , \tag{10}$$

which embodies cumulated innovations in the permanent components of the relative stock price η_{t+i}^{P} and real exchange rate ε_{t+i}^{P}, and of the revision in the expected real return differential $\nabla E_t \nabla rs_t = \nabla E_t \nabla \rho_t + \nabla E_t \nabla q_t$ between the home and foreign market, where $\nabla E_t \nabla \rho_t = v + (\phi - 1)\nabla \rho_t^T$ is the revision of the conditional risk premium and $\nabla E_t \nabla q_t = u + (\vartheta - 1)\nabla q_t^T$ is the revision of the expected real exchange rate, respectively. $\varepsilon_{k,t}^{e}$ can also be considered as the expectation shock as it captures the influence of shocks on the real exchange rate as well as the relative stock price. For the sake of simplicity, we assume k =1 in the following.

On the other hand, we also specify the stochastic process that governs the relative supply, relative demand shock and relative money as follows:

$$y_t^s = y_{t-1}^s + \varepsilon_t^s, \tag{11}$$

$$g_t = g_{t-1} + \varepsilon_t^d - \varepsilon_{t-1}^d, \tag{12}$$

$$m_t = m_{t-1} + \varepsilon_t^n\ . \tag{13}$$

We refer to these as supply, demand and nominal shocks, respectively. Following Clarida and Gali (1994), the relative supply of the output and the relative money are assumed to be a simple random walk processes while the relative demand is allowed to contain the permanent g_{t-1} as well as the transitory components, ε_t^d , ε_{t-1}^d . ε_t^s , ε_t^d and ε_t^n are assumed to be a serial and mutually uncorrelated innovation.

The flexible-price rational expectation equilibrium for the relative output, real exchange rate and relative price levels can be represented as below:

$$y_t^e = y_t^s \tag{14}$$

$$q_t^e = \frac{y_t^s - g_t}{\eta} + \frac{\sigma\gamma\varepsilon_t^d}{\eta(\eta+\sigma)}, \tag{15}$$

$$p_t^e = m_t^s - y_t + \lambda \frac{\gamma\varepsilon_t^d}{(1+\lambda)(\eta+\sigma)}. \tag{16}$$

The above three equations provide the long-run solution for the flexible-price model. In the flexible-price equilibrium, the supply shock is positively related to the levels of relative output and the real exchange rate but negatively related to the relative prices levels, which is in line with the prediction of the Mundell-Fleming-Dornbusch model. On the other hand, a positive demand shock causes the real exchange rate depreciation and generates positive impacts relative price levels as in Equation (15) and (16), respectively. Furthermore, the nominal shock does not influence the long-run level of relative outputs or the real exchange rate.

In order to derive the long-run solution for the relative stock price, it is necessary to substitute the laws of motion for the components of ρ_t and equation (15) into equation (5) and take the conditional expectation on both sides in order to obtain:

$$\rho_t^e = \frac{\xi}{(\phi-1)}u - \frac{\xi}{(\phi-1)}\left(\frac{\gamma\varepsilon_t^d}{(\eta+\sigma)}\right) + \rho_t^P + \frac{\varepsilon_t^e}{(\phi-1)}. \tag{17}$$

From the equation, since $0 < \vartheta, \phi < 1$, the flexible-price relative stock price declines in response to an increase in the temporary component of the demand shock (when $\gamma < 0$), as does a reduction in the expectation shock. In addition, shocks to the permanent component of relative stock price also generate a positive impact on the relative stock price equilibrium. A detailed overview of the expectation shock, $\varepsilon_t^e \equiv \nabla E_t \nabla rs_t$, can be found in this equation. The flexible-price relative stock price decreases in response to the revision of the expected change in the real exchange rate, $\nabla E_t \nabla q_t = u + (\vartheta - 1)\nabla q_t^T$ and of the risk premium of domestic shares relative to foreign shares, $\nabla E_t \nabla \rho_t = v + (\phi - 1)\nabla \rho_t^T$.

Equations (14) to (17) represent the evolution over time of the flexible-price equilibrium and these four equations clearly demonstrate that, in the long-run, the relative output differential, the real exchange rate, the relative inflation and the relative stock price are driven by four shocks – the demand, supply, nominal and expectation shocks. Equations (14) to (17) are the solutions for the flexible-price equilibrium.

In order to explore how the relative stock price responds to the macroeconomic shocks in the short-run, we present a relative stock price equation when the price adjustment is sluggish. Consider the following sluggish price solution[22] for the level of relative output, real exchange rate and relative inflation:

$$p_t = p_t^e - (1-\theta)(\varepsilon_t^n - \varepsilon_t^s + \alpha\gamma\varepsilon_t^d), \tag{18}$$

$$q_t = q_t^e + \upsilon(1-\theta)(\varepsilon_t^n - \varepsilon_t^s + \alpha\gamma\varepsilon_t^d) \tag{19}$$

$$y_t = y_t^s + (\eta+\sigma)(1+\lambda)(1-\theta)(\varepsilon_t^n - \varepsilon_t^s + \alpha\gamma\varepsilon_t^d), \tag{20}$$

where $\alpha \equiv \frac{\lambda}{(1+\lambda)(\eta+\sigma)}$ and $\upsilon \equiv \frac{1+\lambda}{(\lambda+\eta+\sigma)}$. Substitute equations (15), (17) and (19) into equation (5), and taking the conditional expectation on both sides, we obtain:

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[22] Please refer to Clarida and Gali (1994) for more details.

$$\rho_t = \rho_t^e + \frac{\xi}{(\phi - 1)} \upsilon (1-\theta)(\varepsilon_t^n - \varepsilon_t^s + \alpha\gamma\varepsilon_t^d) \qquad (21)$$

Equation (21) suggests that not only the demand shock but also the nominal and supply shocks influence the relative stock price in the short-run when the price is sluggish. Since $0 < \phi < 1$, the supply shock pushes the relative stock price, while the stock price declines in response to a positive nominal shock or the temporary component in the demand shock in the short-run with a sluggish price adjustment.

III Data and Model Specification

4.3a Data Description

In this chapter, the sample covers the period from January 2000 to May 2016. All data used in the empirical estimations are obtained from the International Financial Statistics and DataStream, and are expressed in logarithm. Monthly data are used in our estimations. The frequency of monthly data is high, which enables us to capture a close evolution of the data, particularly the financial variables which change rapidly over time. The relative stock price (ρ_t) between the domestic and foreign country expressed in the domestic currency is calculated by:

$$\rho_t = s_t - s_t^* - e_t$$

where $s_t(s_t^*)$ is the domestic (foreign) stock price and (e_t) is the domestic nominal exchange rate, expressing the domestic currency per unit of US dollar.

The real exchange rate is defined as:

$$q_t = e_t + p_t^* - p_t$$

where $p_t(p_t^*)$ is the domestic (foreign) price index. The relative output is measured by the domestic GDP (y_t) minus the foreign GDP (y_t^*). The monthly GDP (Y) is constructed from the quarterly real GDP using the state-space approach.

Blanchard and Quah (1889) propose an econometric method in order to estimate the structural shocks to the variables by imposing long-run restrictions on the SVAR system. In this chapter, we apply the SVAR model with a long-run identification in order to investigate the determinants of the relative stock returns. One important requirement for this method is that all variables in the model must be stationary. Table 4.1 reports the ADF test results. The results show that all variables in level are non-stationary with the exception of the relative inflation and relative stock prices in Japan. The relative output differential, real exchange rate and relative stock differential become stationary after first-differencing. The number of lags is based on the AIC criteria and the Ljung-Box Q statistics indicates that there is no serial correlation in any of the VAR equations for the SVAR specification.

Table 4.1: The ADF Test

	Canada	China	Japan	Singapore	Thailand	UK
y_t - y_t*	-2.15	-2.10	-0.57	-1.17	-0.86	-2.92
$\triangle(y_t - y_t^*)$	-8.32**	-14.85**	-7.59**	-7.97**	-6.69**	-3.71**
q_t	-1.49	-0.16	-1.83	-0.83	-0.83	-1.88
$\triangle q_t$	-15.45**	-9.70**	-13.02**	-14.95**	-12.44**	-13.54**
p_t - p_t*	-15.07**	-3.13**	-11.32**	-2.61**	-13.38**	-2.45**
$\triangle(p_t - p_t^*)$	-	-	-	-	-	-
ρ_t - ρ_t*	-1.58	-1.96	-2.94**	-1.09	-1.29	-0.03
$\triangle(\rho_t - \rho_t^*)$	-14.25**	-13.75**	-14.82**	-15.44**	-12.82**	-16.27**

Note: ** and * represent the statistical significance at 5% and 10%, respectively.

4.3b Model Specification

The estimations are measured by the vector Y_t, which is defined as follows:

$$\Delta Y_t = \begin{bmatrix} \Delta\left(y_t - y_t^*\right) \\ \Delta q_t \\ p_t - p_t^* \\ \Delta\left(\rho_t - \rho_t^*\right) \end{bmatrix} \tag{22}$$

The vector has a moving-average structural representation given by:

$$\Delta Y_t = C(L)\varepsilon_t \tag{23}$$

Where L is the lag operator and $\varepsilon_t = \left[\varepsilon_t^s, \varepsilon_t^d, \varepsilon_t^n, \varepsilon_t^e\right]$ is a vector of unobserved structural shocks, in which ε_t^s represents the supply shocks, ε_t^d constitutes the demand shocks, ε_t^n refers to the nominal shocks and ε_t^e designates the expectation shocks. The shocks are serial uncorrelated white noise disturbances and have a variance-covariance matrix normalised to the identity matrix, such that $\mathrm{var}(\varepsilon_{1t}) = \mathrm{var}(\varepsilon_{2t}) = \mathrm{var}(\varepsilon_{3t}) = \mathrm{var}(\varepsilon_{4t}) = 1$, or

$$E(\varepsilon_t\varepsilon_t^{'}) = \begin{bmatrix} \mathrm{var}(\varepsilon_{1t}) & \mathrm{cov}(\varepsilon_{1t},\varepsilon_{2t}) & \mathrm{cov}(\varepsilon_{1t},\varepsilon_{3t}) & \mathrm{cov}(\varepsilon_{1t},\varepsilon_{4t}) \\ \mathrm{cov}(\varepsilon_{2t},\varepsilon_{1t}) & \mathrm{var}(\varepsilon_{2t}) & \mathrm{cov}(\varepsilon_{2t},\varepsilon_{3t}) & \mathrm{cov}(\varepsilon_{2t},\varepsilon_{4t}) \\ \mathrm{cov}(\varepsilon_{3t},\varepsilon_{1t}) & \mathrm{cov}(\varepsilon_{3t},\varepsilon_{2t}) & \mathrm{var}(\varepsilon_{3t}) & \mathrm{cov}(\varepsilon_{3t},\varepsilon_{4t}) \\ \mathrm{cov}(\varepsilon_{4t},\varepsilon_{1t}) & \mathrm{cov}(\varepsilon_{4t},\varepsilon_{2t}) & \mathrm{cov}(\varepsilon_{4t},\varepsilon_{3t}) & \mathrm{var}(\varepsilon_{4t}) \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = 1 \tag{24}$$

Given the structural shocks, ε_{it} cannot be observed. In order to estimate the disturbance terms, it is necessary to recover ε_{it} by estimating VAR in an unrestricted form as shown in below:

$$\Delta Y_t = \Phi(L)\Delta Y_{t-1} + u_t\ . \tag{25}$$

To be more accurate, sufficient numbers of the lagged variables are included in order to eliminate the serial correlation problem from the residuals. The number of lag length in each model is based on the Akaike information criterion. The estimated unrestricted VAR model can then be inverted to the Wold moving average representation:

$$\Delta Y_t = A(L)u_t \text{ ,} \tag{26}$$

and the variance-covariance matrix of the vector of the reduced-form innovations is given by:

$$E(u_t u_t') = \begin{bmatrix} \mathrm{var}(u_{1t}) & \mathrm{cov}(u_{1t}, u_{2t}) & \mathrm{cov}(u_{1t}, u_{3t}) & \mathrm{cov}(u_{1t}, u_{4t}) \\ \mathrm{cov}(u_{2t}, u_{1t}) & \mathrm{var}(u_{2t}) & \mathrm{cov}(u_{2t}, u_{3t}) & \mathrm{cov}(u_{2t}, u_{4t}) \\ \mathrm{cov}(u_{3t}, u_{1t}) & \mathrm{cov}(u_{3t}, u_{2t}) & \mathrm{var}(u_{3t}) & \mathrm{cov}(u_{3t}, u_{4t}) \\ \mathrm{cov}(u_{4t}, u_{1t}) & \mathrm{cov}(u_{4t}, u_{2t}) & \mathrm{cov}(u_{4t}, u_{3t}) & \mathrm{var}(u_{4t}) \end{bmatrix} = \Sigma \text{ .} \tag{27}$$

It is clear by now that equations (23) and (26) imply a linear relationship between the residuals of the reduced-form model and the shocks of the structural model, that is:

$$u_t = C_0 \varepsilon_t \tag{28}$$

The identification of the *4 x 4* matrix in C_0 is needed in order to facilitate a recovery of the structural shocks from the reduced form innovations. The restriction imposed to the matrix is generally motivated by the economic theory. A number of economic arguments provide clear implications about the long-run relationship between economic variables. In this chapter, we present a model that builds on the stochastic rational expectations open macro model presented by Obstfeld (1985) and Clarida and Gali (1994) in order to determine the long-run behaviour of the variables in our system in response to structural shocks.

$$\Delta Y_t = u_y + C(L)\varepsilon_s \tag{29}$$

In the last section, equations (14) to (17) provide theoretical solutions for estimating the structural shocks to variables by imposing long-run restrictions on a structural VAR system. These equations suggest that the flexible-price model is not triangular in the long run. Recalling the long-run representation of these equations, all solutions provided in equations (14) to (17) can then be written in the following *4* x *4* matrix form:

$$\begin{bmatrix} \Delta\left(y_t - y_t^*\right) \\ \Delta q_t \\ p_t - p_t^* \\ \Delta\left(\rho_t - \rho_t^*\right) \end{bmatrix} = \begin{pmatrix} C_{11}(1) & 0 & 0 & 0 \\ C_{21}(1) & C_{22}(1) & 0 & 0 \\ C_{31}(1) & C_{32}(1) & C_{33}(1) & 0 \\ 0 & C_{42}(1) & 0 & C_{44}(1) \end{pmatrix} \begin{bmatrix} e_{y,t} \\ e_{q,t} \\ e_{p,t} \\ e_{\rho,t} \end{bmatrix} \tag{30}$$

The first sub-equation suggests that the relative output differential is exogenous to all structural shocks with the exception of supply shocks. This setting is consistent with the structural model proposed by Clarida and Gali (1994) and Hoffmann and MacDonald (2000) suggesting that no demand and nominal shock are expected to have a permanent impact on the relatively output differential. And, of course, the expectation shock of the relative stock price plays no role in determining the relative output. This restriction requires that:

$$C_{12}(1) = C_{13}(1) = C_{14}(1) = 0 \text{ .}$$

The second sub-equation shows the response of the real exchange rate with respect to the demand and supply shocks only. Although, as suggested in Malliaropulos (1998), there is a linkage between the transitory component of the real exchange rate and the transitory component of the relative stock price, we find that the expectation shock does not influence the equilibrium exchange rate in the long-run. It gives:

$$C_{23}(1) = C_{24}(1) = 0$$

The third sub-equation represents the relative inflation function. It shows the relative price-level response to all shocks except for the expectation shock. Therefore,

$$C_{34}(1) = 0 \; .$$

The final sub-equation represents the relative stock differential function. Although the stock price will react quickly to all available market information, the reaction of the stock market performance is transitory. According to equation (17), the relative stock differential is expected to respond to the transitory component of the demand and expectation shocks but not to supply and money shocks. It means that:

$$C_{41}(1) = C_{43}(1) = 0$$

The empirical strategy pursued in this chapter consists of investigating the empirical validity of those predictions by modelling the joint behaviour of the real output differential, real interest rate differential, real exchange rate and relative stock differential for 6 economies (Canada, China, Japan, Singapore, Thailand, the United Kingdom and the United States) for the period from 2000 to 2016 by structural VAR driven by four exogenous disturbances. Those disturbances are well identified so that they can be interpreted as the four structural shocks as suggested in equations (14) to (17): supply, demand, nominal and expectation shocks.

IV Empirical Results

In this section, we present the empirical results of the variance decomposition, historical decomposition and the impulse response, respectively. The forecast error variance decomposition (FEVD) method is used in order to investigate the contribution of each random innovation (structural shock) at various k-horizons ahead in terms of affecting the relative stock price.

Table 4.2 reports the variance decomposition results of the level of relative stock prices. We note that the contribution of supply and nominal shocks is small and stable in most cases. As for the expectation shock, its contribution is apparently higher than the other shocks in China, Japan and Singapore. This suggests that the investors' expectation plays an important role in the stock market volatility. On the other hand, the demand shock is the second most influential shock in all cases with the exception of China. Indeed, financial markets all over the world have been highly integrated in recent decades. The high contribution of the demand shock provides empirical evidence that the international capital funds play an important role for the stock price volatility in most countries. The high capital mobility prompts investors to invest in foreign stock markets if the expected return is high enough to compensate the expected depreciation of the real exchange rate. Nevertheless, the poor performance of the demand shocks in China might reflect the fact that China adopts the fixed exchange rate regime and a high capital control and stock market intervention in the early stages of our sample period. The FEVD results strongly confirm that the demand and expectation shocks are found to largely explain the variability of the relative stock price fluctuation.

Table 4.2: Variance Decomposition of the Relative Stocks Differential

	Canada				China			
	Supply	Demand	Nominal	Expectation	Supply	Demand	Nominal	Expectation
1	2.767	43.913	0.426	52.895	2.865	0.841	0.157	96.136
2	7.287	41.854	0.964	49.895	2.863	1.686	0.523	94.928
3	7.780	41.723	1.010	49.487	3.090	2.643	1.068	93.198
4	7.752	42.133	1.093	49.021	3.536	2.626	2.215	91.623
8	7.953	42.955	2.595	46.498	3.451	3.088	2.367	91.094
15	7.914	42.892	2.855	46.340	3.467	3.101	2.405	91.027
20	7.911	42.895	2.863	46.331	3.467	3.101	2.406	91.026
25	7.911	42.896	2.864	46.329	3.468	3.101	2.406	91.026
	Japan				Singapore			
1	0.049	5.774	2.569	91.608	7.540	25.461	0.944	66.055
2	0.204	5.932	2.822	91.042	10.512	22.953	3.949	62.586
3	0.204	6.016	2.872	90.908	10.516	22.847	4.337	62.299
4	0.316	6.082	2.873	90.729	10.537	22.748	4.665	62.050
8	0.424	7.271	3.398	88.907	12.089	22.639	5.357	59.915
15	0.457	7.276	3.401	88.867	12.275	22.622	5.397	59.705
20	0.461	7.276	3.403	88.861	12.277	22.623	5.398	59.703
25	0.462	7.276	3.403	88.860	12.277	22.623	5.398	59.703
	Thailand				United Kingdom			
1	4.269	48.492	0.003	47.237	3.518	54.334	0.063	42.084
2	4.588	50.131	0.969	44.313	3.879	54.858	0.368	40.895
3	4.576	49.886	1.166	44.373	3.771	52.497	0.479	43.253
4	4.704	49.082	1.774	44.439	3.684	51.431	0.704	44.181
8	4.929	48.359	1.747	44.965	4.530	49.615	1.012	44.843
15	4.967	48.333	1.762	44.938	4.777	49.389	1.018	44.815
20	4.968	48.332	1.763	44.937	4.792	49.378	1.019	44.810
25	4.968	48.332	1.763	44.937	4.796	49.376	1.019	44.809

Note: This table gives the percentage of variance as a function of the supply, demand, nominal and expectation shocks, respectively.

The variance decomposition gives the idea about the contributions of each random innovation to the variance of the relative stock price. We also report the historical decomposition for the relative stock price in level in order to assess the relative importance of all shocks in explaining the evolution of relative stock prices over time. Figure 4.1 provides the historical decomposition for each county. In the figure, the solid line represents the actual level of relative stock prices and the dashed (dashed with symbol) line represents the baseline (baseline plus each variable).

The first impression from Figure 4.1 is that the base plus the nominal shock line moves in close correlation with the baseline, which suggests that the nominal shock plays an unimportant role in explaining the movement of relative stock prices in all cases. On the other hand, the contribution of the demand and expectation shocks are relatively significant among the shocks in most cases, which is consistent with our flexible-price solutions. In the case of Canada and Thailand, we note that when the actual series begins to rise above the base projection, this is at first accompanied by a corresponding increase in the base plus supply shock line while the change in the base plus expectation shock is insignificant, suggesting that the economic performance is more important in these countries.

The significance of the demand and expectation shocks to the fluctuations of the relative stock price in China, Japan and the United Kingdom is strongly evident in the figure because this is not a reflection of an ordering in the SVAR system that allows the real exchange rate and the relative stock price the maximum opportunity to influence the other variables. The strong contribution of the demand shock to the relative stock price may arise from the fact that the positive demand shock increases the interest rate. An increment in the interest rate would increase the rates of the future cash flows of the domestic stocks.

One important finding from this Figure 4.1 is that the base plus the expectation shock line is clearly dissociated from the baseline prior to the 2008 global financial crisis in the case of China, Japan, Singapore and particularly the United Kingdom. This might reflect the investors' optimistic expectation in relation to the performance of the domestic stock market since the expectation shock consists of the expected change in the real exchange rate, $\nabla E_t \nabla q_t$ and of the risk premium of domestic shares relative to foreign shares, $\nabla E_t \nabla \rho$. During the 08 global financial crisis, the magnitude of the decline in the base plus expectation shock line in China and the United Kingdom is much larger than the decline in the actual relative stock price and the subsequent rebound in the actual relative stock price is also less than the increase in the base plus expectation line. It implies that the change in the investors' expectations is sharp and fast, and also provides evidence that a high level of speculation is common in China and the United Kingdom. Compared to the global financial crisis, the expectation shock was relatively less important during the time of the European sovereign debt crisis in late 2011.

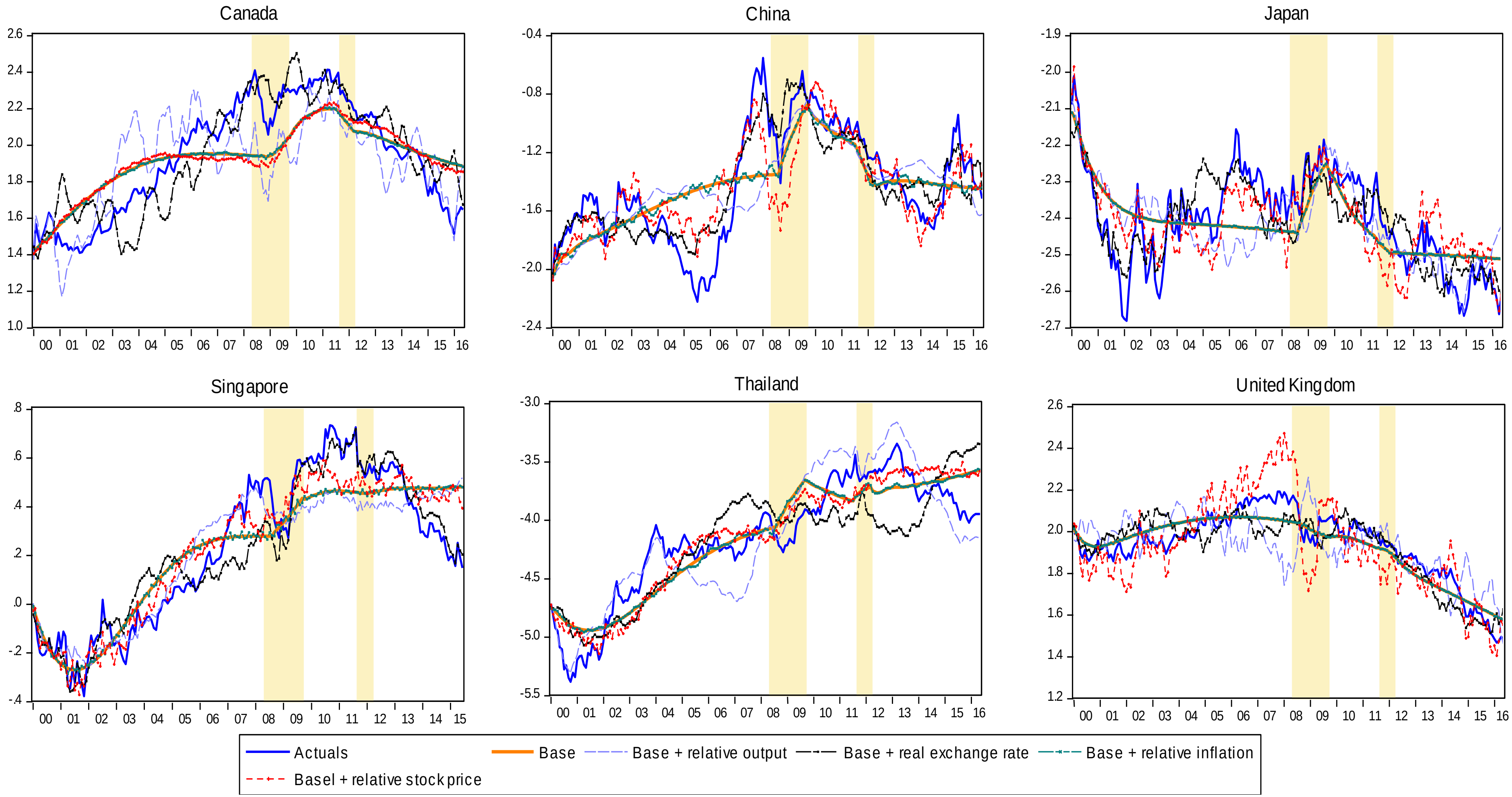

Figure 4.1: The Historical Decomposition of Relative Stock Prices

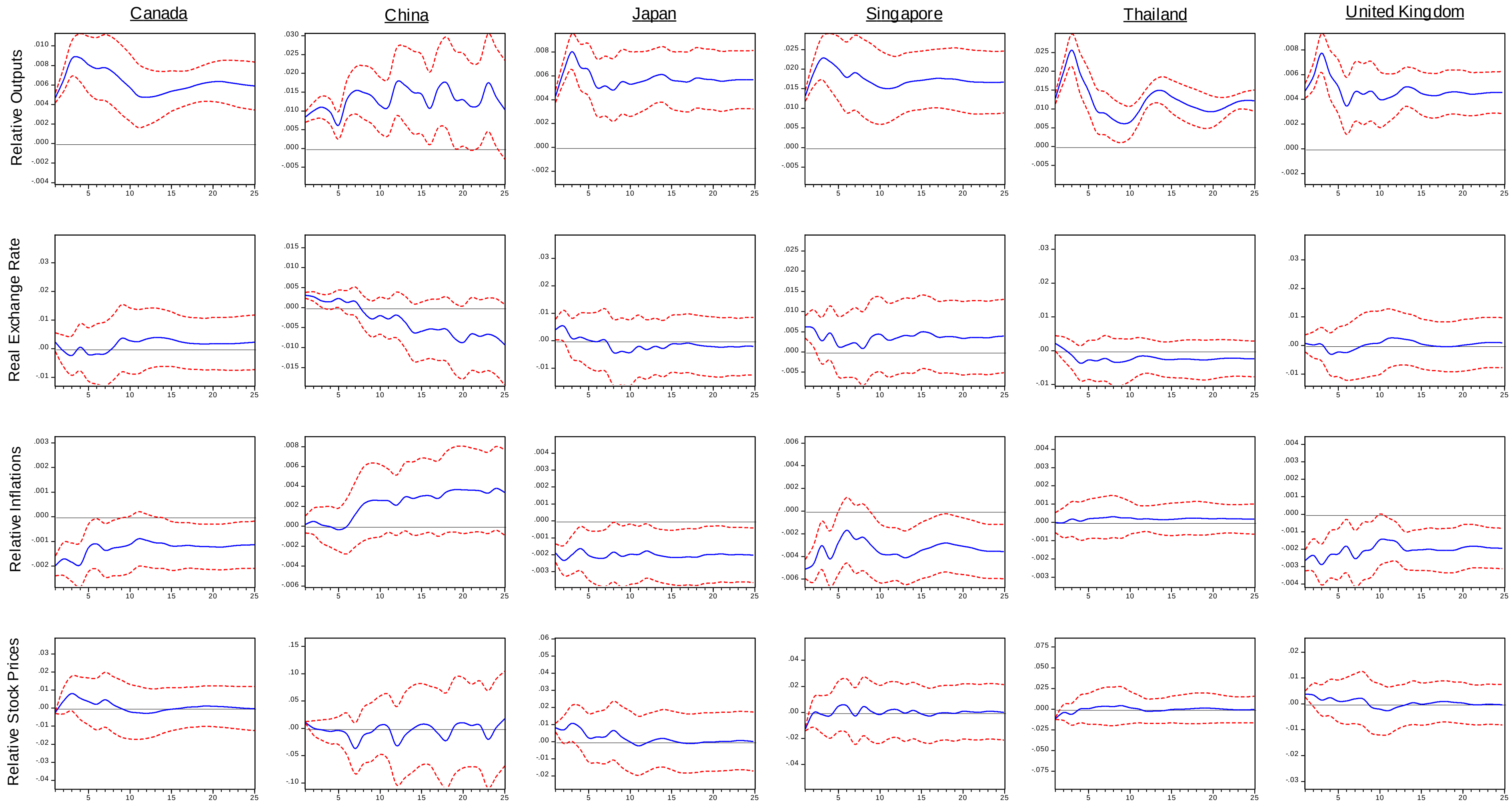

Figure 4.2: The Accumulated Impulse Response Functions to a Supply Shock for all Countries

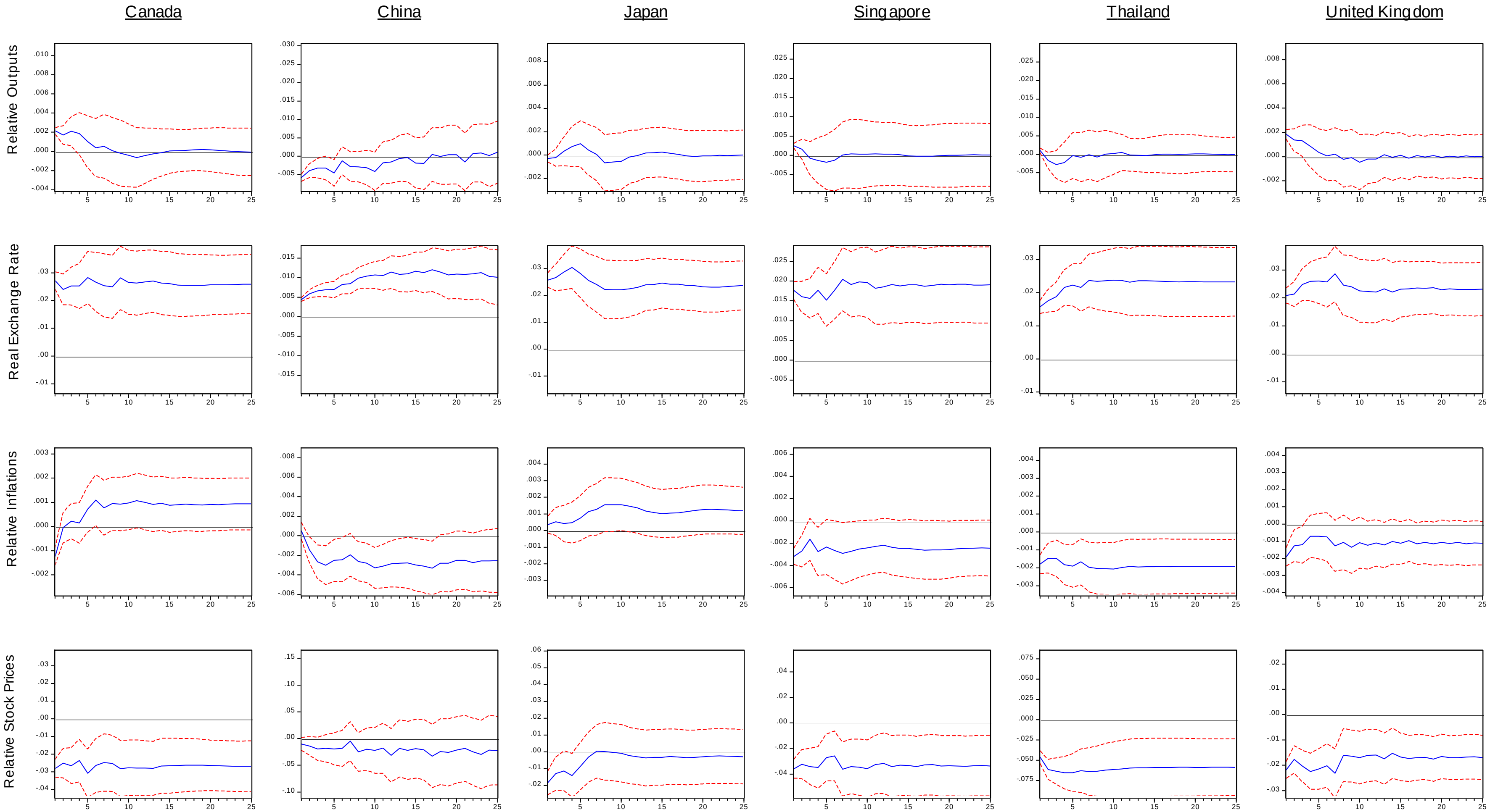

Figure 4.3: The Accumulated Impulse Response Functions to a Demand Shock for all Countries

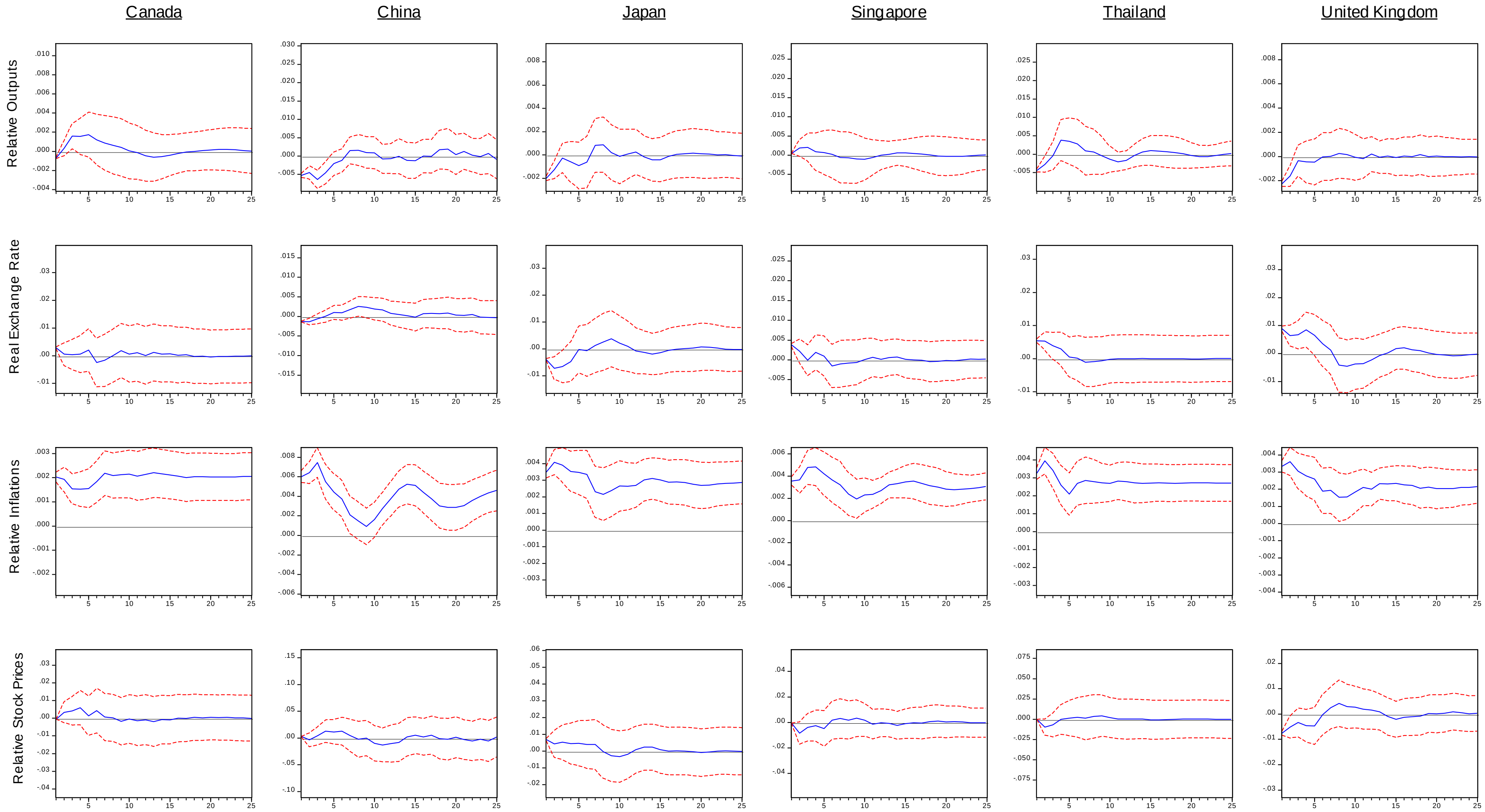

Figure 4.4: The Accumulated Impulse Response Functions to a Nominal Shock for all Countries

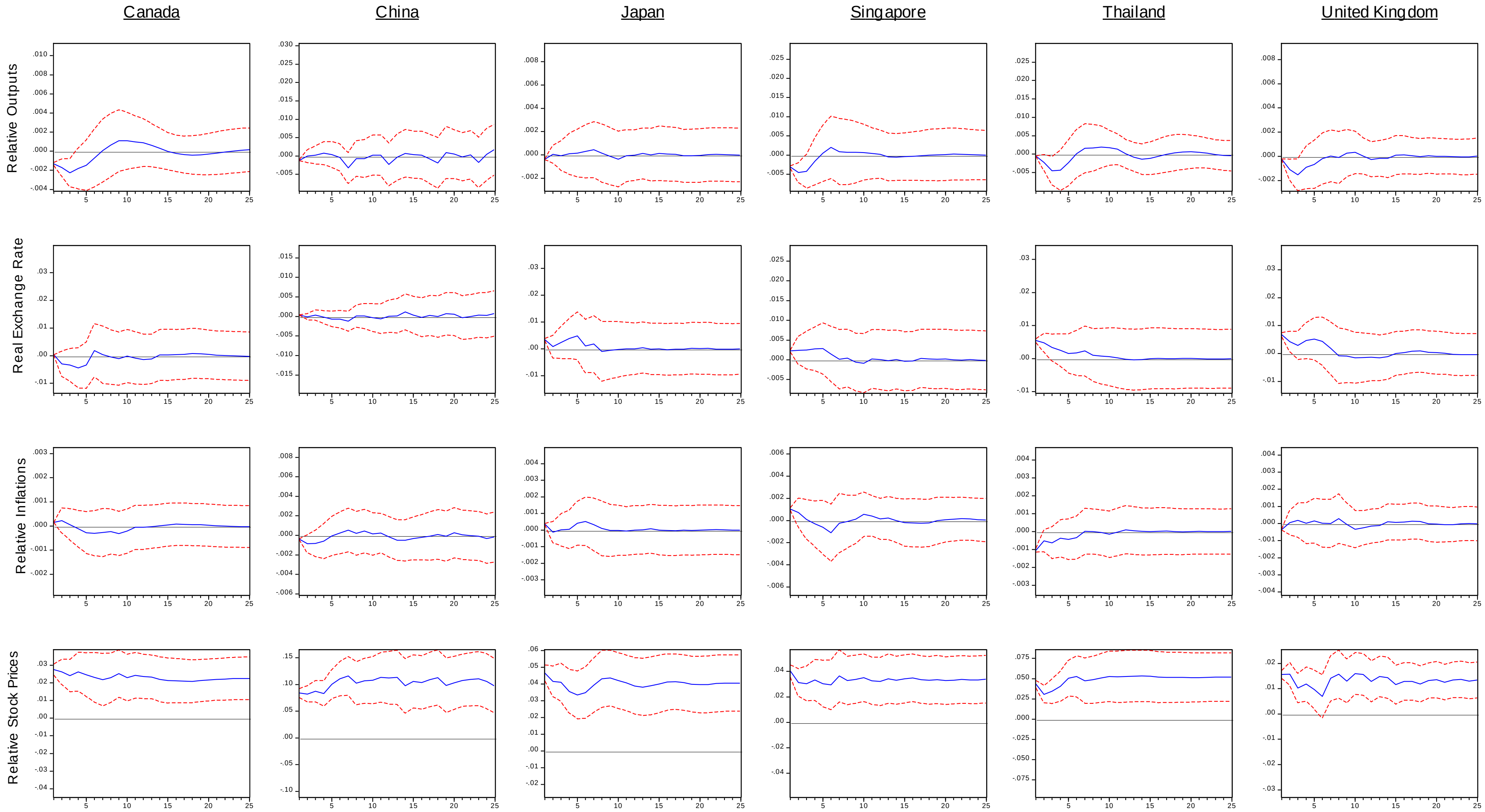

Figure 4.5: The Accumulated Impulse Response Functions to an Expectation Shock for all Countries

We then examine how the variables in Y(t) react to each structural innovation. The impulse response functions can effectively provide a quantitative measure of the dynamic effects of each shock on the variables. Based on the estimated long-run SVAR identification, the dynamic effects of supply, demand, nominal and expectation shocks on each variable are respectively illustrated in Figures 4.2 to 4.5. In this analysis, we consider each structural shock with a structural one standard deviation positive innovation over a horizon of 25 months. The horizontal axis measures the time horizon in terms of months after the shock and the vertical axis represents the response of the variable.

Figure 4.2 reports the accumulated impulse response functions to a supply shock for all countries. In general, the structural dynamic is closely aligned to the prediction of the Mundell-Fleming-Dornbusch model that a positive supply shock results in an increase in relative output in all countries. The accumulated responses generally peak in the fourth month and converge rapidly to their long-run values (with the exception of China and Thailand). In response to a supply shock, the real exchange rate initially depreciates and then appreciates after the third month in most cases, while the relative inflation declines in all countries except for China and Japan. Note that the impact of supply shocks on the real exchange rate and relative inflation is long-lasting in all economies. These results are equivalent to the model whereby supply shocks generate a permanent effect on the real exchange rate and relative inflation, respectively. The reaction of the relative stock price for each country (with the exception of Singapore and Thailand) is consistent as predicted by the economic theories stipulating that a supply shock generates a positive initial impact on the relative stock price.

In Figure 4.3, although the relative outputs generally increase instantaneously in response to the demand shocks, the real exchange rate depreciates while the relative inflation declines apparently, in contradiction to the open macro model. The impacts of the demand shocks on relative stock prices are consistent with the models expected. A negative effect can obviously be found in all cases. For instance, the relative stock prices of Canada in Table 4.3 decline by approximately 3.2% in the first month in response to a positive demand shock. The negative impacts might be explained by the present-value valuation model indicating that the positive demand shocks would increase the interest rate. An increment in the interest rate would increase the rates at which future cash flows are discounted[23]. On the other hand, we could see in Table 4.3 that the responses of the relative stock price become positive at 25 months in four countries (Canada, China, Singapore and the United Kingdom). These findings suggest that the demand shock might generate a positive impact on the relative stock price in the long-run. Moreover, the impacts of demand shocks do not fulfil the model predicted.

Figure 4.4 presents the accumulated impulse response functions to the nominal shocks due to an increment in the domestic money supply or a decline in the domestic money demand relative to the US. It can be noted that the real exchange rate initially depreciates in response to a positive nominal shock in most countries, but the impacts are fully offset after several months. A permanent and positive response can be found in all countries, which is in line with the prediction of the open macro model in the section II. The relationship between inflation and stock returns is controversial in the financial literature. For instance, Lastrapes (1998) indicates that a positive money shock lowers the interest rate and hence increases the real stock prices. Similar findings can

[23] In fact, the effect of demand shocks on stock prices is unclear. One may argue that a positive demand shock would increase stock prices as the increase in the real output would increase the anticipated short-term earnings.

also be found in Rapach (2001). As can be seen in Table 4.3, we find that the initial responses of the relative stock price to the nominal shock are negative in all cases with the exception of Singapore, which is consistent with the model implying that the relative stock price is expected to decline in response to nominal shocks in the short-run when the price is sluggish. This result is similar to the findings of Malliaropulos (1999), who finds empirical evidence that the real nominal shocks lead to a permanent decrease in real stock prices under a structural sticky-price model.

The accumulated impulse response functions to the expectation shocks due to the expected change in the real exchange rate and in the relative stock price (conditional risk premium) between the domestic and the US stock market are presented in Figure 4.5. Although the expectation shock generates negative impacts on the relative output and relative inflation, we do not think that the expectation shock could affect these two variables in the short-run.

In an influential paper, Fama and French (1988) indicate that stock prices contain permanent and transitory components, and show that stock returns contain large predictable components. On the other hand, we note that the error term in equation (17) contains the expected change in the real exchange rate: $\nabla E_t \nabla q_t = u + (\vartheta - 1)\nabla q_t^T$ and the expected change in the relative stock prices: $\nabla E_t \nabla \rho_t = v + (\phi - 1)\nabla \rho_t^T$. Under rational expectations, investors make intelligent use of the available information in the market in order to forecast the variables that would affect their decision-making. In addition, we believe that the property of mean-reversion in the real exchange rate and in the relative stock price is one of the main components that formed the expectation shock. As expected, the real exchange rate depreciates in response to the expectation shock in all cases except for Canada, while the expectation shock results in a significant increase in the relative stock prices.

Table 4.3: Impulse Response of the Relative Stock Prices to all Shocks

	Canada				China			
	Supply	Demand	Nominal	Expectation	Supply	Demand	Nominal	Expectation
1	-3.00E-03	-3.17E-02	-1.12E-03	2.45E-02	1.46E-02	-7.91E-03	-3.42E-03	8.45E-02
2	8.60E-03	4.67E-03	3.67E-03	-1.21E-03	-1.64E-03	-8.03E-03	-5.26E-03	-1.65E-03
3	1.74E-03	-3.09E-03	5.46E-04	-9.36E-05	-4.73E-03	-8.75E-03	6.55E-03	5.48E-03
4	-1.08E-04	5.99E-03	-3.01E-04	1.76E-03	-6.29E-03	-1.60E-03	9.57E-03	-3.68E-03
8	-8.93E-04	5.20E-04	-3.10E-04	6.03E-05	-4.16E-04	8.92E-04	-6.43E-04	-2.17E-03
15	1.51E-05	-1.11E-04	-2.76E-05	3.08E-05	-6.12E-05	-1.85E-04	-3.30E-04	2.02E-04
20	-3.86E-05	1.48E-05	-8.06E-06	-2.86E-06	-2.05E-05	3.11E-05	9.15E-05	-2.07E-05
25	1.71E-05	2.84E-07	5.72E-06	-7.23E-07	2.99E-06	8.17E-06	-2.18E-05	3.18E-06
	Japan				Singapore			
1	2.53E-03	-1.35E-02	-6.93E-03	4.80E-02	-1.62E-02	-2.97E-02	5.73E-03	4.79E-02
2	5.99E-04	1.99E-03	2.10E-03	-3.72E-03	1.20E-02	-1.37E-03	-1.09E-02	-1.11E-02
3	-2.68E-04	1.95E-03	9.04E-04	-1.02E-03	-1.45E-03	3.23E-04	3.98E-03	5.56E-04
4	-2.30E-03	-1.49E-03	9.17E-04	-5.98E-03	-1.71E-03	-8.55E-04	3.70E-03	1.69E-03
8	8.77E-04	-2.40E-06	-9.91E-04	1.11E-03	2.81E-03	1.47E-03	-1.23E-03	3.57E-04
15	-1.10E-05	1.22E-04	-1.73E-04	3.67E-05	-4.46E-04	-4.20E-04	7.44E-05	1.12E-04
20	1.55E-04	-5.87E-05	8.73E-05	-3.37E-05	-6.40E-06	-7.91E-06	6.01E-05	-9.84E-06
25	-1.36E-05	-1.46E-05	1.88E-05	-5.52E-06	1.93E-05	2.32E-05	1.58E-06	-1.02E-05
	Thailand				United Kingdom			
1	-1.28E-02	-4.32E-02	-3.19E-04	4.26E-02	-6.12E-03	-2.40E-02	-8.22E-04	2.12E-02
2	6.16E-03	-1.85E-02	-6.52E-03	-1.16E-02	2.32E-03	5.22E-03	-1.84E-03	-1.87E-03
3	-7.99E-04	-1.39E-03	3.00E-03	3.74E-03	-8.88E-04	-1.27E-03	1.21E-03	-6.99E-03
4	3.03E-03	-9.18E-04	5.32E-03	5.99E-03	3.38E-04	-1.83E-03	-1.68E-03	4.92E-03
8	-2.37E-05	1.97E-03	-5.24E-04	4.14E-04	3.11E-06	4.41E-04	-4.92E-04	-1.52E-03
15	-3.49E-04	5.11E-05	-1.19E-05	-3.76E-05	-4.74E-04	-1.35E-04	-2.88E-05	6.74E-05
20	9.38E-05	-1.11E-05	1.42E-05	-4.79E-06	8.54E-05	4.32E-05	4.27E-08	-1.01E-04
25	-1.45E-05	-3.81E-06	1.62E-05	-2.75E-06	7.56E-05	3.16E-05	9.65E-06	-1.88E-06

Note: This table gives the impulse responses of the relative stock price to the supply, demand, nominal and expectation shocks, respectively.

V Conclusion

The purpose of this study is to investigate whether the relative stock price fluctuations can be explained by four different shocks, which are respectively due to the supply, demand, nominal and expectation disturbances. Following the works of Obstfeld (1985), Clarida and Gali (1994) and Malliaropulos (1998), we present a model which can be used to explain the evolution of relative stock prices with different macroeconomic shocks. On the other hand, given that the disturbance of the relative stock price equation consists of both the expected depreciation of the real exchange rate and the expected risk premium of the domestic stock prices (Malliaropulos, 1998), we recover the disturbance of the relative stock prices by estimating VAR in unrestricted form and term the structural innovation of the relative stock price as 'expectation shocks'. The model predicts that the expectation shocks generate a permanent impact on the relative stock prices and the demand shocks lead to both short- and long-run changes in the relative stock prices. However, the supply and nominal shock only affect relative stock prices on a temporary basis when prices are sluggish.

The historical decomposition results show that investors' expectations play the most important role in stock market volatility. We note that the magnitude of the decline in the base plus expectation shock line in China and the United Kingdom is much larger than the decline in the actual relative stock price and the subsequent rebound in the actual relative stock price is also less than the increase in the base plus expectation line during the global financial crisis. It highlights that the changes in investors' expectations is sharp and rapid, and also provides evidence of a high level of speculation in China and the United Kingdom. Compared to the global financial crisis, the expectation shock is relatively less important in the time of the European sovereign debt crisis.

The demand shock is found to be the second most influential shock in all cases with the exception of China. The strong contribution of the demand shock to the relative stock price may arise from the fact that the positive demand shock increased the interest rate. An increase in the interest rate would increase the rates of the future cash flows of the domestic stocks, while the poor performance of the demand shocks in China might reflect the fact that China exercises a fixed exchange rate regime with high capital control and stock market intervention.

In our impulse response analysis, we find that a supply shock generates a positive initial impact on the relative stock price in most countries, while the impact of the demand shocks on relative stock prices is consistent with the models expected. A negative effect can obviously be found in all cases. The reason for the negative impacts might be explained by the present-value valuation model indicating that the positive demand shocks would increase the interest rate. An increment in the interest rate would increase the rates at which future cash flows are discounted. A negative initial response of the relative stock price to the nominal shock can also be observed in most cases. This is consistent with the model suggesting that the relative stock price is expected to decline in response to nominal shocks in the short-run when the price is sluggish. This result is similar to the results of Malliaropulos (1999), who finds empirical evidence that the nominal shocks lead to a permanent decrease in the real stock prices under a structural sticky-price model. The expectation shock results in a significant increase in the relative stock prices. Fama and French (1988) indicate that the mean-reverting property of the transitionary component of stock prices renders the stock prices predictable so that the mean-reversion of the relative stock prices could be one of the reasons attributed to an increase in the relative stock price.

Chapter 5

The Forward-looking Ability of the Real Exchange Rate and its Misalignment to Forecast the Economic Performance and the Transitory Components of Relative Stock Prices

I Introduction

Many existing papers in the body of exchange rate literature documented that the changes in exchange rates contain sufficient information to forecast the future changes of their fundamentals (see for example: MacDonald & Taylor, 1993; Engel & West, 2005 and Hoffmann & MacDonald, 2009). Other works, such as Marks (1995), provide robust evidence that the long-horizon changes in nominal exchange rates contain an economic significant predictable component by regressing the long-horizon changes in exchange rates on the current exchange rate's deviation from a linear combination of relative money stocks and relative real income. All these papers provide empirical evidence to support the long-horizon predictability of real exchange rates.

In practice, one may often perceive that the changes in the exchange rate affect the performance of the stock market, or, conversely, that the changes in the stock price influence the capital movement. In fact, the remarkable increase in international capital mobility over the course of the past two decades has apparently amplified the importance of the flow of capital on financial markets. Exchange rates, asset prices, economic performance and capital movements have become closely related to each other. Blanchard (1981) indicates that if an asset has a higher expected level of future profitability, the international capital funds would move towards the assets, even across countries. The capital movement would initially reflect on the changes in the exchange rate. If so, it is worth questioning whether the exchange rate can predict future changes in the stock market return and in the economic performance of a country.

On the other hand, we observe that if the relative stock prices of a country fall below its permanent level, this would create expectations for a future increase in relative stock prices among international investors, as the temporary component of relative stock prices contains a mean-reverting property, so that it induces the capital inflow. Due to the short-lasting feature of the capital inflows, those capital funds can then be referred to as ‘speculative[24] capital’. Similarly, some analysts describe these patterns of capital movement as ‘hot money’ that flows from one sector or country to the next

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[24] Kaldor (1939) defines speculation as the purchase (or sale) of goods with the purpose of re-sale (re-purchase) in the future, where the reason behind such action is the expectation of future changes occurring in relevant prices relative to the exchange ruling price.

destination. The inflows of speculative capitals might be the shocks that temporarily knock the exchange rate away from its equilibrium level, and would initially reflect on a short-term exchange rate appreciation and push up the stock prices in consequence.

In Chapter 1, we introduce a theoretical interpretation of the real exchange rate determination. The model, referred to as 'DMFS', is an extension of Dornbusch's dynamic Mundell-Fleming model by incorporating the relative stock prices, which outlines the relationship between the real exchange rate, the real output differential, the relative stock price and the real interest rate differential. The main objective of this chapter is to test whether the real exchange rate can predict the future changes of its forcing variables. Different from the existing body of literature, we focus on testing the short-horizon predictability of the real exchange rate.

Campbell and Shiller (1987) propose a VAR approach for evaluating present value models, which enables econometricians to address the issues of non-stationary time series and incomplete data on the information of market participants. In this chapter, on the basis of a revision that incorporates relative stock price and rational expectation in Dornbusch's dynamic Mundell-Fleming model, we present a simple model that can be used for analysing the forward-looking ability of the real exchange rate. Our model builds on the work of Campbell and Shiller (1987) and MacDonald and Taylor (1993), who developed a stylised model in order to study the rational-expectations present value relation of short bills and long bonds; and the forward-looking rational expectations monetary approach to the exchange rate, respectively.

In addition to the real exchange rate, it is of particular interest to investigate whether the deviation of the real exchange rate from its fundamental value[25] would contain an economically significant predictable component on forecasting the future stock price movement and output. By introducing a particular assumption and transformation, the DMFS model can be converted into a forward-looking version of the real exchange rate (FLRE) or real exchange rate misalignment (FLM), which makes it possible to test whether the real exchange rate/real exchange rate misalignment is a reasonable approximation of the real output differential and the transitory component of relative stock prices.

The remainder of the paper is organised as follows. Section II reviews Dornbusch's dynamic Mundell-Fleming model with relative stock prices (DMFS) and presents the forward-looking real exchange rate (FLRE) and real exchange rate misalignment (FLM) models. Section III provides the data description of the methodology of the behavioural equilibrium exchange rate (BEER) and the autoregressive distributed lag (ARDL) model. The empirical results in Section IV consist of three parts. The first part indicates the estimated behavioural equilibrium exchange rate. The second and final parts respectively, report our empirical findings on the forward-looking real exchange rate (FLRE) and real exchange rate misalignment (FLM) model over the sample period. Section V concludes the paper.

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[25] We use the BEER approach of Clark and MacDonald (1998) in order to construct an equilibrium exchange rate, as this approach can capture all the systematic and fundamental movements of the real exchange rate and can also be subject to rigorous statistical testing.

II The models

5.2a Dornbusch's dynamic Mundell-Fleming model with Relative Stock Prices (DMFS)

In Chapter 1, we develop a simple model for the determination of the exchange rate, output, interest rate and stock price. The model is an extension of Dornbusch's dynamic Mundell-Fleming model by incorporating the relative stock price in the model referred to as DMFS. By introducing a particular assumption, the model makes it possible to test whether the real exchange rate or its misalignment are a reasonable approximation of the real output differential and the transitory component of relative stock prices.

The primary component of our model involves the uncovered interest parity condition. The capital market equilibrium is given by the uncovered interest parity condition augmented by a catch-all variable (u_t):

$$E_t(\Delta e_{t+1} | \Omega_t) = i_t - i_t^* + u_t. \tag{1}$$

where e_t denotes the log of the nominal exchange rate at time t; i_t is the nominal interest rate; Δ is the first-difference operator; and $E_t(\,.\,|\Omega_t)$ is the mathematical conditional expectation operator, conditional on the information set Ω_t available at time *t*. The variable marked by an asterisk represents the foreign counterpart of the domestic variable and the US is assumed to be the foreign country. The statement of the uncovered interest parity condition indicates that the expected rate of depreciation of the domestic exchange rate is equal to the difference between the domestic and the foreign nominal interest rate. Any deviations from the condition are assumed to be captured in (u_t).

Equation (2) represents the standard LM equation, which suggests that the money market is continuously in equilibrium:

$$m_t - p_t = y_t - \lambda i_t, \tag{2}$$

where m_t is the nominal quantity of money, p_t represents the domestic price level and y_t is the real income. As noted in the LM equation, the demand for real money balances is assumed to depend on the domestic interest rate and on the real income and the income elasticity is assumed to be 1.

Equation (3) gives the open-economy IS equation in which the demand for domestic output depends on the relative price of domestic goods ($e_t - p_t$), real income y_t and interest rate i_t :

$$y_t^d = \eta(e_t - p_t) + \gamma y_t - \sigma i_t. \tag{3}$$

From the equation, an increase in the relative price of domestic goods lowers the demand for domestic goods, as does a reduction in real income or an increase in the real interest rate. In addition, the rate of increase in the price of domestic goods can be described as proportional to an excess demand measure:

$$\dot{p}_t = \pi[\eta(e_t - p_t) + (\gamma - 1)y_t - \sigma i_t]. \tag{4}$$

Using the equation of the real exchange rate: $q_t \equiv e_t + p_t^* - p_t$ and the ex-ante real interest rate: $r_t = i_t - [E_t(p_{t+1}) - p_t]$ and setting $\dot{p}_t = 0$, the steady-state real exchange rate implied by equation (4) is:

$$\bar{q}_t = \frac{1}{\eta}[(1-\gamma)\bar{y}_t + \sigma \bar{r}_t], \tag{5}$$

Equation (5) gives the long-run solution of the real exchange rate, which depends on the real income and real interest rate.

Malliaropulos (1998) proposes a theoretical linkage between the real exchange rate and the relative stock differential[26]. Assuming that both the real exchange rate and the relative stock differential consist of transitory and permanent components, the transitory component of the relative stock price ρ_t^T can be expressed as a function of the real exchange rate and of the expected real stock differential $(E_t \Delta rs_t)$:

$$\rho_t^T = \rho_t - \rho_t^p = -\gamma - \frac{\theta - 1}{\phi - 1}(q_t - q_t^P) + \frac{1}{\phi - 1} E_t \Delta rs_t \quad . \tag{6}$$

Since $0 < \theta$ and $\phi < 1$, equation (6) suggests that the temporary component of relative stock prices is negatively correlated to the temporary deviations of the real exchange rate from the purchasing power parity (PPP).

For the sake of simplicity, it is assumed that the permanent component of the relative stock differential and real exchange rate is a driftless random walk process and the expected real stock differentials $(E_t \Delta rs_t)$ are equal to zero. By subtracting q_t from both sides of equation (5) and then substituting the equation into (6), we obtain[27]:

$$q_t = -\gamma + a_1 \bar{y}_t - a_2 \rho_t^T + a_3 \bar{r}_t \ . \tag{7}$$

[26] The relative stock price is constructed by the equation: $\rho_t = s_t - s_t^* - e_t$, where s_t represents the domestic stock price.

[27] We assume that $\bar{q}_t$ is the permanent component of the real exchange rate because the permanent component of the real exchange rate is always considered as the measure of the equilibrium exchange rate (Huizinga, 1987; Cumby & Huizinga, 1990; Claida & Gali 1994).

Where $a_1 = \frac{1-\gamma}{\eta}$, $a_2 = \frac{\phi - 1}{\theta - 1}$ and $a_3 = \frac{\sigma}{\eta}$. Equation (7) gives Dornbusch's dynamic Mundell-Fleming model with the transitory component of the relative stock price to the model (DMFS), which indicates that the real exchange rate is positively related to the long-term real interest rate and output, and is negatively related to the temporary component of relative stock prices. Since the stock market is highly sensitive to news, any information available in the market at time *t* would be captured in the transitory component of relative stock prices and therefore it may affect the flow of speculative capital. In addition, we argue that if the relative stock price falls below its permanent level $(p_t < p_t^P)$, it would generate expectation on a prospective increase in relative stock prices, as the temporary component contains a mean-reverting property. Due to the expected future return on stock prices, international capital funds may flow toward the country and hence cause a real exchange rate appreciation over the short term, while the inflow of speculative capital would push up the stock prices as a result.

5.2b Constructing the Forward-looking Real Exchange Rate (FLRE) Model and the Forward-Looking Real Exchange Rate Misalignment (FLM) Model

In our empirical analysis, it is sought to evaluate whether the real exchange rate provides sufficient information to forecast the future real output and relative stock price movement. In order to do this, by considering $x_t = a_1(y_t - y_t^*) - a_2\rho_t^T$, adding q_t on both side of equation (1) in real term and then substituting equation (1) into (7), the real exchange rate equation becomes:

$$q_t = (1+a_3)^{-1} x_t + a_3(1+a_3)^{-1} E(q_{t+1} | \Omega_t). \tag{8}$$

The common approach adopted by a vast number of existing papers (see for example: Engel & West, 1995; Macdonald & Taylor, 1995) is imposing the 'no bubble' condition that the term $\lim_{t\to\infty}\left[a_3(1+a_3)^{-1}E(q_{t+1}|\Omega_t)\right]$ would be equal to zero. Iterate equation (8) forward to obtain:

$$q_t = (1+a_3)^{-1}\sum_{j=0}^{\infty}\left[a_3/(1+a_3)\right]^j E(x_{t+1}|\Omega_t). \qquad (9)$$

An alternative way is to assume $\lim_{t\to\infty}\left[a_3(1+a_3)^{-1}E(q_{t+1}|\Omega_t)\right]$ equal to the long-run real exchange rate $\bar{q}_t$ (Engel, 2014, 2016). Iterate equation (8) forward to obtain:

$$q_t^M \equiv q_t - \bar{q}_t = (1+a_3)^{-1}\sum_{j=0}^{\infty}\left[a_3/(1+a_3)\right]^j E(x_{t+1}|\Omega_t). \qquad (10)$$

q_t^M represents the real exchange rate misalignment, which represents the deviation between the actual current real exchange rate and its equilibrium level: $q_t - \bar{q}_t$. Equations (9) and (10) provide the forward-looking solution for the real exchange rate (FLRE) and the real exchange rate misalignment (FLM), and suggest respectively that the current real exchange rate/current real exchange rate misalignment contain sufficient information for forecasting the expected change in the forcing variables x_t, conditional on the information available at time *t*.

We apply the methods developed in Campbell and Shiller (1987) and MacDonald and Taylor (1993) in order to test whether the forward-looking relation is valid when the real exchange rate/real exchange rate misalignment is co-integrated with the forcing variables in x_t . In the following, equation (10) would be used for our interpretation. Subtracting x_t from both sides of equation (10) and rearranging leads to:

$$q_t^M - x_t = (1+a_3)^{-1}\sum_{j=1}^{\infty}\left[a_3 / (1+a_3)\right]^j E(\Delta x_{t+j}\left|\Omega_t\right.) \qquad (11)$$

Note that the left hand side of equation (11) includes variables: q_t^M , y_t , y_t^* and ρ_t^T . Many empirical research studies document that y_t , y_t^* and ρ_t^T are first-difference stationary $I(1)$ variables and variable q_t^M is not necessarily stationary even if $\bar{q}_t$ might be $I(0)$[28]. Therefore, the equilibrium error[29] for the real exchange rate misalignment,

$$S_t = q_t^M - a_1(y_t - y_t^*) + a_2\rho_t^T, \qquad (12)$$

should be stationary if there is at least one linear combination between the variables. Substitute (12) into (11) to obtain:

$$S_t = (1+a_3)^{-1}\sum_{j=1}^{\infty}\left[a_3 / (1+a_3)\right]^j E(\Delta x_{t+j}\left|\Omega_t\right.) \; . \qquad (13)$$

Equation (13) suggests that the equilibrium error should be equal to the optimal forecast of the present value of future forcing variables. Although the case in equation (13) *j* is infinite, it can be easily modified to handle a finite value of *j* using the VAR approach

[28] We will test for its stationarity for each economy in Section 4.

[29] The equilibrium error for the real exchange rate is given as: $S_t = q_t - a_1(y_t - y_t^*) + a_2\rho_t$. Note that this co-integration relationship is not inconsistent with the existence corresponding to the DMFS model, as shown in equation (7). This is because, as MacDonald and Taylor (1993) suggest, the interest rate differential must be $I(0)$ for $q_t \sim I(1)$

introduced by Campbell and Shiller (1987) in order to evaluate the present value model. This approach is particularly useful if it is sought to analyse a forward-looking model.

Since the true information set of the market participants cannot be observed, it is necessary to project equation (13) onto a subset of the information set used by market participants. If both S_t and Δx_t are each stationary, *I(0)* process, it may be inferred that $R_t \equiv [\Delta x_t, S_t]$ is also a stationary vector stochastic process. We can then use their histories as our information subset for multi-period forecasting. Consider that R_t can be expressed as a *p*-th-order VAR system (with mean zero). This system can be rewritten as a first-order VAR process in the companion form $\mathbf{z}_t = \mathbf{A}\mathbf{z}_{t-1} + \mathbf{e}_t$, where vector $\mathbf{z}_t = \left[\Delta x_t, \ldots \Delta x_{t-p+1}, S_t, \ldots, S_{t-p+1}\right]'$. Vector $\mathbf{z}_t$ summarises the entire history of S_t and Δx_t . From the companion form, one can compute the optimal forecast of Δx_t over any horizon. The multi-period forecasts formula can be expressed as:

$$E(\mathbf{z}_{t+i} | \mathbf{H}_t) = \mathbf{A}^i \mathbf{z}_t, \tag{14}$$

where $\mathbf{H}_t$ is a VAR information set containing the current and lagged values of $\mathbf{z}_t$.

We then define two row vectors $\mathbf{k}_1'$ and $\mathbf{k}_2'$. Each vector has 2p elements, all of which are zero except for the first element of $\mathbf{k}_2'$ and the (*p* + 1)*th* element of $\mathbf{k}_1'$, which equal unity. Therefore,

$$S_t = \mathbf{k}_1' \mathbf{z}_t \tag{15}$$

and

$$\Delta x_t = \mathbf{k}_2' \mathbf{z}_t \tag{16}$$

Projecting both sides of equation (13) onto the VAR information set $\mathbf{H}_t$, and using equations (14) to (16), we obtain:

$$\mathbf{k}_1^{'}\mathbf{z}_t = \sum_{i=1}^{\infty}[a_3/(1+a_3)]^i \mathbf{k}_2^{'}\mathbf{A}^i\mathbf{z}_t$$

$$= \mathbf{k}_2^{'}\delta\mathbf{A}(I-\delta\mathbf{A})^{-1}\mathbf{z}_t \ , \qquad (17)$$

where $\delta = a_3/(1+a_3)$. Equation (17) indicates that the equilibrium error must equal the unrestricted forecast of the present value of future Δx_t from the VAR, evaluated using multi-period forecasts formula (14). If equation (17) is to hold nontrivially, the following 2*p* parameter restrictions are imposed on the coefficients of the VAR:

$$\mathbf{k}_1^{'} - \mathbf{k}_2^{'}\delta\mathbf{A}(I-\delta\mathbf{A})^{-1} = 0, \qquad (18)$$

which can be rewritten in linear form by postmultiplying $(I-\delta\mathbf{A})$:

$$H_0 = \mathbf{k}_1^{'}(I-\delta\mathbf{A}) - \mathbf{k}_2^{'}\delta\mathbf{A} = 0 \qquad (19)$$

Equation (19) gives a set of 2*p* linear forward-looking restrictions, which can be imposed on the VAR for $(\Delta x_t, S_t)$.

III Data and Econometric Methodology

All *data* in this chapter are *obtained* from DataStream, the International Financial Statistics and World Economic Outlook Database. The sample covers the period from May 2002 to May 2016. The data used for constructing the equilibrium real exchange rate includes the real exchange rate, the real interest rate differential, the trade balance, the terms of trade, the ratio of domestic government liabilities to the nominal GDP and the GDP per capita for seven economies (Canada, China, Hong Kong, Japan, Korea, Thailand and the United Kingdom). The US is considered as the 'foreign' country.

The real exchange rate is expressed in logarithm and calculated by the equation $q_t = e_t + p_t^* - p_t$, where e_t is the nominal exchange rate against the US dollar and p_t^* (p_t) represents the foreign (home) consumer price index. The real interest rate is expressed in the Fisher equation format: $r_t = i_t - (E_t p_{t+1} - p_t)$, which is equal to the nominal interest i_t rate minus the expected inflation rate. The expected inflation rate for each economy is generated by the AR (1) process. We construct the Beveridge-Nelson (1981) measures of the transitory component of the relative stock price ρ_t^T . The relative stock price ρ_t between the home economy and the foreign economy expressed in the domestic currency is calculated by the equation: $\rho_t = \tau_t + \tau_t^* - e_t$, where τ_t (τ_t^*) is the domestic (foreign) stock price. All the series are expressed in logarithm except for the interest rates, trade balance and the ratio of domestic government liabilities to the nominal GDP. In this chapter, we use monthly data for our estimation. In the case where the only available data frequency is quarterly or annual, the interpolation technique is used in order to convert them to comparable monthly data.

5.3a The behavioural equilibrium exchange rate (BEER) approach

The procedure to derive the behavioural equilibrium exchange rate (BEER) is relatively standard. In general, it consists of three steps. The first step is to estimate the real exchange rate with a set of economic fundamentals. Assume the system is described by the following (6 x 1) vector autoregressive (VAR) in levels:

$$\mathbf{x}_t = \boldsymbol{\eta} + \sum_{i=1}^{p} \Pi_t \mathbf{x}_{t-i} + \Psi \mathbf{D}_t + \boldsymbol{\varepsilon}_t, \qquad (20)$$

where $\boldsymbol{\eta}$ is a (6 x 1) vector of constants; Π_i are the matrices of the coefficient of the lagged variables, where $i = 1 \ldots P$; $\mathbf{D}_t$ is a vector of dummy variables and $\boldsymbol{\varepsilon}_t$ is a (6 x 1) vector of white noise disturbance with mean zero and covariance matrix Ω. In conformance to Macdonald and Dias (2007), the economic variables entering $\mathbf{x}_t$ in our work include:

$$\mathbf{x}_t = [q_t, debt_t, prod_t, r_t - r_t^*, tb_t, tot_t].$$

where q_t denotes the real exchange rate; $prod_t$ is the relative productivity, measured by the domestic GDP per capita relative to the US; $r_t - r_t^*$ is the real interest rate differential, tb_t is the trade balance and tot_t represents the terms of trade. In addition, the variable $debt_t$, which is the ratio of domestic government liabilities to the nominal GDP, is also considered in our estimations. Table 5.1 reports the statistic results for the Augmented Dickey-Fuller (ADF) test in levels and the first differences of the variables. The results indicate that all series in levels are non-stationary but become stationary after being first-differenced. Since the variables in x_t are integrated of order one, equation (20) can be reparametrised into the vector error correction mechanism (VECM) representation:

$$\Delta \mathbf{x}_t = \boldsymbol{\eta} + \prod \mathbf{x}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta \mathbf{x}_{t-i} + \Psi \mathbf{D}_t + \mathbf{e}_t \, , \tag{21}$$

where Δ represents the first difference operator; Γ_i is a (6 x 6) coefficient matrix (equal to $-\sum_{j=i+1}^{P} \Pi_j$) and Π is (6 x 6) matrix (equal to $\sum_{i=1}^{P} \Pi_i - I$) whose rank determines the number of cointegrating vectors.

Table 5.1: The ADF test for the variables in the BEER model

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
q_t	-1.54	-1.33	-0.88	0.31	-0.29	-1.09	-0.35
Δq_t	-3.79**	-2.71**	-4.55**	-2.69**	-3.52**	-3.56**	-4.02**
DEBT	-1.68	-0.73	-1.89	-1.75	-1.55	-1.31	0.73
	-2.13**	-3.11**	-10.23**	-3.66**	-2.30**	[-5.61**]	-2.15**
$prod_t$	1.85	2.15	2.07	2.00	2.07	2.32	1.38
	-12.34**	(-12.66)**	-11.85**	-12.23**	-11.97**	-11.73**	-12.23**
i_t^T - i_t^{T*}	-1.37**	-1.60	-1.39	-1.69	-1.27	-0.86	-1.84
$\Delta(i_t^T$ - $i_t^{T*})$	-13.35**	-11.67**	-12.71**	-4.36**	-12.13**	-7.43**	-4.16**
tb_t	-1.10845	1.38835	0.279071	-1.65909	0.284429	-1.71845	0.326964
	-16.15**	-4.71**	-8.20**	-21.06**	-10.76**	-12.29**	-17.34**
TOT	0.10	0.15	-1.42	-1.14	3.41	1.05	0.32
	-9.43**	-15.50**	-16.40**	-7.57**	-3.61**	-12.82**	-14.71**

Notes: The figures in parentheses ( ) represent the ADF test results with intercept but no time trend. The figures in parentheses [ ] represent the ADF test results with intercept and time trend. ** and * represent the statistical significance at 5% and 10%, respectively.

Secondly, the trace test of Johansen (1995) is used in order to determine the cointegration amounts in system $\mathbf{x}_t$. We assume that the cointegrating vector is normalised by the real exchange rate. If Π is of either full rank (Π =6) or zero (Π =0) rank, then no cointegrating relation exists among the variables. In these cases, it will be appropriate to estimate the model, respectively, in levels for full rank or first difference for zero rank. If Π is of reduced rank (*r*), where r < 6, it may be observed that there is *r* cointegration(s) exists among the variables, and (*n* x *r*) matrices α and β , such that $\Pi = \alpha\beta^{'}$ where the matrix α represents the speed of adjustment to the disequilibrium and $\beta^{'}$ is the matrix whose columns represent the linearly independent cointegrating vector(s). Finally, after confirming the existence of cointegration, the estimated vector β can then be used as a measure of the equilibrium real exchange rate and also as a quantification of the real exchange rate misalignment, which constitutes the difference between the actual real exchange rate and its equilibrium level.

5.3b The autoregressive distributed lag (ARDL) model

Pesaran et al. (2001) propose a bound testing approach, which is applicable irrespective of whether the underlying regressors are purely *I*(0), or *I*(1) or mutually co-integrated, for testing the existence of a level relationship between a dependent variable and a set of regressors. As shown in Table 5.2, the ADF result indicates that not all variables in equations (7), (9) and (10) are *I*(1) in levels. q_t^M is *I*(0) in all cases. The temporary component of relative stock prices is *I*(1) in Hong Kong and Korea, and *I*(0) in other economies. The rejection of the null hypothesis of a unit root is rarely statistically significant at the 5% level in the case of the real output differential (China and Thailand) and the real interest rate differential (Canada and the United Kingdom) is only rejected at the 5% level of significance. As can be seen, the order of integration of the underlying variables is mixed, therefore the use of the ARDL approach is more appropriate.

Table 5.2: The ADF test for the variables in the DMFS, FLRE and FLM models

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
q_t	-1.54	-1.33	-0.88	0.31	-0.29	-1.09	-0.35
Δq_t	-3.79**	-2.71**	-4.55**	-2.69**	-3.52**	-3.56**	-4.02**
q_t^M	-6.59**	-2.73**	-6.72**	-4.06**	-5.84**	-3.76**	-3.52**
ρ_t^T	-15.85**	-4.66**	-0.33	-9.94**	-0.32	-12.92**	-13.67**
$\Delta\rho_t^T$	-	-	-	-	-	-	-
y_t - y_t*	0.11	-6.35**	-1.74*	-2.44**	1.67*	-2.09**	-0.12
$\Delta(y_t$ - y_t*)	-3.37**	-	-2.89**	-	-9.00**	-	-3.49**
r_t^T - r_t^{T*}	-3.51**	-1.60	-1.64*	-1.27	-1.68*	-1.20	-2.15**
$\Delta(\mathrm{r}_t^T$ - $r_t^{T*})$	-	-11.67**	-7.33**	-4.36**	-12.05**	-7.37**	-

Notes: ** and * represent the statistical significance at 5% and 10%, respectively.

The first procedure for the ARDL model is to confirm the existence of a level relationship between the dependent variable and the regressors by testing for the significance of the lagged level of the variable in the error correction form of the ARDL model. The DMFS model of equation (7) in ARDL form is given as follows:

$$\Delta q_t = c_0 - \pi_{yy} q_{t-1} + \boldsymbol{\pi}_{yx,x} \mathbf{x}_{t-1} - \sum_{i=1}^{p-1} \boldsymbol{\psi}'_i \Delta \mathbf{z}_{t-i} + \varpi' \Delta \mathbf{x}_t + \xi D_t + u_t \qquad (22)$$

where c_0 is a set of deterministic variables; $\mathbf{x}_t$ is a (3 x 1) vector of independent variables; vector $\mathbf{z}_t$ includes the scalar variable q_t and vector $\mathbf{x}_t$; $\boldsymbol{\pi}_{yx,x}$ is the vector of coefficients; D_t is a vector of dummy variables and u_t is a white noise process.

In order to test for the absence of a level relationship between q_t and the forcing variable $\mathbf{x}_t$, the joint hypothesis test on the coefficients of the lagged level of variables: $\pi_{yy} = 0$ and $\boldsymbol{\pi}_{yx,x} = \mathbf{0}'$ in the univariate ECM is applied. However, it is complicated by the fact that the asymptotic distribution of the F-statistic is nonstandard and will depend on whether the variables in $\mathbf{x}_t$ are $I(0)$ or $I(1)$. Pesaran et al. (2001) provide two sets of asymptotic critical values: a lower bound value assuming $\mathbf{x}_t$ is purely $I(0)$ and an upper bound value assuming $\mathbf{x}_t$ is purely $I(1)$. If the calculated F-statistics: i) fall outside the critical value bounds, the null hypothesis of a no level relationship irrespective of the orders of integration of the time series can be rejected; ii) fall within the outside critical value bounds, the inference would be inconclusive.

IV Empirical Results

5.4a Constructing the equilibrium and temporary component of exchange rate

For each economy, we employ the Johansen cointegration procedure on an unrestricted vector autoregressive (VAR) model (equation (1)) in order to test for the number of cointegrating relationships among the 6 variables in our systems. The Akaike Information Criterion (AIC) statistic results suggest that the appropriate lag length is 4 for Japan, Thailand and the United Kingdom, 5 for Canada, Hong Kong and Korea and 6 for China. The dummy variables[30] for the 2008/09 financial crisis and the 2011/12 European Sovereign Debt crisis are included in order to prevent the presence of outliers.

The results of the trace test for the cointegration rank are reported in the top panel of Table 5.3. The cointegration test results clearly indicate the existence of a cointegration relationship for each economy, as the null hypothesis stipulating that there is no cointegrating vector is significantly rejected in all cases. Hence, the cointegration test results suggest that there is a long-run relationship between the real exchange rate and the identified fundamentals thereof for each economy. We then move into computing the equilibrium real exchange rate by using the long-run component of the fundamentals and the estimated cointegrating vectors. It is assumed that the cointegration vector is normalised by setting the real exchange rate $q_t = \beta_1 = 1$ and leaving the second cointegration vectors unrestricted for the system with $r > 1$.

[30] The θ_{GFC} is introduced to cover the 2008 financial crisis from September 2008 to September 2009. The θ_{ESC} is included in order to capture the impacts of the European Sovereign Debt crisis from August 2011 to March 2012. At that time, the yields of the long-term government bonds of some countries in the Eurozone rose above 6%, which indicates that the financial markets are highly concerned about the credit-worthiness of the countries.

Table 5.3: Trace test of the cointegration rank and the estimated coefficients for BEER

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
Cointegration rank							
H_0: r							
0	117.38**	168.33**	162.75**	117.76**	74.55**	146.3**1	147.84**
1	77.61**	80.06**	83.08**	78.82**	51.78**	100.63**	78.32**
2	42.60	52.24**	52.10**	41.96**	30.19**	57.53**	45.72
3	23.49	27.99	24.99	18.62	22.35**	32.52**	21.73
4	11.41	13.91	9.26	7.01	12.22	15.34	6.51
5	2.14	2.52	2.45	2.37	5.84	6.47**	0.82
Coefficients							
$DEBT$	0.203	0.176	0.068	0.503	-0.646	0.330	1.438
	(0.091)**	(0.056)**	(0.025)**	(0.198)**	(0.134)**	(0.054)**	(0.150)**
$prod_t$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)**	(0.000)**	(0.000)	(0.000)**	(0.000)*	(0.000)**	(0.000)**
r_t - r_t^*	0.027	-0.019	-0.001	-0.199	0.026	0.032	-0.089
	(0.015)*	(0.007)**	(0.001)**	(0.031)**	(0.013)**	(0.013)**	(0.025)**
tb_t	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)**	(0.000)	(0.000)	(0.000) *	(0.000)**	(0.000)	(0.000)
TOT	-0.020	0.003	0.000	0.002	0.001	0.014	0.004
	(0.002)**	(0.001)**	(0.000)	(0.001)**	(0.001)	(0.002)**	(0.004)
c	1.364	1.772	2.088	2.430	7.350	1.967	-1.675
	(0.314)**	(0.092)**	(0.028)**	(0.456)**	(0.112)**	(0.228)**	(0.383)**
θ_{GFC}	0.053	-0.085	-0.002	-0.053	0.176	0.017	0.087
	(0.028)*	(0.021)**	(0.001)**	(0.053)	(0.032)**	(0.026)	(0.031)**
θ_{ESC}	-0.047	-0.013	0.001	-0.064	0.028	0.012	-0.007
	(0.026)*	(0.024)	(0.001)	(0.066)	(0.036)	(0.032)	(0.037)

Note: The figures in parentheses represent the standard errors of the coefficients; ** and * represent the statistical significance at 5% and 10%, respectively.

The bottom panel of Table 5.3 gives the estimates for the cointegrating vector together with their standard errors. The estimated coefficient of the debt ratio is statistically significant at the 5% level of significance in all economies. All coefficients (except Korea) are positive, which suggests that a high debt ratio will result in a real depreciation in the home currency. The estimated coefficient of relative productivity is significant in all economies except for China and five of them are negatively related to the real exchange rate, which is correctly signed in terms of the theoretical interpretation of the effects of productivity on the exchange rate (see, for instance, MacDonald & Ricci, 2002). As for the real interest rate differentials, all economies are statistically significant at the 10% level of significance or less. Note that China, Hong Kong, Japan and the United Kingdom have the expected negative sign, which is consistent with Dornbusch's sticky-price version of exchange rate determination. All the estimated coefficients of trade balance are significant except for Thailand but the value is extremely small, suggesting that its impact on the real exchange rate is negligible. The terms of trade variable is significant in Canada, China, Japan and Thailand and correctly signed with the exception of Canada. The European debt crisis seems to exert no impact on the real exchange rate as the dummy variable θ_{ESC} is statistically insignificant in all economies. Conversely, the dummy θ_{GFC} is significant in most cases, implying that the effect of the outliers on the estimates is eliminated.

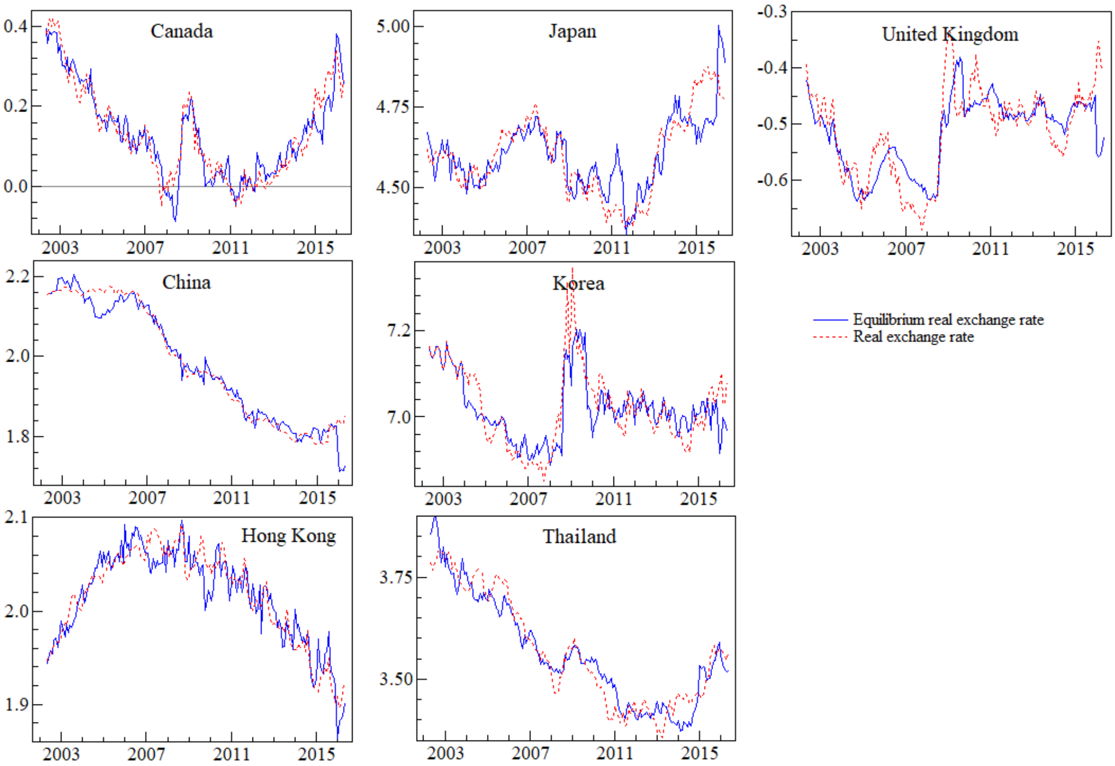

Figure 5.1: Time series plot of the real exchange rate and equilibrium real exchange rate

Figure 5.1 displays the evolution of the actual real exchange rate (dash line) and the estimated equilibrium exchange rate (solid line) for the seven economies from the period of 2002 to 2016, respectively. Although, in general, the real exchange rate and the equilibrium exchange rate move in the same direction, deviations can also be found between two lines in most cases, particularly during the onset of the 2008 financial crisis, in which the real exchange rate overshot to its equilibrium level.

5.4b The forward-looking real exchange rate

Panel A of Table 5.4 shows the bound test results for testing for the existence of a level relation between the real exchange rate and the forcing variables, as shown in equation (7). We used the critical value bounds[31] provided by Pesaran et al. (2001) to compare with our calculated F-statistic for each economy. It is apparent that the F-statistic is outside the 5% critical value bounds in all cases except Japan at a 10% level of significance. We can then conclusively reject the null hypothesis that there is no level relationship, irrespective of whether the regressors are purely $I(0)$ or purely $I(1)$.

The next step for the ARDL model is to estimate the level relationship for the DMFS model by means of OLS. The estimated coefficients of the level equation with the p-value in parentheses are also reported in Panel A. The temporary relative stock is significantly different from zero with 10% or less in Canada, Korea and the UK and the signs are as the model predicted. The coefficient of the real output differential is negative and significant in most cases which is not consistent with the model predicted. Interestingly, the real interest rate differential is statistically insignificant in all cases. It

[31] Please refer to Appendix C for details.

might be the fact that the quantitative easing and low interest rate policy were adopted in many economies after the 2008 financial crisis.

We also tested for the level relationship between the vectors of the variables excluding the real interest rate differential (equation (9)). The null hypothesis of the no level relationship is rejected in all cases except for Japan, in which case the calculated F-statistic falls within the outside critical value bounds. The inference is inconclusive. Panel B also reports the estimated coefficients. The results are basically similar to the model with the real interest rate differential.

Table 5.4: The ARDL model for the DMFS and FLRE models

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
Panel A: The DMFS model							
F-bound test	12.89**	5.07**	9.96**	3.16*	5.10**	7.94**	11.87**
Coefficients							
ρ_t^T	-288.751	0.564	-0.032	23.390	-0.221	-12640	-25.396
	(176.996)*	(0.538)	(0.029)	(18.461)	(0.058)**	(14074)	(7.928)**
y_t - y_t*	-0.034	-0.722	-0.588	1.298	-0.031	-1.710	0.140
	(0.034)	(0.142)**	(0.016)**	(0.064)**	(0.161)	(0.211)**	(0.007)**
r_t - r_t^*	-0.002	-0.011	-0.014	0.099	0.016	0.269	-0.008
	(0.087)	(0.010)	(0.013)	(0.121)	(0.023)	(0.225)	(0.018)
Panel B: The FLRE model							
F-Bounds Test	16.776**	6.397**	12.855**	2.189	7.396**	9.417**	20.769**
ρ_t^T	-237.732	0.160	-0.029	34.666	-0.201	32834	-29.385
	(154.742)	(0.597)	(0.029)	(53.248)	(0.052)**	70200	(8.526)**
y_t - y_t*	-0.039	-0.807	-0.588	1.377	-0.028	-2.113	0.140
	(0.032)	(0.452)**	(0.016)**	(0.154)**	(0.146)	(0.440)**	(0.006)**

Notes: The figures in parentheses represent the standard errors of the coefficients. ** and * represent the statistical significance at 5% and 10%, respectively.

Table 5.5 gives the ADF test as well as the Granger causality test results between the equilibrium error S_t and Δx_t. The ADF test results show that the Δx_t for each economy becomes $I(0)$ after being first-differenced, and all the equilibrium errors are stationary with the exception of China. Hong Kong and Korea are also included in the forward-looking test though the ADF test result is just statistically significant at the 10% level.

Table 5.5: The ADF and causality test for the forward-looking real exchange rate model (FLRE)

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
Panel A: ADF test							
S_t	-15.24**	3.85	-1.78*	-8.66**	-2.72‡‡	-12.49**	-13.47**
Δx_t	-11.85**	-12.13††	-3.53**	-10.69**	-12.74**	-9.07**	-12.06**
Panel B: Granger causality test							
$S_t \nrightarrow \Delta x_t$	25.62	-	3.6	29.82	1.76	38.5	22.17
	(0.000)**	-	(0.001)**	(0.000)**	(0.112)	(0.000)**	(0.000)**
$\Delta x_t \nrightarrow S_t$	0.81	-	9.57	0.63	3.09	13.28	0.13
	(0.445)	-	(0.000)**	(0.5362)	(0.007)**	(0.000)**	(0.878)

Note: †† represents the ADF test result and the statistical significance at 5% with intercept but no time trend; ‡‡ represents the ADF test result and the statistical significance at 5% with intercept and time trend. ** and * represent the statistical significance at 5% and 10%, respectively; $S_t \nrightarrow \Delta x_t$ indicates that S_t does not Granger-cause Δx_t; $\Delta x_t \nrightarrow S_t$ indicates that Δx_t does not Granger-cause S_t. The figures in parentheses represent the *p*-value.

Campbell and Shiller (1987) suggest that if variable S_t is the present value of a variable Δx_t, then S_t either Granger-causes Δx_t relative to the bivariate information set consisting of lags of S_t and Δx_t, or S_t is an exact distributed lag of the current and past value of Δx_t. In short, as long as S_t embodies some information in addition to that included in the past value of Δx_t, S_t Granger-causes Δx_t. The Granger causality test results are provided at the bottom of Table 5.5. The

AIC criteria suggest that the lag length of 2 for Canada, Japan and the United Kingdom; 3 for Thailand; 6 for Korea, and 8 for Hong Kong. There is strong evidence to suggest that the equilibrium error S_t Granger-causes Δx_t in most cases, suggesting that Δx_t Δx_t and S_t as opposed to using the history of Δx_t alone. A bidirectional causality runs between Δx_t and S_t in Hong Kong and Thailand as both the F-test statistics reject the null hypothesis of no causality. The DMFS model with rational expectation can be definitely confirmed in the case of Canada, Japan and the UK, as they strictly fulfil the condition that the equilibrium error Granger-causes Δx_t but not vice versa, which implies that the equilibrium error S_t is an optimal forecast of a weighted sum of the future value of the forcing variables included in Δx_t, conditional on the agents' full information set.

Table 5.6: The Wald test results for the forward-looking real exchange rate model (FLRE)

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
Discount factor							
$\hat{\delta}$	2.72	-	0.80	9459.45	1350	1293.78	0.11
	(0.000)**	-	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
0.9	**1.04**	-	89.15	**1.16**	44660.25	**1.14**	**0.20**
	(0.904)	-	(0.000)**	(0.884)	(0.000)**	(0.888)	(0.995)
0.8	**5.17**	-	219.13	**5.85**	225867	**5.83**	**0.73**
	(0.270)	-	(0.000)**	(0.211)	(0.000)**	(0.212)	(0.948)
0.6	36.58	-	1001.16	41.42	1605545	41.66	17.48
	(0.000)**	-	(0.000)**	(0.069)*	(0.000)**	(0.000)**	(0.002)
0.2	1313.36	-	28430.82	1488.16	*5.78*	1503.40	971.03
	(0.000)**	-	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**

Note: All the results for $\hat{\delta}$ are divided by 10^7. The figures in parentheses represent the *p*-value. The values in bold indicate that the forward-looking restriction is accepted. ** and * represent the statistical significance at 5% and 10%, respectively.

A formal test of the forward-looking restrictions (equation (19) imposed on equation (9) is given in Table 5.6. We use the estimated coefficient of the real interest rate differential from equation (7) to construct the discount factor $\hat{\delta}$. As can be seen in Table 5.6, the Wald test for forward-looking restrictions is strongly rejected in all economies. Accordingly, we tried four other discount factor values, 0.2, 0.6, 0.8 and 0.9. For the discount factor 0.9 and 0.8, four countries (Canada, Japan, Thailand and the UK) cannot reject the null hypothesis at the 5% level of significance. For $\delta = 0.6$, the forward-looking restrictions cannot be statistically rejected in Japan at the 5% level of significance. Similar to the results of the estimated coefficient, none of the economies are statistically insignificant for $\delta = 0.2$.

Summarising the results of the forward-looking restrictions, the forward-looking model is confirmed with part of our assumed δ in Canada, Japan, Thailand and the UK, respectively. We note that the lag length of these four countries are relatively short. In addition, since the output y_t is assumed fixed in the short-run, so the changes in the real exchange rate should mainly explain the future changes of the temporary component of stock market return.

One possible reason for this exchange rate-stock return relationship might be that if the relative stock prices of a country fall below its permanent level, this would create expectations for a future increase in relative stock prices among international investors, as the temporary component of the relative stock prices contains a mean-reverting property, capable of inducing capital inflow. On the other hand, herd behaviour might constitute an additional reason. The Federal Reserve Bank of New York (2013) reports that the five largest firms accounted for 74% market share in the spot market in 2010. It suggests that some currencies are dominated by a few big players. Their actions would cause the clear changes in the exchange rate and push up the stock prices. The stock prices would further increase subsequently due to the other investors follow those big players' actions.

5.4c The forward-looking real exchange rate misalignment

Table 5.7 shows the bound test results for the FLM model. The level relationship between the real exchange rate misalignment and the forcing variables is confirmed in all cases. We then estimate the level relationship for the FLM model by OLS. The results in Table 5.7 provide clear empirical evidence for the linkage between the real exchange rate misalignment and the temporary relative stock returns, as the coefficients of the temporary relative stock returns are significantly different from zero in all cases except Japan, and indicate that the signs of the coefficients are as the model predicted with the exception of China and Japan. The reason for this may be due to the barriers imposed by the Chinese government on foreign investors, while Japan has been considered as a currency shelter on various occasions over the course of the financial crisis. The response of the real exchange rate misalignment to the relative real output is confirmed in China, Hong Kong, Korea and Thailand but the estimated signs are not as expected.

Table 5.7: The ARDL model for the forward-looking real exchange rate misalignment model (FLM)

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
F-Bounds Test	10.29**	5.53**	22.69**	5.13**	7.60**	14.72**	8.07**
Coefficients							
ρ_t^T	-3.91	0.755	-0.030	0.15	-0.21	-636.76	-0.220
	(1.734)**	(0.335)**	(0.008)**	(0.795)	(0.068)**	(209.797)**	(0.067)**
$y_t - y_t^*$	0.00	-0.245	-0.075	0.00	-0.38	-0.01	-0.203
	(0.004)	(0.115)**	(0.027)**	(0.006)	(0.123)**	(0.004)	(0.143)

Notes: The figures in parentheses represent the standard errors of the coefficients. ** and * represent the statistical significance at 5% and 10%, respectively.

Table 5.8: The ADF and causality test results for the forward-looking real exchange rate misalignment (FLM)

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
Panel A: ADF test							
S_t	-5.27**	-2.07†	-7.34**	-4.05**	-3.14†	-11.55**	-11.27**
Δx_t	-11.85**	-16.43**	-12.22**	-10.71**	-11.82**	-9.09**	-12.06**
Panel B: Granger causality test							
$S_t \nrightarrow \Delta x_t$	1.61	0.24	0.08	1.54	2.62	1.96	4.50
	(0.136)	(0.784)	(0.990)	(0.170)	(0.027)	(0.056)	(0.005)**
$\Delta x_t \nrightarrow S_t$	2.19	2.11	1.20	1.13	4.36	2.41	5.56
	(0.038)	(0.125)	(0.311)	(0.348)	(0.000)**	(0.018)	(0.001)**

Note: † indicates that the ADF test result is statistically significant at 10% with intercept but no time trend. ** and * represent the statistical significance at 5% and 10%, respectively; $S_t \nrightarrow \Delta x_t$ indicates that S_t does not Granger-cause Δx_t ; $\Delta x_t \nrightarrow S_t$ indicates that Δx_t does not Granger-cause S_t . The figures in parentheses represent the *p*-value.

Table 5.8 reports the ADF test and the Granger causality test results between the equilibrium error obtained from equation (12) and Δx_t . The ADF test results show that

Δx_t and all the equilibrium errors are stationary at the 10% level of significance or below in all economies. The AIC criteria suggest that the lag length of 2 for China, 3 for the United Kingdom, 4 for Hong Kong, 5 for Korea, 6 for Japan, 7 for Canada and 8 for Thailand. Different to the results in Table 5.5, the null hypothesis is accepted in most economies, indicating that the equilibrium error s_t does not Granger-cause Δx_t and the expectation theory cannot be confirmed in all cases.

Table 5.9 reports the Wald test results for the FLM model. We test with the estimated coefficient of the real interest rate differential in order to construct the discount factor $\hat{\delta}$ and four other values of discount factor, 0.2, 0.6, 0.8 and 0.9. The Wald statistics of the null hypothesis in equation (19) are strongly rejected in all economies. The hypothesis tests give very similar results with Table 5.6. The forward-looking model can be confirmed if the discount factor is equal to 0.8 or 0.9. Of the fourteen Wald test statistics results, only four cases (in Thailand and the UK) are not statistically significant at the 5% level of significance. Also, none of the cases with δ = 0.6 and 0.2 are accepted. This particular set of restrictions is rejected outright by the data in most of the economies. However, as mentioned by Campbell and Shiller (1987), a present value model may well be economically significant, even though its particular cross-equation restrictions may be rejected by the data. This is because the model may explain most of the variation in even if it is rejected at 5% level of significance.

Table 5.9: The Wald test for the forward-looking real exchange rate misalignment (FLM)

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
Discount factor							
$\hat{\delta}$	74.60	25.80	33700.00	0.60	0.86	0.12	0.04
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
0.9	58.22	129.27	347.58	47.35	334.30	**3.35**	**3.07**
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.999)	(0.800)
0.8	84.50	532.61	1562.87	92.67	1511.33	**8.88**	**8.20**
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.918)	(0.224)
0.6	205.47	3441.28	10684.35	333.51	10385.27	45.27	42.98
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
0.2	3448.90	118437.90	379339.00	7922.97	369251.50	1404.89	1374.14
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**

Note: All the results for $\hat{\delta}$ are divided by 10^7. The figures in parentheses represent the *p*-value. The values in bold indicate that the forward-looking restriction is accepted. ** and * represent the statistical significance at 5% and 10%, respectively.

V Conclusion

This chapter begins by specifying that the real exchange rate/real exchange rate misalignment can predict future changes in the stock market return and the economic performance of a country. We argue that if the relative stock price of a country falls below its permanent level, speculators would expect a future increase in the relative stock prices as the temporary component of relative stock prices contains a mean-reverting property. The inflow of the speculative capitals might be the shocks that temporary knock the exchange rate away from its equilibrium level, and would initially reflect on a short-term exchange rate appreciation and push up the stock prices as a result.

With the revision that incorporates the relative stock price and rational expectation in Dornbusch's dynamic Mundell-Fleming model, we theoretically demonstrated that the real exchange rate or the real exchange rate misalignment may incorporate information about future forcing variables (relative outputs and temporary component of relative stock prices). The level relationship between: i) the real exchange rate; ii) the real exchange rate misalignment, and its forcing variables are strongly confirmed in the ARDL analysis. In addition, we also provide empirical support for Dornbusch's dynamic Mundell-Fleming model with the temporary component of relative stock prices (DMFS). The signs of the coefficients of the variables in the models are generally consistent with the models predicted.

In order to test whether the real exchange rate/real exchange rate misalignment is a reasonable approximation of the real output differential and the transitory component of relative stock prices, we propose the forward-looking model for the real exchange rate (FLRE) and for the real exchange rate misalignment (FLM) by building on the

VAR approach for the present-value models of Campbell and Shiller (1987). Both models involve solving the entire expected future path of the forcing variables. The changes of the real exchange rate/ real exchange rate misalignment may provide a good indicator for investors to predict the future changes of relative stock returns.

Our Granger causality results provide strong evidence that the equilibrium error Granger-causes Δx_t in most cases, suggesting that Δx_t can be better predicted using the histories of both Δx_t and the equilibrium error as opposed to using the history of Δx_t alone. The DMFS model with rational expectation can be definitely confirmed in the case of Canada, Japan and the UK, as they strictly fulfil the condition that the equilibrium error Granger-causes Δx_t, but not vice versa. With respect to the real exchange rate misalignment, the results demonstrate that the equilibrium error s_t does not Granger-cause Δx_t in most economies and the expectation theory cannot be confirmed in all cases.

On the other hand, it has been analytically proven that if the discount factors are large (δ = 0.8 or 0.9), then the forward-looking model for the real exchange rate (FLRE) can be confirmed in Canada, Japan, Thailand and the UK, respectively. Similar findings can also be seen in the Wald test results for the FLM model. If the discount factor is small, this particular set of restrictions is strongly rejected outright by the data in most of the economies. However, as mentioned by Campbell and Shiller (1987), a present value model may well be economically as well as statistically significant, even though its particular cross-equation restrictions may be rejected by the data.

Conclusion

This PhD thesis is constituted by five essays, which focus on investigating the long- and short-run determinants of the real exchange rate, as well as the source of the relative stock differential fluctuation. A number of empirical findings are presented in this thesis. In this section, we summarise the main empirical findings of this study, and provide several implications for investors and central banks.

In Chapter 1, we determine the long-run structural relationship between finance, money and goods markets on the basis of the real exchange rate, real interest rate, relative stock differential and relative output differential. A theoretical model is presented in an attempt to explain the interaction between the four variables and suggests that the temporary component of the relative stock differential can be used in order to explain the evolution of the real exchange rate. The empirical results are consistent with our theoretical model, indicating that the relative stock differential is informative in terms of explaining the long-run real exchange rate determination. However, we do not find any empirical support for the idea that a single stationary relationship holds in the cointegration vector. This result is informative to the literature as it provides robust empirical evidence that no particular relationship is sufficient in order to develop a long-run structural relationship between the variables in our system.

Several important findings can also be found in the first chapter. For instance, in determining the real exchange rate and the real interest rate differential (RERI) relationship, we suggest an alternative method, whereby only the homogeneity restriction and normalised exchange rate are imposed in the system. Our empirical results indicate that the signs of the estimated coefficient are positive in most cases, which is consistent with the expected sign of the flexible-price approach of the RERI relationship. The flexible-price version of the exchange rate determination is likely to be more appropriate to explain the evolution of the exchange rate in the modern economy. On the other hand, previous literature on the exchange rate determination seems to be inconclusive with respect to the choice between short- and long-term rates as proxies of the interest rate variable. Our empirical results suggest that the RERI relationship is not only confirmed in the long-term interest rates (Treasury bills rate and Government bonds rate), but that it rather also exists in the short-term interest rate (Money market rate), thus providing empirical support for the long-run relationship between the real exchange rate and the short-term real interest rate differential.

After determining the long-run determinants of the real exchange rate, Chapter 2 identifies the sources of the real exchange rate short-run fluctuation. Following the conceptual framework of Dornbusch (1976), Clarida and Gali (1994), Malliaropulos (1998) and Hoffmann and MacDonald (2000), we present a simple model, which demonstrates that the relative output differential, the real interest rate differential, the real exchange rate and the relative stock price differential are driven by four structural shocks, namely the supply shock, the monetary shock, the currency risk premium shock and the expectation shock in the short-run, when price-stickiness is assumed. Since the error term of the relative stock prices equation contains the expected depreciation of the real exchange rate and the expected risk premium of domestic stock prices (Malliaropulos, 1998), we recover the disturbance of relative stock prices by estimating VAR in unrestricted form and refer to the structural innovations of the relative stock price as 'expectation shocks'. In addition, the shock generated from the deviation of the uncovered interest rate parity is also considered.

In the impulse response analysis, the empirical results are generally in line with the prediction of our model suggesting that, in the short-run, the ‘sticky-price’ real exchange rate appreciates in response to the monetary shock and the currency risk premium (CRP) shock. In response to a monetary shock, a negative effect can be initially identified in most of the sample countries. However, the effects experience an opposing direction after the second month and reach a peak at roughly 3 to 4 months. This is consistent with Dornbusch’s overshooting model indicating that, under the assumption of price rigidity, any unanticipated decrease in the money supply will lead to a persistent appreciation of the exchange rate in the beginning. The initial appreciation must be proportionately larger than the long-term depreciation. The excess exchange rate appreciation ensures the depreciation required in order to simultaneously clear the money and bonds markets in each case.

On the other hand, there is likely a ‘delayed’ real appreciation of the real exchange in response to a positive expectation shock in most cases. The impact is short-lasting in that the real exchange rate is apparently appreciated during the second month and then the response quickly reverts to its pre-shock level after the third month in most countries. One possible reason for the delayed appreciation might be the herd behaviour in the financial markets. We note that the rebound of the relative stock differential is likely matched with the time of the delayed appreciation. According to the Federal Reserve Bank of New York (1998), some currencies are dominated by a few big players. Capital will flow into domestic countries if those big players become aware of the fact that the domestic stock market is profitable. Their actions would initially cause changes in the real exchange rate and the relative stock differential and the real exchange rate would further appreciate once the other investors become aware of these trends and follow those big players’ actions.

Due to the high fluctuations of the real exchange rate during financial crises, one of the main objectives in Chapter 3 is to investigate how the exchange rate regime switching of a country affects the real exchange rate of the other neighbouring countries. The dynamic equicorrelation (DECO) model of Eagle and Kelly (2012) is used in order to estimate the time-varying average cross-country - i) real exchange rate correlation, or real exchange rate equicorrelation (REC) respectively, ii) behavioural equilibrium exchange rate equicorrelation (BEC) and iii) temporary real exchange rate equicorrelation (TEC) among the four Asian countries (Korea, Thailand, Malaysia and Indonesia) over the sample period. We note that the collapse of the fixed exchange rate of Thailand's currency and the subsequent unexpected shift in the exchange rate regime to independently floating in Indonesia and Korea during the Asian financial crisis (AFC) caused a rapid increase in the REC and TEC, and the change in the REC is apparently more significant than in the case of the TEC. An interesting finding from the equicorrelations' analysis is that asymmetric responses can be found from the REC correlation in response to the 'in' and 'out' pegged exchange rate system in Malaysia. The correlation decreases slightly and steadily after September 1998 (managed floating to pegged) but increases rapidly after July 2005 (pegged to managed floating).

The impacts of the US monetary policy action (FFR, M1 and M2) on the REC, BEC and TEC are also examined. No instantaneous relationship between the monetary variables and the equicorrelations can be found in the pre-AFC and post-AFC periods. This suggests that the US monetary policy does not generate significant impacts on the equicorrelations instantaneously if at least one of the sample countries is operating a pegged exchange rate regime. In the pre-AFC period, a contractionary monetary policy through either the FFR or M1 would produce an increase in the REC but this relationship disappears after the AFC. All monetary policy variables are found to relate to the BEC and TEC with 5% when all countries were operating either a floating or managed a floating exchange rate regime. Compared to the FFR and M1, the impact of M2 on the correlations is the strongest among the three monetary variables, and its lagged value is the only monetary variable that is statistically significant in all correlations.

In Chapter 4, we build on the works of Obstfeld (1985), Clarida and Gali (1994) and Malliaropulos (1998) in order to present a model, which can be used to explain the evolution of relative stock prices with different macroeconomic (demand, supply and nominal) and expectation shocks. The model predicts that the expectation shocks generate a permanent impact on the relative stock prices and the demand shocks lead to both short- and long-run changes in the relative stock prices. However, the supply and nominal shocks only affect relative stock prices on a temporary basis when prices are sluggish.

In identifying the source of the relative stock price fluctuation, the demand and expectation shocks are particularly important in explaining the evolution of the relative stock price, which is consistent with our model. In the historical decomposition analysis, the magnitude of the decline in the base plus expectation shock line in China and the United Kingdom is much larger than the decline in the actual relative stock price and the subsequent rebound in the actual relative stock price is also less than the increase in the base plus expectation line during the global financial crisis. It implies that the changes in investors' expectations are sharp and rapid, and also provides empirical evidence of a high level of speculation in China and the United Kingdom. On the other hand, the high contribution of the demand shock to the relative stock price may arise from the fact that the positive demand shock increased the interest rate. An increment in the interest rate would increase the rates of the future cash flows of the domestic stocks.

The nominal shock is found to generate a negative impact on the relative stock price in most countries. This result is not only consistent with the model suggesting that the relative stock price is expected to decrease in response to a nominal shock in the short-run when the price is sluggish, but is also similar to the empirical results of Malliaropulos (1999) implying that the real nominal shocks would lead to a permanent decrease in the real stock prices under a sticky-price model.

The expectation shock results in a significant increase in the real exchange rate and the relative stock prices. As illustrated in the relative stock price equation, the error term contains the expected change in the real exchange rate: $\nabla E_t \nabla q_t = u + (\vartheta - 1)\nabla q_t^T$ and the expected change in the relative stock prices: $\nabla E_t \nabla \rho_t = v + (\phi - 1)\nabla \rho_t^T$, and embodies the transitory component of the real exchange rate and relative stock prices. Fama and French (1988) indicate that the mean-reverting property of the transitory component of stock prices renders the stock prices predictable so that the mean-reversion of the relative stock prices could be one of the reasons attributed to an increase in the real exchange rate and the relative stock price. Assuming that if the relative stock price of a country falls below its permanent level, speculators would expect a future increase in the relative stock prices, as the temporary component of the relative stock prices contains a mean-reverting property. The inflow of the speculative capitals might be the shocks that temporarily knock the exchange rate away from its equilibrium level, and would initially reflect on a short-term exchange rate appreciation and push up the stock prices as a result.

Many existing papers in the body of exchange rate literature indicated that the changes in exchange rates contain sufficient information to forecast the future changes of their fundamentals (see for example: MacDonald & Taylor, 1993; Engel & West, 2005 and Hoffmann & MacDonald, 2009). Summarising the findings from Chapters 1 to 4, it may be inferred that there is a strong relationship between the real exchange rate and the relative stock differential. In Chapter 5, we try to investigate whether the exchange rate can predict future changes in the stock market return and in the economic performance of a country.

In Chapter 1, we introduce a theoretical interpretation of the real exchange rate determination. The model, referred to as 'DMFS', is an extension of Dornbusch's dynamic Mundell-Fleming model by incorporating the relative stock prices, which outlines the relationship between the real exchange rate, the real output differential, the relative stock price and the real interest rate differential. The changes of the real exchange rate/real exchange rate misalignment may provide a good indicator for investors to predict the future changes of relative stock returns. On the basis of a revision that incorporates the relative stock price and rational expectation in Dornbusch's dynamic Mundell-Fleming model that we presented in Chapter 1, we propose the forward-looking model for the real exchange rate (FLRE) and for the real exchange rate misalignment (FLM) by building on the VAR approach for the present-value models of Campbell and Shiller (1987) and MacDonald and Taylor (1993). Both models involve solving the entire expected future path of the forcing variables Δx_t (real output differential and the transitory component of relative stock prices).

The Granger causality results provide strong evidence that the equilibrium error (obtained from the cointegrating relation between the real exchange rate and the forcing variables) Granger-causes Δx_t in most cases, suggesting that the forcing variables Δx_t can be better predicted using the histories of both Δx_t and the equilibrium error, as opposed to using the history of Δx_t alone. The DMFS rational expectations model can be definitely confirmed in the case of Canada, Japan and the UK, as they strictly fulfil the condition that the equilibrium error Granger-causes Δx_t, but not vice versa, which implies that the equilibrium error s_t is an optimal forecast of a weighted sum of the future value of the forcing variables included in Δx_t, conditional on the agents' full information set. With respect to the real exchange rate misalignment, the results demonstrate that the equilibrium error s_t does not Granger-cause Δx_t in most economies and the expectation theory cannot be confirmed in all cases.

On the other hand, it has been analytically proven that if the discount factors are large (δ= 0.8 or 0.9), then the forward-looking model for the real exchange rate (FLRE) can be confirmed in Canada, Japan, Thailand and the UK, respectively. Similar findings can also be seen in the Wald test results for the FLM model. If the discount factor is small, this particular set of restrictions is strongly rejected outright by the data in most economies. However, as mentioned by Campbell and Shiller (1987), a present value model may well be economically as well as statistically significant, even though its particular cross-equation restrictions may be rejected by the data.

Implications for investors and central banks:

In this thesis, we aim to investigate the long- and short-run determinants of the real exchange rate as well as the source of the relative stock differential fluctuation.

In identifying the source of the relative stock price and the real exchange rate fluctuation, the demand and expectation shocks are particularly important, while the supply shock is likely to be negligible in explaining their evolution. Investors are in no need to over-react to any unfavourable news related to the supply shock.

The impacts of the financial crises and the US monetary action on the time-varying average cross-country real exchange rate correlation are also examined in this thesis. It is particularly useful to understand what drives the exchange rates co-movement and the evolution of the exchange rate correlations, as it is relevant for various areas in finance, including portfolio diversification, risk management, hedging and pricing of financial derivatives and other structural products, and asset allocation decisions. Specifically, we decomposed the real exchange rate into the temporary and equilibrium exchange rates in order to examine the evolution of the cross-country equilibrium real exchange rates correlation (BEC) and cross-country temporary real exchange rates correlation (TEC). This decomposition is more applicable in the case of institutional investors looking to decide their short- and long-term investments.

Our empirical results show that the exchange rate regime switching of a country affects the real exchange rate of the other neighbouring countries. Thus, if a country is likely to shift its exchange rate regime from fixed to float, it may raise the market's concerns on the exchange rate system of the neighbouring countries, causing an outflow of capital. The central banks of the nearby countries should have taken appropriate measures (such as issuing central bank securities to manage liquidity) in order to anticipate any likely exchange rate shocks rather than become involved in market intervention subsequent to a shock.

In practice, one may often perceive that the changes in the exchange rate affect the performance of the stock market, or, conversely, that the changes in the stock price influence the capital movement. We find some empirical evidence suggesting that the current real exchange rate/current real exchange rate misalignment contain sufficient information in order to forecast the expected change in the real output differential and the transitory component of relative stock prices when the discount factor is high. One possible reason for this predictability might be the mean-reverting property of relative stock returns. Considering that if the relative stock price of a country falls below its permanent level, speculators would expect a future increase in the relative stock prices as the temporary component of relative stock prices contains a mean-reverting property. The inflow of the speculative capitals might be the shocks that temporarily knock the exchange rate away from its equilibrium level, and would initially reflect on a short-term exchange rate appreciation and push up the stock prices as a result.

Appendices

Appendix A: The Variable used in Cointegration

Canada	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Money market rate (Home & Foreign) ii) Treasury bill rate (Home & Foreign) iii) Government bond rate (Home & Foreign)
UK	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Money market rate (Home & Foreign) ii) Treasury bill rate (Home & Foreign) iii) Government bond rate (Home & Foreign)
Germany	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Money market rate (Home), Money market rate Foreign)
	ii) Government bond rate (Home), Government bond rate (Foreign)
France	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Treasury bill rate (Home), Treasury bill rate (Foreign)
	ii)Government bond rate (Home), Government bond rate (Foreign)
Italy	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Treasury bill rate (Home), Treasury bill rate (Foreign)
	ii) Government bond rate (Home), Government bond rate (Foreign)
Japan	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Money market rate (Home & Foreign) ii) Treasury bill rate (Home & Foreign) iii) Government bond rate (Home & Foreign)
Korea	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Money market rate (Home), Money market rate Foreign)
	ii) Government bond rate (Home), Government bond rate (Foreign)
Singapore	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Money market rate (Home), Money market rate Foreign)
	ii) Treasury bill rate (Home), Treasury bill rate (Foreign)
Thailand	Monthly stock return (Home & Foreign), Real exchange rate, Real GDP (Home & Foreign) and respectively
	i) Money market rate (Home), Money market rate Foreign)
	ii) Government bond rate (Home), Government bond rate (Foreign)

	Period	Exchange rate arrangement
Korea	3/1980 - 10/1997	Managed Floating
	11/1997 -	Independently Floating
Indonesia	11/1978-6/1997	Managed Floating
	7/1997 -	Independently Floating
Thailand	1/1970 - 6/1997	Fixed
	7/1997 -	Independently Floating
Malaysia	12/1992 - 9/1998	Managed Floating
	9/1998 - 7/2005	Pegged Arrangement
	8/2005 -	Managed Floating

Appendix B: The official IMF classification of the exchange rate regime for the four countries

Appendix B reports the official IMF classification[32] of the exchange rate regime for our four countries before and after the Asian financial crisis (AFC). It indicates that Korea, Indonesia and Thailand shifted their exchange rate regimes into a direction of greater flexibility (independently float) as a result of the AFC, while Malaysia adopted a stricter exchange rate regime (pegged arrangement) after the crisis and shift to managed floating again in August 2005.

[32] The exchange rate regime classification is based on the annual report on the exchange rate arrangements and exchange restrictions issued by the IMF.

Appendix C: The critical values of the F-bound test for the DMFS, FLRE and FLM models

	Canada	China	Hong Kong	Japan	Korea	Thailand	UK
Panel A: 10% significance level							
DMFS model							
critical value							
$I(1)$	3.1	4.45	3.1	3.1	3.77	3.1	3.1
$I(0)$	2.01	3.47	2.01	2.01	2.72	2.01	2.01
FLRE model							
$I(1)$	3.19	5.06	3.19	3.19	4.14	3.19	3.19
$I(0)$	2.17	4.19	2.17	2.17	3.17	2.17	2.17
FLM model							
$I(1)$	3.1	5.06	4.14	3.1	4.14	3.1	3.1
$I(0)$	2.01	4.19	3.17	2.01	3.17	2.01	2.01
Panel B: 5% significance level							
DMFS model							
$I(1)$	3.63	5.07	3.63	3.63	4.14	3.63	3.63
$I(0)$	2.45	4.01	2.45	2.45	3.17	2.45	2.45
FLRE model							
$I(1)$	3.83	5.85	3.83	3.83	4.85	3.83	3.83
$I(0)$	2.72	4.87	2.72	2.72	3.79	2.72	2.72
FLM model							
$I(1)$	3.63	5.85	4.85	3.63	4.85	3.63	3.63
$I(0)$	2.45	4.87	3.79	2.45	3.79	2.45	2.45

References

Aielli, G. P., 2009, Consistent estimation of large scale dynamic conditional correlations. Working paper n.47, University of Messina, Department of Economics, Statistics, Mathematics and Sociology.

Bahmani-Oskooee, M. and A. Sohrabian (1992), "Stock Prices and Effective Exchange Rate of the Dollar", *Applied Economics*, Vol. 24 (1992), pp.459-464

Balassa, B. (1964), "The Purchasing Power Parity Doctrine: A Reappraisal", *Journal of Political Economy*, Vol. 72, 584-596.

Bautista, C. C., (2006), "The exchange rate-interest differential relationship in six East Asian countries", *Economics Letters,* 92, 137-142.

Baxter, M., (1994), "Real exchange rates and real interest differentials: Have we missed the business-cycle relationship?," *Journal of Monetary Economics*, vol. 33(1), pages 5-37, February.

Beaudry P. and Devereux M.B., (1995), "Money and the real exchange rate with sticky prices and increasing returns.", *Carnegie-Rochester Conference Series on Public Policy* 43, 55-102.

Bekaert, G., Hodrick, R., and X. Zhang, (2009), "International Stock Return Comovements", *Journal of Finance,* 64, 2591-2626.

Bernanke B. S. and Blinder A. S., (1992), "The Federal Funds Rate and the Channels of Monetary Transmission", *The American Economic Review*, Vol. 82, Issue 4, 901 – 921.

Bernanke, B., Mihov, I., (1998), “Measuring monetary policy”, *Quarterly Journal of Economics*, 113, 869–902.

Bilson, J., (1978), “The monetary approach to exchange rate – some empirical evidence,” *IMF Staff Papers*, 25, 48-75

Blanchard, O., (1981), “Output, the stock market, and interest rate”, *American Economic Review*, 71, 1, 132–143.

Blanchard, O. and D. Quah (1889), “The Dynamic Effects of Aggregate of Demand and Supply Disturbances”, *American Economic Review*, 25, 7 – 27.

Calvo, G., (1998), “Capital flows and capital-market crises: the simple economics of sudden stops”, *Applied Economics*, 1 November, 35-54.

Campbell, J.Y. and Shiller, R. (1987), “Cointegration and tests of present value models”, *Journal of Political Economy*, vol. 95, 1062-1088.

Caporin, M. and McAleer, M., (2014), “Robust ranking of multivariate GARCH models by problem dimension”, *Computational Statistics & Data Analysis*, 76, 172–85

Chadha, B. and Prasad, E. (1997), "Real Exchange Rate Fluctuations and the Business Cycle: Evidence from Japan", *IMF Staff Papers* No. 44, 328-355.

Chari, V. V. and Kehoe, P. J., (2003), “Hot money”, *Journal of Political Economy*, 111 (6), 1262-1292.

Chari, V., P., Kehoe, P. and McGrattan, E., (2002), "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?", *Review of Economic Studies* 69, 533-563.

Chinn, M., (2000), "Before the Fall: Were East Asian Currencies Overvalued?'', *Emerging Markets Review* 1(2) 101–126.

Chortareas, G., E. and Driver R., L., (2001) "PPP and the Real Exchange Rate - Real Interest Rate Differential Puzzle Revisited: Evidence from Non-Stationary Panel Data." *Bank of England Working Paper* No. 138.

Christoffersen P., Errunza V., Jacobs K. and Jin X., (2014), "Correlation dynamics and international diversification benefits", *International Journal of Forecasting*, Vol. 30, Issue 3, Pages 807–824

Clark, P. and MacDonald, R., (1998), "Exchange rates and economic fundamentals: A methodological comparison of BEERs and FEERs", *IMF Working Paper,* No.98/67.

Clarida, R., and J. Gali (1994), "Sources of Real Exchange Rate Fluctuations: How Important are Nominal Shocks?," *Carnegie-Rochester Conference on Public Policy*, 41,1 - 56.

Cumby, R. and J. Huizinga, (1990), "The predictability of real exchange rate changes in the short run and the long run", *NBER Working Paper,* no. 3468.

Corsetti, G., Prsenti, P. and Roubini, N., (1999), "What caused the Asian currency and financial crisis?", *Japan and the World Economy,* 11, 305-373.

Coughlin C. C., and Koedijk, K., (1990), “What do we know about the long-run real exchange rate?”, *St. Louis Federal Reserve Bank Review*, 72, 36-48.

Cunby, R. E. and J.Huizinga (1990), “The Predictability of Real Exchange Rate Change in the Short Run and Long Run”, *NBER Working Paper* No. 3468.

Dellas, H. and Hess, M., (2005), “Financial development and stock returns: A cross-country analysis”, *Journal of International Money and Finance*, 24(6), 891–912

Dornbusch, R., (1976), “Expectations and exchange rate dynamics,” *Journal of Political Economy*, 84, 1161–1176.

Edison, H. J. and Pauls, B., (1993), “A re-assessment of the relationship between real exchange rate and real interest rates: 1974-1990”, *Journal of Monetary Economics*, 31 (2), 165-187.

Edison, H. J. and Melick, W. R., (1999), “Alternative approaches to real exchange rates and real interest rate: Three up and three down”, *International Journal of Finance and Economics*, 4, 93-111.

Ehrmann, M. and M. Fratzscher, (2004), “Taking Stock: Monetary Policy Transmission to Equity Markets”, *Journal of Money, Credit and Banking,* 36(4): 719-37.

Enders, W. and Lee, B. (1997), "Accounting for Real and Nominal Exchange Rate Movements in the Post-Bretton Woods Period", *Journal of International Money and Finance*, Vol. 107, 507-538.

Engel C. and West K., (2005), “Exchange rate and fundamental”, *Journal of Political Economy*, vol. 113, issue 3, 485-517.

Engel C., 2013, Exchange rates and interest parity, NBER Working Paper No. 19336

Engel C., 2016, Exchange rates, interest rates, and the risk premium, American Economic Review, Vol. 106, No.2, 436-474

Engle R., (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models", J*ournal of Business and Economic Statistics*, 20(3), 339– 350.

Engle R. & Kelly B., (2012), "Dynamic Equicorrelation", *Journal of Business & Economic Statistics*, 30:2, 212-228

Eichengreen, B., Ito, T., Kawai, M. and Portes, R., (1998), "Recent currency crisis in Asia", *Journal of the Japanese and International Economies*, 12, 535-542.

Eichler S. and Maltritz D. (2011), "Currency Crises and the Stock Market: Empirical Evidence for Another Type of Twin Crisis", *Applied Economics*, 43, 4561 – 4587.

Fama E. F. (1981), "Stock returns, real activity, inflation, and money", *American Economic Review*, vol. 71, issue 4, 545-65.

Fama E. F. and French K. (1988), "Dividend yields and expected stock returns', J*ournal of Financial Economics*, 22, 3-25.

Fama E. F. and Schwert G. (1977), "Asset returns and inflation", *Journal of Financial Economics*, vol.5, issue 2, 115-146.

Franck P. and Young A. (1972), “Stock Price Reaction of Multinational Firms to Exchange Realignments”, *Financial Management*, Vol. 1, No. 3 (Winter, 1972), pp. 66-73

Frankel, J., (1979), “On the mark: A theory of floating exchange rates based on real interest differential”, *American Economic Review*, **69**, 610–622.

Frenkel, J., (1976), “A monetary approach to exchange rate: Doctrinal aspects and empirical evidence”, *Scandinavian Journal of Economics,* 78, 255-276.

Fleming, J. M., (1962), “Domestic financial policies under fixed and under floating exchange rates”, *IMF Staff Papers*, 9, 369–379.

Gallagher L. A. & Taylor M. P. (2002), “The stock return-inflation puzzle revisited”. *Economics Letters*, 75, pp. 147-56.

Giovanimi A. and Jorion P. (1987), “Interest rates and risk premia in the stock market and in the foreign exchange market", *Journal of International Money and Finance*, vol. 6(1), pages 107-123,

Glosten, L., R. Jagannathan, and D. Runkle, (1993), On the relation between the expected value and the volatility of the nominal excess return on stocks, *Journal of Finance*, 48 (5), 1779–1801.

Hess, P. J. and B.-S. Lee (1999), “Stock returns and inflation with supply and demand disturbances”, *The Review of Financial Studies,* 12, 1203- 1218.

Hoffmann, M. and R. Macdonald (2000) “A real differential view of equilibrium real exchange rates and misalignments”, *CFS Working Paper No. 2000/8,* Center for Financial Studies, Frankfurt am Main.

Hoffmann, M. and MacDonald, R., (2003), “A Re-examination of the Link between Real Exchange Rates and Real Interest Rate Differentials,” *CESifo Working Paper Series* 894, CESifo Group Munich.

Hoffmann, M. and MacDonald, R., (2009), “Real exchange rates and real interest rate differentials: A present value interpretation”, *European Economic Review*, vol. 53(8), 952-970,

Hooper P. and Morton J., (1982), “Fluctuations in the dollar: A model of nominal and real exchange rate determination”. *Journal of International Money and Finance* **1**, 39–56.

Huizinga, J., (1987), “An Empirical Investigation of the Long-run Behavior of Real Exchange Rates”, *Carnegie-Rochester Conference Series on Public Policy*, 27: 149-214.

Johansen, S., (1988), “Statistical analysis of cointegration vectors,” Journal of Economic Dynamics and Control, Vol. 12, No. 2–3, pp. 231–254.

Johansen, S., (1991), “Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models,” Econometrica, Vol. 59, No. 6, pp. 1551–1580.

Johansen, S., (1995), “Likelihood-based inference in cointegrated vector autoregressive models”, *Oxford University Press,* New York

Kaldor, N., (1939), “Speculation and economic stability”, *The Review of Economic Studies*, 7: 1- 27.

Kalyvitis S. and Michaelides A., (2001), “New Evidence on the Effects of US Monetary Policy on Exchange Rates”, *Economics Letters* 71 255 -263

“

Kaminsky, G.L.and Schmukler, S.L, (1999), What Triggers Market Jitters? A Chronicle of the Asian Crisis”, *Journal of International Money and Finance*, 18, 537–560

Lastrapes, W.D. (1992), "Sources of Fluctuations in Real and Nominal Exchange Rates", *Review of Economics and Statistics*, Vol. 74, 530-539.

Lastrapes, W.D. (1998), "International evidence on equity prices, interest rates and money”, *Journal of International Money and Finance*, Vol. 17, issue 3, 377-406.

Lewis K. K. (1995), “Are Foreign Exchange Intervention and Monetary Policy Related, and Does It Really Matter?”, *The Journal of Business*, Vol. 68, No. 2, 185-214

Longin, F., & Solnik, B., (1995), “Is the correlation in international equity return constant: 1960–1990?”, *Journal of International Money and Finance*, 14, 3–26.

MacDonald R., (1997), “What determines real exchange rate: the long and short for it”, *Journal of International Financial Markets, Institutions, and Money*, 8, 117 -153.

MacDonald, R. and P. Dias, (2007), “Behavioural equilibrium exchange rate estimates and implied exchange rate adjustments for ten countries”, *Peterson Institute of International Economics Global Imbalances Workshop Paper*.

MacDonald and Ricci, (2002), “Estimation of the Equilibrium Real Exchange Rate for South Africa”, *IMF Working Papers,* 03/44,

MacDonald, R. and Swagel, P. (2000), "Business Cycle In.uences on Exchange Rates: Survey and Evidence", I*MF World Economic Outlook Supporting Studies*, Chapter IV, 129-160.

MacDonald, R. and Taylor, M. P. ,(1993), “The monetary approach to the exchange rate: rational expectations, long-run equilibrium and forecasting short-run dynamics and how to beat a random walk”, *IMF Staff Papers*, 40. 89-107.

Malliaropulos, D. (1998), “International stock return differentials and real exchange rate changes”, *Journal of International Money and Finance*, 17: 493-511.

Malliaropulos, D. (1999), “Mean reversion in southeast Asian stock markets”, *Journal of Empirical Finance*, 6(4), 355-384.

Mark, N.C., (1995), “Exchange rate and fundamentals: evidence on long-horizon predictability”, *American Economic Review*, No. 85, pp. 201-218

Mauro P., (2000), “Stock returns and output growth in emerging and advanced economies”, *IMF Working Paper No.* 00/89.

Meese, R., Rogoff, K. (1988), “Was it real? The exchange rate-interest rate differential relation over the modern floating-rate period”, *Journal of Finance*, 43, (4), 933-948.

Mundell, R. A., (1961), “A theory of optimum currency areas”, *American Economic Review*, 51, 657–665.

Nieh C. C. and Lee C. F. (2001), “Dynamic relationship between stock prices and exchange rates for G-7 countries”, *The Quarterly Review of Economics and Finance*, 41 (2001) 477–490

Obstfeld, M., (1985) “Floating Exchange Rates: Experience and Prospects”, *Brookings Papers on Economic Activity*, 2:369-450,

Pesaran M. H., Y. Shin and Smith R. J., (2001), “Bounds testing approaches to the analysis of level relationships”, *Journal of Applied Econometrics*, vol. 16, pp. 289–326, May, 2001

Poterba, J. M. and Summers, L. H., (1988), “Mean reversion in stock prices: Evidence and implications” *Journal of Financial Economics*, 22: 27-59.

Radelet, S. and Sachs, J., (1998a), “The East Asian Financial Crisis: Diagnosis, Remedies and Prospects”, Harvard Institute for International Development, Cambridge: MA.

Radelet, S. and Sachs, J., (1998b), The Onset of the East Asian Financial Crisis, Harvard Institute for International Development, Cambridge: MA.

Rapach D. E. (2001), “Macro shocks and real stock prices”, Journal of Economics and Business, vol. 53, issue 1, 5-26.

Rigobon, R., (1998), Information Speculative Attacks: Good News is No News. Cambridge MA: Massachusetts Institute of Technology.

Rogers, J. (1999), "Monetary Shocks and Real Exchange Rates", *Journal of International Economics*, Vol. 49, 269-288.

Rogoff, K., (1996), “The Purchasing Power Parity Puzzle”, *Journal of Economic Literature*, 34, 647-668.

Saikkonen, P. and Lütkepohl, H. (2000), “Testing for the cointegrating rank of a VAR process with a time trend”, *Journal of Econometrics*, Vol. 95, issue 1, 177-198

Samuelson, P. (1964), "Theoretical Notes on Trade Problems", *Review of Economics and Statistics*, Vol. 46, 145-154.

Sims, C. A. and Zha, T., (1995), “Does Monetary Policy Generate Recessions?: Using Less Aggregate Price Data to Identify Monetary Policy”, *Yale University Working Paper*.

Soenen, L.A. and Hennigar, E.S. (1988), “An Analysis of Exchange Rates, and Stock Prices—The U.S. Experience between 1980 and 1986”, *Akron Business and Economic Review*, 19, 7-16.

Sollis, R. and Wohar, M. E., (2006), “The real exchange rate – real interest rate relation: Evidence from tests for symmetric and asymmetric threshold cointegration”, *International Journal of Finance and Economics*, 11, 139-153.

Solnik B. (1987), “Using Financial Prices to Test Exchange Rate Models: A Note”, *The Journal of Finance*, Vol. 42, No. 1 (Mar., 1987), pp. 141-149

Throop, A. W. (1994), “International financial market integration and linkages of national interest rates”, Federal Reserve Bank of San Francisco Economic Review, 3-18.

Webber, A. (1997), "Sources of Purchasing Power Disparities Between the G3 Economies", *Journal of the Japanese and International Economies*, Vol. 11, 548-583.

Williamson J., (1994), “Estimating equilibrium exchange rates”, Peterson Institute Press: All Books, Peterson Institute for International Economics, no. 17.

Wong, K. T. and Li, K.-W. (2009), “Comparing the performance of relative stock return differential and real exchange rate in two financial crises”. *Applied Financial Economics*

Wren-Lewis, S., (1992), “On the Analytical Foundations of the Fundamental Equilibrium Exchange Rate” in Macroeconomic Modelling of the Long-Run, ed. Colin P. Hargreaves, Edward Elgar.

Wu Y. (2000),” Stock prices and exchange rates in a VEC model – The case of Singapore in the 1990s”, *Journal of Economics and Finance*, Vol. 24, No. 3, Fall 2000, pp. 260 – 274

The foreign exchange and interest rate derivatives markets: Turnover in the United States, (1998), Federal Reserve Bank of New York

The foreign exchange and interest rate derivatives markets: Turnover in the United States, (2013), Federal Reserve Bank of New York